Paolo M. Panteghini

Corporate Taxation in a Dynamic World

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With 6 Figures and 6 Tables

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Preface

When I decided to write this book, I was not fully aware of the reason why I was doing so. During the entire year spent in writing it, however, I had the opportunity to reflect upon its benefits for my professional maturity. First of all, this book has enabled me to write a sort of balance sheet of the first decade I have devoted to the study of corporate taxation. Quite surprisingly I have realized that there has been at least a minimum of coherence in my research. More importantly, however, I have realized the full meaning of Socrates' well-known motto: "I am the wisest man alive, for I know one thing, and that is that I know nothing". In reading other scholars' contributions I have just realized that I know virtually nothing: I think that this will be a good stimulus for my future research.

The book analyzes both positive and tax policy issues. In the first part, I have applied option pricing techniques to tax problems. In particular, I have analyzed the effects of taxation on entrepreneurship and on firms' decisions, concerning organizational form, capital structure, investment timing and foreign direct investment location.

The second part deals with policy issues. The focus has been on imputation systems, which is a viable and promising tax device. Again, I have applied option pricing to their study. I believe that this method is a powerful tool for tax economists. Given that the economic environment is inherently stochastic, option pricing enables scholars to improve their understanding of the effects of taxation.

This preface allows me to thank all my co-authors. Special thanks go to Massimo Bordignon and Silvia Giannini, who gave me the opportunity to concentrate on policy issues. I also want to thank Guttorm Schjelderup, who helped me to deal with international tax problems. Many colleagues have made fairly useful comments about my articles. I wish to thank the late Aldo Chiancone, as well as Gianni Amisano, Antonio Guccione, Vesa Kanniainen, Alessandro Missale, Michele Moretto, Carlo Scarpa, and Peter Birch Sørensen. I am also indebted to two patient colleagues of mine, Roberto Casarin and Francesco Menoncin, who have helped me in resolving editing problems.

Last but not least, I wish to thank the Italian soccer team that inspired me when I was writing the first draft of this manuscript.

March 2007 Paolo M. Panteghini

Contents

List of acronyms

ACE	Allowance for Corporate Equity
BET	Business Enterprise Tax
BNP	Bad News Principle
CBIT	Comprehensive Income Tax
DIT	Dual Income Tax
EBIT	Earning Before Interest and Taxes
ECJ	European Court of Justice
GIT	Growth and Investment Tax
IAIT	Interest Adjusted Income Tax
IRAP	Imposta Regionale sulle Attività Produttive
IRS	Internal Revenue Service
MNC	Multinational Company
NPV	Net Present Value
PRT	Petroleum Revenue Tax
ROA	Return On Assets
SBT	Single Business Tax
S-H-S	Schanz-Haig-Simons
SIT	Simplified Income Tax
SPC	Smooth Pasting Condition
VAT	Value Added Tax
VC	Venture Capital
VMC	Value Matching Condition

Part I

Basic issues

1 The real option approach

A firms' activity is usually characterized by flexibility, as business strategies are very seldom based on commitment to a determined static once-and-for-all decision. Since firms' policies usually consist of an intertemporal sequence of linked decisions, flexibility allows firms to react to changes in market conditions. Each opportunity to make strategic decisions can be viewed as a real option. Following Trigeorgis (1996) we can say that a firm has:

1. an option to delay, when it can decide not only whether but also when to invest;

2. a time-to-build option, when the overall investment project consists of a sequence of stages: each of them can be considered as an option on the value of subsequent stages;[1]

3. an option to abandon, when market conditions get worse and the firm can abandon its business activity and realize the resale value (if any) of its capital on second-hand markets;

[1] As Dixit and Pindyck (1994) point out undertaking investment takes time. Thus firms often complete the early stages and then wait before undertaking the following stages. Moreover, different investment stages may require different skills or they may be located in different places.

4. an option to switch, when management can change not only the firm's technology (in terms of both input and output mix), but also the organizational form of the firm itself (e.g., by incorporating);[2]

5. an option to alter operating scale and a growth option, when given favorable market conditions, management can either expand the scale of production, or open up growth opportunities (e.g., by enriching the set of goods produced).

Real options are increasingly widespread. As found for instance by Graham and Harvey (2001) more than 25% of US companies surveyed always or almost always incorporate real options when evaluating a project. Furthermore, McDonald (2000) argues that even when firms apply standard techniques, it is possible that they adopt *ad hoc* rules of thumb which proxy for real option evaluation.

The real option approach aims at measuring the value of business flexibility, by applying the pricing techniques developed by the relevant finance literature. Such techniques are adapted to account for the *ad hoc* characteristics of firms' investment projects.

As pointed out, this approach is helpful to evaluate business activities whenever firms can adapt their strategies and revise their decision to respond to new market conditions. Accordingly, the value of a business project at time t is equal to

$$NPV_t^e = NPV_t + O_t, \tag{1.1}$$

where NPV_t^e is the expanded Net Present Value (NPV) of a project, NPV_t is the static NPV, measuring the project value when the firms commit to a given operating strategy, and O_t is the option value that measures a firm's ability to react to new market conditions.

It is worth noting that without business flexibility, O_t falls to zero and the project's expanded NPV reduces to the static one. We can therefore say that the traditional Net-Present-Value rule provides a precise measure of investment projects only if firms can neither delay business decisions nor modify strategies. However, real life shows that this set of conditions is fairly infrequent.

In most cases firms have more than one option: for example, they can both expand their business activity and abandon production,

[2] The option to incorporate will be discussed in chapter 3.

depending on market conditions. When firms are endowed with a set of business opportunities, we can say that they own a compound option. As pointed out by Trigeorgis (1996), interactions between firms' options imply that the value of the compound option may differ from the sum of their separate option values.

1.1 Real call options

The option to delay, the time-to-build option, and the growth option are real call options as they entail investment decisions. To deal with such options we must recall what Dixit and Pindyck (1994, p. 3) say: "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 capital specificity, and from "lemon effects" (see Dixit and Pindyck, 1994, and Trigeorgis, 1996). Even when brand-new capital can be employed in different activities, indeed, it may become specific once it is installed. Irreversibility may also be caused by industry comovement: 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 lower price than an insider would be willing to pay if it did not face the same bad conditions as the seller. The resale price is even lower under asymmetric information when lemon effects make second-hand markets inefficient.

In the absence of uncertainty, irreversibility is not a problem since there are no unexpected changes in market conditions which might induce the firm to modify its strategy. In a stochastic environment, instead, the ability to adapt to new market conditions is crucial for a firm to survive. In most cases, firms have an opportunity to delay their investment decision and wait until new information (e.g., on market prices, and competitors' moves) is available.

As pointed out by McDonald and Siegel (1986), the opportunity to delay is like a call option, and therefore, investment is undertaken when it is optimal to exercise this option. To deal with optimal timing let us then focus on the investment strategy of a representative firm. Without any opportunity to delay irreversible investment, the firm must decide at time t whether to invest or not. According to this now-or-never case the investment decision will follow a standard NPV rule:

$$\max\{NPV_t, 0\}. \tag{1.2}$$

According to the standard NPV rule (1.2), if $NPV_t > 0$ investing at time t is profitable and vice versa.

As commonly argued in the literature on investment decisions,[3] agents are well aware that any decision to undertake irreversible investment reduces the flexibility of their strategy. Investment opportunities, therefore, are not obligations, but option-rights. If agents can postpone irreversible investments, they will choose the optimal exercise timing, and the rule given in (1.2) must be modified in order to account for the option to delay.[4] To see the implications of this, let us suppose the firm can delay investment until time $t+1$. If the firm invests immediately, it will enjoy the profit stream between time t and time $t+1$. If it waits until time $t+1$, it has the possibility of acquiring new information, which may emerge in the form of good news (profits) or bad news (losses). Therefore, investing at time 0 implies the exercise of the option to delay and entails paying an opportunity cost for the flexibility lost in the firm's strategy. To decide when to invest, the firm compares NPV_t with the expected present value of the investment opportunity at time $t+1$, NPV_{t+1}. The optimal decision entails choosing the maximum value, i.e.,

$$\max\{NPV_t, NPV_{t+1}\}. \tag{1.3}$$

Equation (1.3) shows that the firm chooses the optimal investment timing by comparing the two alternative policies. If the inequality $NPV_t > NPV_{t+1}$ holds, immediate investment is undertaken. If,

[3] For further details on this literature see e.g. Smit and Trigeorgis (2004).

[4] This point was raised by Cukierman (1980, p. 462), who argued that: "in a world of risk-averse investors, an increase in uncertainty usually decreases the equilibrium level of investment. Much less attention has been paid to the possibility that there may be another additional channel through which increased uncertainty affects the current level of investment: For given costs of acquiring information, an increase in uncertainty about the relevant parameters makes it profitable to spend more time and resources in acquiring information before making a particular investment decision. This element is particularly important when there are a range of possible investment projects out of which only a subset will ultimately be undertaken and when these projects, once started, cannot be reversed easily".

instead, $NPV_{t+1} > NPV_t$, then waiting until time 1 is the optimal choice.

1.1.1 A two-period model

To have a clearer idea of how the investment decision may change when timing is accounted for, we introduce the two-period model discussed in Dixit and Pindyck (1994). We assume that:

1. risk is fully diversifiable;
2. the risk-free interest rate r is fixed;
3. 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 upward and downward 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:

$$\sum_{t=1}^{\infty} \frac{(1+u)\Pi_0}{(1+r)^t} > \frac{I}{1+r} > \sum_{t=1}^{\infty} \frac{(1-d)\Pi_0}{(1+r)^t}, \tag{1.4}$$

where $\sum_{t=1}^{\infty} \frac{(1+u)\Pi_0}{(1+r)^t} = \frac{(1+u)\Pi_0}{r}$ measures the present discounted value of the flow of future profits from time 1 to infinity, if gross profits increase, $\sum_{t=1}^{\infty} \frac{(1-d)\Pi_0}{(1+r)^t} = \frac{(1-d)\Pi_0}{r}$ is the present value when profits fall, and $\frac{I}{1+r}$ is the discounted cost of the investment undertaken at time 1.

Inequalities (1.4) are necessary to qualify good and bad news. As can be seen the upward jump in profits (i.e., good news) is such that the present value of future expected operating profits overcomes the investment cost $\frac{I}{1+r}$. The converse is true when the firm faces a downward jump in profits. Since the expected net return from undertaking investment is negative the firm receives bad news.

1.1.2 The threshold point

Let us now study the firm's investment policy. If, at time 0, the firm cannot postpone it in the future (see Dixit and Pindyck, 1994, p. 6), the optimal investment rule is based on the NPV of the investment. According to rule (1.2), the firm will invest if the expected NPV at time $t = 0$ of its future payoffs, is positive, i.e.,

$$NPV_0 = -I + \Pi_0 + \sum_{t=1}^{\infty} \frac{[q(1+u) + (1-q)(1-d)]\,\Pi_0}{(1+r)^t} > 0. \quad (1.5)$$

When the firm can postpone investment, the rule (1.2) is no longer valid, as the firm must account for the opportunity to wait for new information. This implies that the firm is endowed with an option to delay. To decide when investing, therefore, the firm compares NPV_0 with the expected NPV of the investment opportunity at time 1, i.e.,

$$NPV_1 = -\frac{qI}{1+r} + \sum_{t=1}^{\infty} \frac{q(1+u)\Pi_0}{(1+r)^t}. \quad (1.6)$$

Note that equation (1.6) 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).

According to rule (1.3), the firm 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 (1.5) equal to (1.6), i.e.,

$$NPV_0 = NPV_1,$$

and solving for Π_0 we obtain the trigger value, above which immediate investment is preferred:

$$\Pi_0^* = \frac{r + (1-q)}{r + (1-q)(1-d)} \cdot \frac{r}{1+r} \cdot I. \quad (1.7)$$

As shown by equation (1.7), 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, uncertainty acts asymmetrically since only unfavorable events affect the current propensity to invest.[5] The intuition behind the BNP is straightforward: a firm that invests either at time 0 or 1 and receives good news, will not regret its investment decisions, since it is profitable irrespective of the firm's timing. In contrast, timing is crucial if bad news is reported. To see this, assume that the firm waits until time 1 and then receives bad news. In this case it will not invest and the choice of waiting turns out to be a good choice. If, instead, it had invested at time 0, it would have regretted its choice. Thus, bad news matters for the timing of investment, but good news does not.

To understand this result let us rewrite (1.7) in terms of the Return On Assets (ROA), i.e.,

$$\frac{\Pi_0^*}{I} = \frac{r}{1+r} + \left[\frac{(1-q)d}{r+(1-q)(1-d)}\right]. \tag{1.8}$$

According to (1.8), the initial ROA, i.e. Π_0^*/I, is equal to the sum between the (risk-free) normal return $\frac{r}{1+r}$, and the term $\frac{(1-q)d}{r+(1-q)(1-d)}$ which measures the additional return that is required by the firm to exercise its call option and invest at time 0. This latter term measures the opportunity cost of losing business flexibility.

The implication of the BNP is that the worse the news, the higher is the return required to compensate for irreversibility, and the higher is the trigger point Π_0^*. In line with the BNP, indeed, the threshold return (1.8) depends on both the seriousness and the probability of the bad news. If, in fact, bad news vanished (i.e., if either $d=0$ or $q=1$) the required return would collapse to $\frac{r}{1+r}$, that is the expected return of reversible investment.

[5] As stated by Bernanke (1983, pp. 92-93), "this "bad news principle of irreversible investments"–that of possible future outcomes, only the unfavorable ones have bearing on the current propensity to undertake a given project–is easily explained once we return to the basic option value idea. The investor who declines to invest in project i today (but retains the right to do so tomorrow) gives up short-run returns. In exchange for this sacrifice, he enters period $t+1$ with an "option" that entitles him to invest in some project other than i (or to wait longer) if he chooses. This option is valueless in states where investing in i is the best alternative. In deciding to "buy" this option (by declining to make a commitment in t), the investor thus considers only possible "bad news" states in $t+1$, in which an early attachment to i would be regretted". He then adds that "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".

1.2 Real put options

The option to abandon is a real put option. Similarly, the option to alter operating scale and the option to switch are put options as long as they entail a reduction either in the scale of production or in the number of goods produced. The ownership of a put option allows the firm to either disinvest or reduce the riskiness of its activity.

Using (1.1), we can say that the firm's expanded NPV at time t is equal to

$$NPV_t^e = NPV_t + P_t, \tag{1.9}$$

where P_t measures the value of the put option.

To provide an example of put option let us recall the two-period model used in the previous section, and assume that:

1. $d > 1$,
2. the firm can decide whether or not to abandon a project.

Given the inequality $d > 1$, at time 1 the firm faces an operating loss equal to $-(d-1)\Pi_0$ with probability $(1-q)$. In this case the firm will find it optimal to abandon the project. To measure the value of the put option to abandon let us first calculate the firm's expanded NPV, i.e.,

$$NPV_0^e = -I + \Pi_0 + \sum_{t=1}^{\infty} \frac{q(1+u) + (1-q)\max\{(1-d), 0\}}{(1+r)^t} \Pi_0, \tag{1.10}$$

where $\max\{(1-d), 0\}$ means that, in the event of bad news, the firm can abandon the business activity.

Substituting (1.5) and (1.10) into (1.9) and computing the difference between the expanded NPV and the static one gives the put option value

$$P_0 = NPV_0^e - NPV_0 = \frac{(1-q)(d-1)\Pi_0}{r}.$$

As can be seen the higher is both expected operating loss $(d-1)\Pi_0$ and its probability $(1-q)$, the more valuable is the put option to abandon. Similar results can be found when we assume that the firm is endowed with an option to reduce either the scale of production or the number of goods produced.

The importance of these real put options is highlighted by Smit and Trigeorgis (2004, p. xxvii): "if management is asymmetrically positioned to capitalize on upside opportunities but can cut losses on the downside, more uncertainty can actually be beneficial when it comes to option value".

1.3 Tax neutrality

So far we have seen that the investment decision rule depends on whether the agent can time it or not. We will now show that the effects of taxation also depend on whether the agent can postpone or not his decision. To do so we first need to derive a sufficient condition for tax neutrality in the now-or-never case and then turn to the real-option case.

1.3.1 The Brown condition in a static context

To show how this condition changes when firms own real options we can use the above two-period model.

Let us define T_0 as the present discounted value of tax payments when investment is undertaken at time 0. Therefore, the after-tax expected NPV of profits is equal to

$$NPV_0^T \equiv NPV_0 - T_0.$$

According to Brown (1948), a sufficient neutrality condition is reached when, defining τ as the relevant tax rate, the after-tax NPV is $(1-\tau)$ times the before-tax NPV, namely

$$NPV_0^T \equiv NPV_0 - T_0 = (1-\tau) \cdot NPV_0. \tag{1.11}$$

As explained by Johansson (1969, p. 104), this condition implies that "Corporate income taxation is neutral, if [...] identical ranking of alternative investments is obtained in a before-tax and after-tax profitability analysis". If therefore NPV_0 is positive and investment is profitable, then neutrality entails that NPV_0^T is positive too, and vice versa.

1.3.2 The Brown condition in a real option context

In order to obtain a sufficient neutrality condition, all the costs must be deductible. When the firm can modify its strategy, the Brown condition must be modified, in order to embody the firm's real options.[6] Let us then define

$$NPV_1^T \equiv NPV_1 - T_1$$

as the after-tax NPV of the investment opportunity at time 1, where T_1 is the present value of tax payments when investment is undertaken at time 1. It is worth noting that a change in business strategy may cause a change in the expected present value of tax payments. Depending on the sign the tax wedge $(T_0 - T_1)$, therefore, taxation may or may not discourage changes in business strategies.

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

$$(NPV_0 - T_0) - (NPV_1 - T_1) = (1 - \tau) \cdot (NPV_0 - NPV_1). \quad (1.12)$$

It is worth noting that condition (1.11) is a special case of condition (1.12). When the firm cannot postpone investment, its after-tax option to delay, $(NPV_1 - T_1)$, is nil and condition (1.12) reduces to (1.11).

Condition (1.12) means that there exists an identical ranking in a before-tax and in an after-tax profitability analysis. In other words, (1.12) implies that the after-tax threshold point is equal to the laissez-faire one of equation (1.7). 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. Therefore, when condition (1.12) holds, these offsetting effects neutralize each other. Similarly, neutrality entails that the decision to abandon or reduce the scale of production is unaffected by taxation.

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[6] For further details on tax neutrality in a real-option setting see Niemann (1999), and Panteghini (2001a).

1.4 An emerging literature

Since the beginning of the 1990s, tax economists have studied the interactions between, on the one hand, irreversibility, uncertainty and investment timing, and, on the other hand, corporate taxation. A pioneering article is that of MacKie-Mason (1990), who showed that an asymmetric corporation tax always reduces the value of the investment project. Under some circumstances, however, he found a tax paradox: increasing the corporate income tax rate can stimulate investment by lowering the option value of the project.[7]

In two interesting papers, Alvarez and Kanniainen (1997, 1998) analyzed the Johansson-Samuelson Theorem[8] in a real-option setting. They showed that as long as taxation leaves the project's value unchanged but raises the option value of the project, a uniform tax discourages investment.[9] Moreover, they proved that the lack of full refundability makes the cash-flow taxation distortive as well.[10] Faig and Shum (1999) found that the higher the degree of irreversibility, the more distortive is a corporate tax system. Furthermore, they pointed out that distortions are amplified by tax asymmetries.[11]

Finally, some authors have studied the effects of irreversibility on some existing tax schemes. In particular, McKenzie (1994) analyzed 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

[7] On the real-option approach see also Pennings (2000).

[8] The Johansson-Samuelson Theorem is the joint result of Johansson's (1969) and Samuelson's (1964) articles on comprehensive income taxation. Assuming that all kinds of capital are subject to the same marginal tax rate, they find that the value of an investment project is unaffected by taxation on condition that fiscal depreciation allowances coincide with economic depreciation and debt interest is fully deductible. According to this Theorem, therefore, a uniform comprehensive income tax is neutral in terms of investment choices. For further details on this result see Sinn (1987, ch. 5).

[9] Niemann (1999) showed that the Johansson-Samuelson Theorem holds on condition that the firm's option to delay is deductible, as any other cost.

[10] In line with Ball and Bowers (1983), Alvarez and Kanniainen (1997) justified the absence of full refundability by arguing that future positive revenues may be not sufficient to draw previous losses.

[11] Faig and Shum (1999) proposed an interesting reinterpretation of Stiglitz' (1973) neutrality result. They showed that under investment irreversibility, tax distortions are reduced when the firm is debt-financed at the margin.

investment. Similarly, due to its asymmetries,[12] the PRT was distortive.

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

2

The entrepreneurial decision

The effects of taxation on entrepreneurship were analyzed in a pioneering work by Domar and Musgrave (1944). They pointed out that taxation shifts risk from the entrepreneur to the government, which can be considered as a kind of "sleeping partner" that receives dividends, if any, by means of taxation.[1] Under full loss-offset, the tax rate measures the portion of the upside and downside variation in the entrepreneur's payoff which belongs to the government. By absorbing a part of the risk, therefore, Domar and Musgrave (1944) argued that taxation can encourage risk-averse agents to undertake a risky activity.[2]

[1] This point has recently been taken up by Auerbach (2004) with reference to president Clinton administration's proposal of applying part of the resources of the social security system to buy shares of US companies. Auerbach (2004) has advised caution given that the government was already significantly involved in share holding thanks to fiscal leverage. Therefore, by investing in US shares, the government would be excessively exposed to any stock exchange crashes.

[2] As regards risk, Domar and Musgrave (1944, p. 390) maintained that "a distinction must be drawn between private risk (and yield), which is carried by the investor, and the total risk (and yield), which includes also the share borne by the Treasury". Therefore, under taxation the investor will "increase his private risk above the unadjusted level to which it was lowered by the tax" and "total risk must have increased above the pre-tax level".

Domar and Musgrave's (1944) point was developed by Stiglitz (1969). By applying a mean-variance model, he proved that the effects of income taxation depend on risk aversion. In particular, he showed that, under full loss-offset, an increase in the income tax rate stimulates the demand for risky assets if: 1) the risk-free interest rate is zero; 2) absolute risk aversion is constant or increasing; 3) absolute risk aversion is decreasing and relative risk aversion is increasing or constant. If none of these conditions is satisfied, a tax rate increase may discourage the demand for risky assets. Moreover, Stiglitz (1969) showed that, with no loss offset, the demand for risky activities decreases for sufficiently high tax rates.

Kanbur (1979) analyzed the effects of progressive taxation on national income and on the propensity to undertake risky activities. He showed that progressivity has an ambiguous impact on entrepreneurship. In particular, at extremes of risk aversion and risk love, greater progressivity is associated with higher national income, and higher propensity to undertake risky activities. Otherwise, tax progressivity has a depressing effect on the economy.

Empirical evidence regarding the effects of taxation on entrepreneurship is mixed. In line with Kanbur (1979), Gentry and Hubbard (2000) estimated the impact of progressive taxation on entrepreneurship, and showed that an increase at time t of tax progressivity reduces the probability of undertaking a business activity at time $t+1$.

Bruce (2000) found that reducing an individual's marginal tax rate on self-employment income, while leaving his marginal wage tax rate unchanged, reduces the probability of entering the business sector.

Gordon (1998) focused on tax avoiding practices. He maintained that setting up new firms can avoid taxation by reclassifying their earnings as corporate rather than personal income, as long as the former is taxed less heavily than the latter. He then showed that tax avoiding practices may favor entrepreneurial activity. More recently, Lee and Gordon (2005) have used cross-country macro data during the 1970-1997 period and have found that a cut in the statutory tax rate by 10 percentage points raises the annual growth rate by more than one percentage point. Their explanation is that, given the personal tax rate, a more favorable treatment of risky activities encourages more people to go into business for themselves. However they admit that available information is not sufficient to draw a definitive conclusion about the links between taxation, business activity and growth.

As argued by Kanniainen, Kari and Ylä-Liedenpohja (2005), small non-corporate firms have received less attention than corporations. For this reason, they develop a model describing the life-cycle of a firm, with both a start-up and an expansion phase. Quite realistically, in the former stage the firm is assumed to be non-corporate. In the latter one, however, the entrepreneur can exercise an option to incorporate. As they show, personal taxation has an ambiguous effect. On the one hand, the cost of capital in the start-up stage is raised by dividend taxation. On the other hand, capital gains taxation, levied in the second stage, acts as a balancing force on the start-up cost of capital.

The model presented in the next section puts the emphasis on the relationship between the start-up decision and taxation. We depart from most of the relevant literature which, apart from a few exceptions, analyzes entrepreneurial choice by means of optimal-portfolio decisions. According to this framework, agents can decide on how much to invest in risky activities while buying with the remaining resources risk-free activities. However, the evidence shows that most entrepreneurial choices are dichotomous ones. Therefore the optimal-portfolio approach may be unsuitable for the analysis of entrepreneurship. For this reason we will focus on self-employed risk-neutral individuals and analyze how riskiness matters. In doing so we will disregard the insurance effect played by taxation, extensively discussed by the relevant literature, and focus on the BNP described in chapter 1. The option to incorporate and organizational issues, analyzed by Kanniainen, Kari and Ylä-Liedenpohja (2005), will be discussed in chapter 3.

In the next chapters we will apply option pricing techniques. To allow an easy reading of this book, we will provide *ad hoc* appendices on the most relevant mathematical steps and will focus on the properties of the stochastic processes applied. In order to make reading even easier, we will use a notation which is as close as possible to that used by Dixit and Pindyck (1994).

2.1 The entrepreneurial choice without taxation

Let us analyze the entrepreneurial choice by an individual who initially works and has an opportunity to start a new business activity. Here we concentrate on the start-up decision and assume that the firm starts non-corporate. For simplicity we disregard personal taxation and assume that the individual is infinitely-lived.[3] Moreover we introduce the following:

Assumption 1 *At time $t = 0$ the individual is a worker, earning an exogenous wage w, and is endowed with an option to start an entrepreneurial activity.*

Assumption 2 *To undertake the risky activity the individual must pay a sunk start-up cost I.*

Assumption 3 *After entry, the firm's payoff at time t, defined as Π_t, is stochastic and moves according to the following process:*

$$\frac{d\Pi_t}{\Pi_t} = \alpha dt + \sigma dz_t \text{ with } \Pi_0 > 0, \tag{2.1}$$

where α is the growth rate, σ is the instantaneous standard deviation of $\frac{d\Pi_t}{\Pi_t}$, and dz_t is the increment of a Brownian motion (which is also known as Wiener process).

Assumptions 1 to 3 deserve some comments. For simplicity in assumption 1, we assume that the before-tax wage rate is exogenously given: this implies that labor supply is fully elastic. Moreover we let the individual decide not only whether but also when to become an entrepreneur. This means that he is endowed with a call option. Since this option can be exercised at any future instant we can say we have an American call option.[4]

When the individual decides to become an entrepreneur, and thus exercises the option, he loses his wage and, according to assumption 2, must pay I, which accounts for consultancy and administrative costs, and represents the strike price of the individual's option.

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[3] This simplifying assumption does not affect the quality of results. Assuming finite lifetime simply entails an increase in the discount rate from r to $r + p$, where p is the probability of death at each instant.

[4] For further details see McDonald and Siegel (1985, 1986), and Merton (1990).

According to assumption 3, the firm's payoff follows a stochastic process. In particular, the process described in (2.1) is a geometric Brownian motion, that represents the continuous-time limit of a random walk in discrete time. One attracting feature of this process is the fact that the change rate $\frac{d\Pi_t}{\Pi_t}$ is normally distributed. Moreover, assuming the existence of a geometric Brownian motion allows us to find, in many cases, closed-form solutions. Further details on this process are provided in appendix 2.4.1.

Notice that although we assume that business projects are characterized by irreversible choices, this assumption does not rule out the possibility of having variable and also reversible inputs. Indeed, Π_t can be considered as the reduced form of a more general function which can account for both market imperfections and variable inputs. In other words, we could assume that

$$\Pi_t = \arg\max_L \Pi\left(L; t\right),$$

where L is some variable input (including effort), and the quality of results would not change.[5] For simplicity, hereafter we will omit the time variable.

2.1.1 The worker's value function

To study the entrepreneurial choice we must calculate the individual's value functions before and after his decision. In this chapter we also assume that the business activity is self-financed.[6]

Using dynamic programming we can write the individual's before-entry value function as a summation between the current wage (that is the wage received in the short interval wdt) and the remaining value, that is the value function after the instant dt has passed. We thus have:

$$O(\Pi) = wdt + e^{-rdt}\left\{\xi\left[O(\Pi + d\Pi)\right]\right\}, \tag{2.2}$$

where r is the risk-free interest rate, and $\xi\left[O(\Pi + d\Pi)\right]$ is the expected value at time $t + dt$.

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[5] For further details on this point, see Dixit and Pindyck (1994, ch. 10).

[6] In chapter 4 we will introduce debt and analyze the effects of taxation on firms' financial choices.

According to assumption 1 the individual is aware that he could resign at any instant t and start the risky activity. As shown in appendix 2.4.2, the worker's function (2.2) can be rewritten as

$$O(\Pi) = \frac{w}{r} + A_1 \Pi^{\beta_1}, \tag{2.3}$$

which consists of two terms. The first one is a perpetual rent accounting for future labor income earned by the individual. Since, by assumption, the worker's lifetime is infinite, the relevant discount rate is r.[7] The second term measures the individual's option to start the business activity. A_1 is an unknown parameter to be determined, and

$$\beta_1 = \frac{1}{2} - \frac{\alpha}{\sigma^2} + \sqrt{\left(\frac{\alpha}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2r}{\sigma^2}} > 1$$

is found in appendix 2.4.2.

2.1.2 The firm's value function

Let us next calculate the individual's value function after starting the business activity. Applying dynamic programming we can write it as

$$V(\Pi) = \Pi dt + e^{-rdt} \left\{ \xi \left[V(\Pi + d\Pi) \right] \right\}. \tag{2.4}$$

As shown in appendix 2.4.3, we can rewrite (2.4) as follows

$$V(\Pi) = \frac{\Pi}{r - \alpha}. \tag{2.5}$$

It is worth noting that the relevant discount rate is given by the difference between the risk-free interest rate r and the drift α. By using the adjusted discount rate $r - \alpha$ we thus account for the expected increase in Π.

As shown in (2.5), the individual's value function is simply a perpetual rent. This is due to the fact that, after entering the business sector, the individual is assumed not to make further decisions. In section 2.4 we will remove this simplifying assumption by allowing the entrepreneur to exit from the business sector and re-enter the labor market.

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[7] Remember that assuming limited lifetime would simply require an increase in the discount rate.

2.1.3 Optimal start-up timing

Let us next analyze the individual' intertemporal decision. The individual's problem is one of choosing the optimal entrepreneurial timing, which can be associated with a trigger point $\overline{\Pi}$. This means that whenever the current income reaches $\overline{\Pi}$, the individual starts his business activity.

To find $\overline{\Pi}$ we introduce the Value Matching Condition (VMC) and the Smooth Pasting Condition (SPC). The VMC requires the equality between the present value of the project, net of the investment cost, and the value of the option to delay investment, at point $\Pi = \overline{\Pi}$, namely:

$$V(\overline{\Pi}) - I = O(\overline{\Pi}). \tag{2.6}$$

The VMC (2.6) implies that when the option is exercised optimally (i.e., at point $\Pi = \overline{\Pi}$) the entrepreneur receives a net payoff equal to $V(\overline{\Pi}) - I$.

The SPC requires the equality between the slopes of $[V(\Pi) - I]$ and $O(\Pi)$ at point $\Pi = \overline{\Pi}$, i.e.

$$\left.\frac{\partial\left[V(\Pi) - I\right]}{\partial \Pi}\right|_{\Pi=\overline{\Pi}} = \left.\frac{\partial O(\Pi)}{\partial \Pi}\right|_{\Pi=\overline{\Pi}}. \tag{2.7}$$

The SPC (2.7) equates the marginal benefit of entrepreneurship (on the LHS) and the marginal cost of exercising the option (on the RHS), that is the marginal cost of losing business flexibility.

The VMC and SPC allow us to calculate the trigger point $\overline{\Pi}$ and the unknown A_1. Substituting (2.3) and (2.5) into (2.6) and (2.7) we thus obtain the following two-equation system

$$\frac{w}{r} + A_1\overline{\Pi}^{\beta_1} = \frac{\overline{\Pi}}{r-\alpha} - I, \tag{2.8}$$

$$\beta_1 A_1 \overline{\Pi}^{\beta_1 - 1} = \frac{1}{r-\alpha}. \tag{2.9}$$

Solving (2.8) and (2.9) gives

$$A_1 = \frac{1}{\beta_1}\frac{\overline{\Pi}^{1-\beta_1}}{r-\alpha} > 0,$$

and

$$\overline{\Pi} = \frac{\beta_1}{\beta_1 - 1}(r-\alpha)\left(\frac{w}{r} + I\right).$$

As can be seen, term A_1 is positive: this implies that the value of the option, $A_1\Pi^{\beta_1}$, exponentially increases with current payoff Π.

The trigger point $\overline{\Pi}$ is proportional to the summation between the present value of future wages lost, i.e., $\frac{w}{r}$, and the sunk cost I. However, the individual not only faces explicit costs but also loses flexibility in terms of future decisions. Since the start-up decision is irreversible, indeed, the exercise of the option entails that the individual gives up any opportunity to delay. The term $\frac{\beta_1}{\beta_1-1} > 1$, known as the "option value multiple", accounts for the additional return required to compensate for the loss in flexibility. Due to the term $\frac{\beta_1}{\beta_1-1}$ we have $\overline{\Pi} > (r-\alpha)\left(\frac{w}{r}+I\right)$.[8] According to the static NPV approach, the differential $\left[\overline{\Pi}-(r-\alpha)\left(\frac{w}{r}+I\right)\right]$ would be considered as a rent. In a real-option setting, instead, there may be positive payoff states, i.e., with $V(\Pi)-I>0$, in which the individual does not enter the business sector but rather prefers to wait. This means that he waits for future better market conditions. Therefore, the difference $\left[\overline{\Pi}-(r-\alpha)\left(\frac{w}{r}+I\right)\right]$ cannot be considered as a rent, but rather as the additional income required to cover the implicit cost of losing flexibility.[9]

Let us finally analyze the impact of volatility on the individual's propensity to enter the business sector. It is easy to show that the option value multiple is positively affected by volatility,[10] i.e.,

$$\frac{\partial}{\partial\sigma}\left(\frac{\beta_1}{\beta_1-1}\right) = -\frac{1}{(\beta_1-1)^2}\cdot\underbrace{\frac{\partial\beta_1}{\partial\sigma}}_{<0} > 0.$$

Remember that we have assumed that the individual is risk neutral. Therefore, the effect of volatility is not due to the individual's risk aversion, but rather to the BNP: in other words the higher the standard deviation σ is, the worse the news that the individual may receive is, and, due to irreversibility, the greater the premium needed to exercise entrepreneurial option.

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[8] The term $\frac{\beta_1}{\beta_1-1} > 1$ is equivalent to the term $\frac{r+(1-q)}{r+(1-q)(1-d)} > 1$ found in the two-period model of chapter 1.

[9] For the readers that would like to understand the optimal timing problem better, in appendix 2.4.4 we have provided an alternative way for finding $\overline{\Pi}$.

[10] For further details on comparative statics analysis, see Dixit and Pindyck (1994, ch. 5).

2.2 The start-up decision under taxation

In this section we generalize the model by introducing both depreciation and taxation.

In order to introduce depreciation in a fairly tractable way we assume that, after investment, the relevant discount rate raises from r to $r + \lambda$. *Coeteris paribus*,[11] therefore, the increase in the discount rate reduces the individual's value function. Such a reduction can be motivated by the fact that, as time passes, the productivity of the investment cost decreases or that, equivalently, maintenance costs rise. It is worth noting that although we have introduced depreciation, we still assume that the individual's lifetime is infinite and that he owns the start-up option forever. Namely, his option is assumed not to depreciate.[12]

The second extension regards taxation. We assume that Π is taxed at rate τ, and that, at any time period, a portion ρ of the investment cost I is deductible from current tax base. Thus tax payments are equal to

$$T = \tau \left(\Pi - \rho I \right). \tag{2.10}$$

Given (2.10), the firm's after-tax cash flow will then be

$$\Pi^N = \left(1 - \tau \right) \Pi + \tau \rho I. \tag{2.11}$$

The tax parameter ρ may account for both (linear) fiscal depreciation allowances, and an imputation cost (if any) related to the resources invested by the entrepreneur.[13]

In what follows we assume a zero tax rate on the interest income. This is consistent with the assumption that the individual is operating in a small open economy. As shown by Eijffinger, Huizinga and Lemmen (1998), non-resident interest withholding taxes are compounded one-for-one into higher interest rates. If this is the case, therefore, the net interest rate remains unchanged and we can consider r as an exogenously given net interest rate.

Following the same procedure of the previous section, we obtain the worker's value function. Since, by assumption, the start-up op-

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[11] This is not a mistake: *coeteris paribus* is as correct as *ceteris paribus*.

[12] Again, the quality of results would not change if we assumed that such an option depreciates with time.

[13] Remember that we have assumed self-financing. In chapter 4 we will analyze debt-financing strategies.

tion does not depreciate, the individual's discount rate is r and the value function is equal to:

$$O^T(\Pi) = \frac{(1-\tau_w)\,w}{r} + A_1^T \Pi^{\beta_1}, \tag{2.12}$$

where $\frac{(1-\tau_w)w}{r}$ is the present value of an after-tax perpetual rent yielding $(1-\tau_w)\,w$, and A_1^T is an unknown to be determined. The value of A_1^T is necessary to calculate the start-up option.

As regards the entrepreneur's value function, we apply dynamic programming and obtain

$$V^T(\Pi) = \Pi^N dt + e^{-(r+\lambda)dt}\left\{\xi\left[V(\Pi + d\Pi)\right]\right\}. \tag{2.13}$$

As shown in appendix 2.4.5, the entrepreneur's value function (2.13) is a perpetual rent, namely

$$V^T(\Pi) = \frac{(1-\tau)\,\Pi}{r+\lambda-\alpha} + \frac{\rho}{r+\lambda}\tau I. \tag{2.14}$$

It is worth noting that the firm's value is a perpetual rent since, after entry, no other decisions can be made. In other words, the firm owns no real option after entry.

To find the worker's trigger point we can substitute (2.12) and (2.14) into the VMC (2.6) and SPC (2.7) so as to obtain

$$\frac{(1-\tau_w)\,w}{r} + A_1^T \Pi^{*\beta_1} = \frac{(1-\tau)\,\Pi^*}{r+\lambda-\alpha} - \left(1 - \frac{\rho}{r+\lambda}\tau\right) I, \tag{2.15}$$

$$\beta_1 A_1^T \Pi^{*\beta_1 - 1} = \frac{(1-\tau)}{r+\lambda-\alpha}. \tag{2.16}$$

Solving (2.15) and (2.16) gives

$$A_1^T = \frac{1}{\beta_1}\frac{(1-\tau)}{r+\lambda-\alpha}\Pi^{*1-\beta_1} > 0, \tag{2.17}$$

and

$$\Pi^* = \frac{\beta_1}{\beta_1 - 1}(r+\lambda-\alpha)\left[\frac{(1-\tau_w)}{(1-\tau)}\frac{w}{r} + \frac{\left(1 - \frac{\rho}{r+\lambda}\tau\right)}{(1-\tau)} I\right]. \tag{2.18}$$

The trigger point Π^* is affected by tax rates τ_w and τ, as well as by the depreciation parameter λ. To investigate the effects of taxation we need first to analyze the neutrality properties of the tax system. Let us then use the standard neutrality condition proposed by Brown (1948). Thus, we can show how this condition must be changed in a real-option setting.

Define $T(\Pi)$ as the present discounted value of the firm's tax burden. If, therefore, the after-tax NPV, i.e., $[V(\Pi) - T(\Pi) - I]$, is positive, investing is profitable. According to Brown (1948, p. 533), "[t]he tax would not increase investment incentives over what they would be if no tax were imposed. Any investment in excess of the amount that would be made if no tax were in effect would also prove to be unprofitable after these adjustments in the tax. It would still fail to earn an amount sufficient to pay for the cost of funds used to make the investment". This condition holds if the after-tax NPV is $(1-\tau)$ times the before-tax NPV, i.e.,

$$V^T(\Pi) - I = V(\Pi) - T(\Pi) - I = (1-\tau)\left[V(\Pi) - I\right]. \tag{2.19}$$

As pointed out in chapter 1, condition (2.19) means that, in the absence of any option, taxation does not distort the rank of alternative investment.

When the firm has an option to delay irreversible investment, neutrality holds if such an option is fully deductible. Following Niemann (1999) and Panteghini (2001a) we can rewrite the neutrality condition (1.12) discussed in chapter 1, in terms of the VMC and SPC, namely

$$\left. V^T(\Pi) - I - O^T(\Pi)\right|_{\Pi=\Pi^*} = (1-\tau)\left.\left[V(\Pi) - I - O(\Pi)\right]\right|_{\Pi=\overline{\Pi}} = 0, \tag{2.20}$$

and

$$\left.\frac{\partial\left[V^T(\Pi) - I - O^T(\Pi)\right]}{\partial\Pi}\right|_{\Pi=\Pi^*} = (1-\tau)\left.\frac{\partial\left[V(\Pi) - I - O(\Pi)\right]}{\partial\Pi}\right|_{\Pi=\overline{\Pi}} = 0. \tag{2.21}$$

The former equation arises from the VMC, and requires equality between the before-tax present value of the project,[14] less the in-

[14] This is the relevant measure of profitability in the absence of any option to change investment strategies.

vestment cost and the option value multiple, i.e.,

$$\left[V^T(\Pi^*) - I - O^T(\Pi^*)\right],$$

and the product between $(1-\tau)$ and the before-tax one, namely

$$(1-\tau)\cdot\left[V(\overline{\Pi}) - I - O(\overline{\Pi})\right].$$

Condition (2.21) is derived from the SPC and requires the equality between the slope of the present value of the project, net of the investment cost and the option, and $(1-\tau)$ multiplied by the slope of the before-tax one.

Conditions (2.20) and (2.21) are sufficient to ensure neutrality. If they are met, indeed, the equality

$$\overline{\Pi} = \Pi^* \qquad (2.22)$$

holds. This implies that investment timing is unaffected by taxation. To understand this neutrality result, let us assume a tax rate increase. As we have pointed out in chapter 1, on the one hand, this increase reduces the present value of future discounted profits, thereby discouraging investment. On the other hand, it reduces the option value multiple, and thus encourages investment. Condition (2.22) thus means that these offsetting effects neutralize each other.

To analyze neutrality properties we show under what conditions the equality $\overline{\Pi} = \Pi^*$ holds. Given (2.18) it is straightforward to obtain the following result:

Proposition 1 *If* $\rho = r+\lambda$, *and* $\tau_w = \tau$ *the entrepreneurial decision is unaffected by taxation.*

In proposition 1 the equality $\rho = r+\lambda$ makes the tax treatment of the sunk cost equivalent to that ensured by a cash flow tax, according to which the investment cost is immediately written off. Under both systems, indeed, the net sunk cost is equal to $(1-\tau)\,I$.[15] This point will be discussed in chapter 6.

The second requirement, namely the existence of uniform taxation, is in line with the Johansson-Samuelson Theorem.

[15] Brown (1948, p. 537) argued that distortions "can be substantially eliminated by a system which permits the firm to deduct either (1) current outlays (or an average of outlays for a short period) on depreciable assets or (2) normal depreciation on total assets".

Notice that here we do not focus on tax determinants of investment size, but rather on timing. However, it is straightforward to show that if conditions (2.20) and (2.21) hold for any incremental investment, then capital accumulation is unaffected by taxation.

2.3 Entry and the option to quit

So far we have analyzed the entrepreneurial choice by assuming that the individual cannot exit from the risky sector, and find a new job.

In this section we study the impact of taxation when the individual also has an option to quit his business activity, and re-enter the labor market. This implies that the entrepreneurial choice is now partially reversible.[16] Since the entrepreneur can eliminate business risk we can say that the opportunity to quit is a put option.

Like the case analyzed in section 2.2 the form of the worker's function is

$$O^T(\Pi) = \frac{(1-\tau_w)\,w}{r} + B_1^T \Pi^{\beta_1}. \tag{2.23}$$

In this case, we will show that the option value multiple $B_1^T \Pi^{\beta_1}$ differs from the term $A_1^T \Pi^{\beta_1}$ of function (2.12) in so far as it accounts for the higher degree of flexibility, due to the option to quit.

Since the sole proprietor can now decide to close his business activity and re-enter the labor market, the value function is

$$V^T(\Pi) = \frac{(1-\tau)\,\Pi}{r+\lambda-\alpha} + \frac{\rho}{r+\lambda}\tau I + H_2^T \Pi^{\beta_2(\lambda)}. \tag{2.24}$$

If we compare (2.24) with (2.14), we have now an additional term, i.e., $H_2^T \Pi^{\beta_2(\lambda)}$, which measures the individual' option to quit and to re-enter labor market. Unlike the case analyzed in section 2.2, where we applied the boundary condition $V^T(0) = 0$ and thus set $H_2^T = 0$ (see appendix 2.4.5), in this case the individual will find it optimal to quit for $V^T(\Pi) > 0$. Since condition $V^T(0) = 0$ cannot be applied, we have $H_2^T \neq 0$.

Let us finally measure the value function of the ex entrepreneur who has re-entered the labor market. We assume that when re-entering the labor market, the individual receives a gross wage rate

[16] Since the individual faced a sunk cost when entered the business sector, reversibility cannot be full.

equal to $(1-\phi)\,w$, where ϕ is a parameter which measures how costly is to re-enter the labor market. This parameter can be considered as a proxy for on-the-job-search costs under unemployment. It is realistic to assume that the higher the unemployment rate is, the higher the parameter ϕ is, and, thus, the more costly it is to re-enter the labor market. This assumption is in line with Bruce (2002), who found that unemployment discourages exit.

Assuming that re-entering labor market is an irreversible choice, the value function will be equal to the following perpetual rent

$$W^{T}(\Pi)=\frac{(1-\tau_{w})\,(1-\phi)\,w}{r}. \tag{2.25}$$

Given (2.23), (2.24) and (2.25) we can now analyze the individual's decisions. Solutions are found backwards. Namely we first find the optimal exit point $\widetilde{\Pi}$ and then calculate the entry trigger point Π^{**}.

To find the optimal exit point, we substitute (2.24) and (2.25) into (2.6) and (2.7). We thus obtain a two-equation system

$$\frac{(1-\tau)\,\widetilde{\Pi}}{r+\lambda-\alpha}+\frac{\rho}{r+\lambda}\tau I+H_{2}^{T}\widetilde{\Pi}^{\beta_{2}(\lambda)}=\frac{(1-\tau_{w})\,(1-\phi)\,w}{r}, \tag{2.26}$$

$$\frac{(1-\tau)}{r+\lambda-\alpha}+\beta_{2}\,(\lambda)\,H_{2}^{T}\widetilde{\Pi}^{\beta_{2}(\lambda)-1}=0, \tag{2.27}$$

where the threshold point $\widetilde{\Pi}$ and the parameter value H_2^T are the two unknowns. Solving (2.26) and (2.27) for $\widetilde{\Pi}$ and H_2^T we have

$$\widetilde{\Pi}=\frac{\beta_{2}\,(\lambda)}{\beta_{2}\,(\lambda)-1}\,(r+\lambda-\alpha)\left[\frac{(1-\tau_{w})}{(1-\tau)}\frac{(1-\phi)\,w}{r}-\frac{\rho}{r+\lambda}\tau I\right],$$

and

$$H_{2}^{T}=-\frac{1}{\beta_{2}\,(\lambda)}\frac{(1-\tau)}{r+\lambda-\alpha}\widetilde{\Pi}^{1-\beta_{2}(\lambda)}>0.$$

Given $H_2^T>0$, it is straightforward to calculate the entrepreneur's option to exit, namely $H_2^T\Pi^{\beta_2(\lambda)}$.

As can be seen, the trigger point $\widetilde{\Pi}$ is positively affected by the labor wage rate: the higher the wage, the higher the propensity to quit risky activity is. On the other hand, $\widetilde{\Pi}$ is negatively affected by the entrepreneurial sunk cost I. As we have assumed, indeed, the tax system ensures a tax benefit equal to $\tau\rho I$. Such a benefit is lost when the individual decides to quit his business activity. Not surprisingly, therefore, the higher the tax benefit $\tau\rho I$ is, the lower the point $\widetilde{\Pi}$ is, and the lower the probability of exit is.

As we know, the firm's payoff is subject to the absorbing barrier $\Pi = 0$. This means that $\widetilde{\Pi}$ must be positive in order for the exit strategy to be feasible. Since

$$\widetilde{\Pi} \propto \left[\frac{(1-\tau_w)}{(1-\tau)} \frac{(1-\phi)\, w}{r} - \frac{\rho}{r+\lambda} \tau I \right],$$

we can say that the optimal exit point $\widetilde{\Pi}$ is positive if

$$\frac{(1-\phi)\, w}{I} > \frac{(1-\tau)\, \tau}{(1-\tau_w)} \frac{\rho}{r+\lambda} r, \tag{2.28}$$

namely if the ratio between the worker's gross wage and the entrepreneurial sunk cost is high enough.

Let us next analyze the impact of taxation on the decision to exit. As regards the impact of τ_w on the entrepreneurial strategy, it is easy to show that

$$\frac{\partial \widetilde{\Pi}}{\partial \tau_w} < 0,$$

namely an increase in τ_w reduces the after-tax wage rate, thereby discouraging exit.

The impact of τ on $\widetilde{\Pi}$ is ambiguous. It is straightforward to show that

$$\frac{\partial \widetilde{\Pi}}{\partial \tau} > 0 \text{ if } \frac{(1-\phi)\, w}{I} > \frac{(1-\tau)^2}{(1-\tau_w)} \frac{\rho}{r+\lambda} r, \tag{2.29}$$

and vice versa. In order to check the sign of $\frac{\partial \widetilde{\Pi}}{\partial \tau}$, let us compare (2.28) with (2.29). We can show that

$$\frac{(1-\tau)^2}{(1-\tau_w)} \frac{\rho}{r+\lambda} r > \frac{(1-\tau)\, \tau}{(1-\tau_w)} \frac{\rho}{r+\lambda} r \text{ if } \tau < 0.5.$$

This means that if $\tau < 0.5$, the impact of business taxation may be ambiguous: if the ratio between the worker's gross wage and the entrepreneurial sunk cost is high enough, the tax benefit arising from the deduction of the investment cost, i.e., $\frac{\rho}{r+\lambda}\tau I$ is relatively low. This implies that an increase in the tax rate τ raises the threshold point $\widetilde{\Pi}$, thereby encouraging exit. If otherwise we have $\tau > 0.5$, the derivative $\frac{\partial \widetilde{\Pi}}{\partial \tau}$ is negative. The intuition is straightforward: if the business tax rate is high enough (i.e., higher than 50%) the tax benefit arising from the deduction of I is so generous that an increase in τ induces the entrepreneur to delay exit.

This ambiguity is in line with Bruce's (2002) estimates, according to which higher marginal tax rates on self-employment income do not necessarily increase the probability of exit. In agreement with the relevant literature, Bruce (2002) provides a theoretical framework aiming to explain this ambiguity. Applying an optimal-portfolio approach he shows that, under risk aversion, a higher marginal tax rate may reduce the propensity to undertake a self-employed activity. On the other hand, the higher marginal tax rate might also act as an insurance against business risk. In this chapter we have shown that ambiguity may arise even if the representative agent is risk neutral.

Once we have studied the optimal exit strategy we can focus on the optimal entry decision. The optimal start-up timing is calculated by substituting (2.23) and (2.24) into (2.6) and (2.7). Defining Π^{**} as the trigger point, we thus obtain

$$\begin{aligned} \tfrac{(1-\tau)\Pi^{**}}{r+\lambda-\alpha} + \tfrac{\rho}{r+\lambda}\tau I + \beta_2(\lambda) H_2^T {\Pi^{**}}^{\beta_2(\lambda)} - I = \\ = \tfrac{(1-\tau_w)w}{r} + B_1^T {\Pi^{**}}^{\beta_1}, \end{aligned} \tag{2.30}$$

and

$$\frac{(1-\tau)}{r+\lambda-\alpha} + \beta_2(\lambda) H_2^T {\Pi^{**}}^{\beta_2(\lambda)-1} = \beta_1 B_1^T {\Pi^{**}}^{\beta_1 - 1}. \tag{2.31}$$

Using the two-equation system (2.30)-(2.31) gives

$$\begin{aligned} \Pi^{**} = \tfrac{\beta_1}{\beta_1 - 1}(r+\lambda-\alpha)\cdot \\ \cdot\left[\tfrac{(1-\tau_w)}{(1-\tau)}\tfrac{w}{r} + \tfrac{\left(1-\frac{\rho}{r+\lambda}\tau\right)}{(1-\tau)} I + \left(1-\tfrac{\beta_2(\lambda)}{\beta_1}\right)\tfrac{1}{\beta_2(\lambda)}\tfrac{(1-\tau)}{r+\lambda-\alpha}\widetilde{\Pi}\left(\tfrac{\widetilde{\Pi}}{\Pi^{**}}\right)^{-\beta_2(\lambda)}\right], \end{aligned} \tag{2.32}$$

and

$$B_1^T = \frac{{\Pi^{**}}^{1-\beta_1}}{\beta_1}\left[\frac{(1-\tau)}{r+\lambda-\alpha} + \beta_2(\lambda) H_2^T {\Pi^{**}}^{\beta_2(\lambda)-1}\right]. \tag{2.33}$$

Despite the fact that (2.32) is not a closed-form solution, we can compare Π^{**} with Π^{*}. Since the inequality

$$\left(1-\frac{\beta_2(\lambda)}{\beta_1}\right)\frac{1}{\beta_2(\lambda)}\frac{(1-\tau)}{r+\lambda-\alpha}\widetilde{\Pi}\left(\frac{\widetilde{\Pi}}{\Pi^{**}}\right)^{\beta_2(\lambda)} < 0$$

holds, the comparison between (2.18) and (2.32) allows us to conclude that

$$\Pi^{*} > \Pi^{**}.$$

The reasoning behind this inequality is straightforward: the ability to exit ensures additional business flexibility. Given partial reversibility, therefore, the cost of undertaking the business activity is lower.

Let us next compare (2.17) with (2.33). Given inequality $\Pi^{*} > \Pi^{**}$, we have ${\Pi^{*}}^{1-\beta_1} < {\Pi^{**}}^{1-\beta_1}$. Moreover the term $\beta_2(\lambda) H_2^T {\Pi^{**}}^{\beta_2(\lambda)-1}$ is negative. It is therefore easy to ascertain that

$$B_1^T < A_1^T.$$

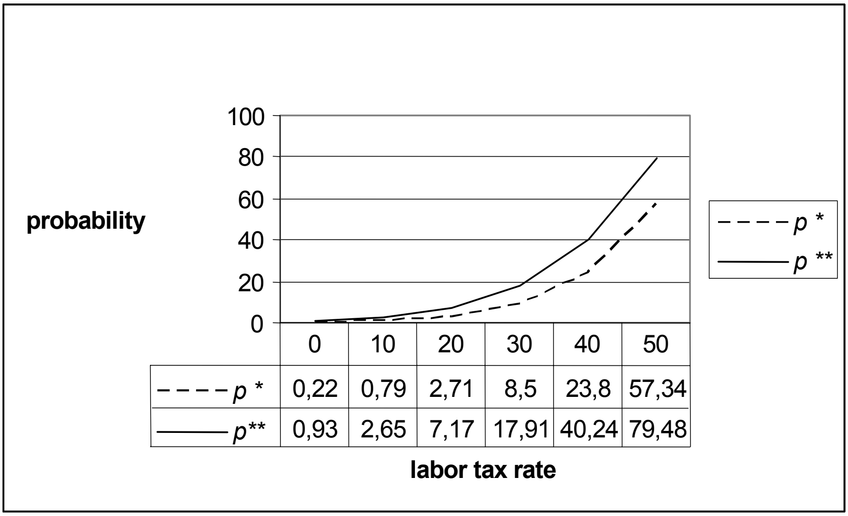
In other words, the existence of the option to quit makes the worker's option to start less valuable. This lower value may explain why the option is exercised earlier, i.e., $\Pi^{*} > \Pi^{**}$.

It is worth noting that risk does not affect the sign of the above tax effects. However, it significantly affects the propensity to make entrepreneurial decisions. We may recall that empirical investigation usually aims to estimate the probability of transition. Therefore, to understand how business flexibility affects entry decisions we follow Sarkar (2000) and calculate the probability of entering the business sector. This is equivalent to computing the probability that, at a given future time T, the current payoff is no less than a given trigger point. In line with Harrison (1985), Sarkar shows that this probability is

$$Prob\,(\Pi \geq x) = \Phi\left(\frac{\ln(\Pi/x)+\left(\alpha-\frac{\sigma^2}{2}\right)}{\sigma\sqrt{T}}\right) +$$

$$+\left(\frac{x}{\Pi}\right)^{\frac{2\alpha}{\sigma^2}-1}\Phi\left(\frac{\ln(\Pi/x)-\left(\alpha-\frac{\sigma^2}{2}\right)}{\sigma\sqrt{T}}\right),$$

where $\Phi(.)$ is a function which measures the area under a standard normal distribution. The term Π is the current payoff, and $x = \Pi^{*}, \Pi^{**}$, depending on whether the entrepreneur owns the option to exit or not.



	0	10	20	30	40	50
p^*	0,22	0,79	2,71	8,5	23,8	57,34
p^{**}	0,93	2,65	7,17	17,91	40,24	79,48

FIGURE 2.1. The effect of labor income taxation on the probability to start the business activity (in %).

Let us then set $r = 0.04$, $\alpha = 0.01$, $\sigma = 0.2$, and $\lambda = 0$,[17] and calculate the probability that after 1 period (i.e., at time $T = 1$) the current payoff reaches trigger points Π^* and Π^{**}, respectively. For convenience we will define

$$p^* \equiv Prob\,(\Pi \geq \Pi^*)$$

and

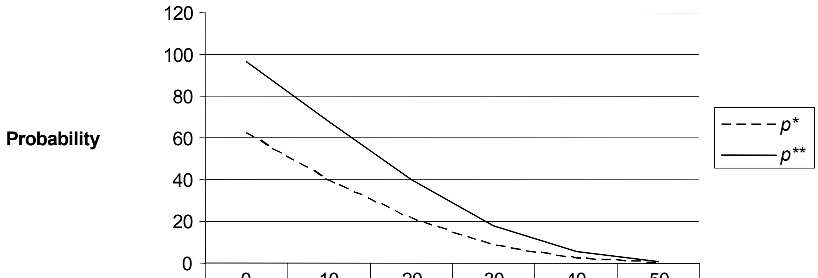
$$p^{**} \equiv Prob\,(\Pi \geq \Pi^{**}),$$

respectively.

As shown in figure 2.1 the probability of undertaking the investment decision within one period is increasing in the labor tax rate τ_w. This is due to the fact that an increase in τ_w makes business activity more attractive.

Figure 2.2 shows that an increase in the business tax rate τ reduces the probability to enter.

[17] These parameter values are coherent with the empirical evidence. See for instance Jorion and Goetzman (1999), and Dimson, Marsh and Staunton (2002).



	0	10	20	30	40	50
p*	61,85	39,64	21,11	8,5	2,21	0,28
p**	96,23	67,42	39,72	17,87	5,23	0,75

profits tax rate

FIGURE 2.2. The effect of profits taxation on the probability to start the business activity (in %).

As shown in figures 2.1 and 2.2 the differences between p^* and p^{**} may be dramatic. This has important implications in terms of empirical investigation: regressions aimed at estimating the probability of transition should be controlled not only for labor market characteristics (such as the unemployment rate as a proxy for search costs) but also for industry-specific riskiness. To our knowledge, empirical investigations have not yet dealt with this risk. We therefore believe that future research in this direction would be fairly useful to improve the understanding of entrepreneurship.

2.4 Appendix

2.4.1 The geometric Brownian motion

The Brownian motion (2.1) describes the same dynamics of the following discrete-time random walk

$$\Pi_t = \Pi_{t-1} + z_t \tag{2.34}$$

in continuous time. The stochastic variable z_t is normally distributed with zero mean.

Brownian motions (also known as Wiener processes) have three fundamental properties:

1. they are Markov processes, whose probability of distribution for all future values depends on their current value; this means that the random walk (2.34), as well as its continuous-time version (2.1), satisfies the Markov property, which entails that the expected value of $\Pi_{t+\Delta t}$ is equal to Π_t, i.e.,

$$\xi\left(\Pi_{t+\Delta t}\right) = \Pi_t,$$

   where $\xi\left(.\right)$ is the expectation operator and $\Delta t > 0$ is any future period;

2. they have independent increments: therefore the probability of distribution for the change in the process over time is independent of any other time interval;

3. changes in the process, over any interval Δt, are normally distributed.

According to these three properties, the Brownian motion z_t is such that the change Δz_t over the time interval Δt is

$$\Delta z_t = \epsilon_t \sqrt{\Delta t},$$

where $\epsilon_t \sim N\left(0,1\right)$, i.e., is normally distributed with zero mean and standard deviation equal to unity. Moreover, the stochastic variable is serially uncorrelated, so that $\xi\left(\epsilon_t, \epsilon_{t+\Delta t}\right) = 0$ for any Δt.

Let us next analyze this process in continuous time. We thus let Δt become infinitesimally small, and have

$$dz_t = \epsilon_t \sqrt{dt}.$$

Since ϵ_t has zero mean and a standard deviation equal to 1, we have

$$\xi\left(dz_t\right) = 0,$$

$$Var\left(dz_t\right) = \xi\left[\left(dz_t\right)^2\right] = \xi\left[\left(\epsilon_t \sqrt{dt}\right)^2\right] = dt.$$

It is worth noting that for $dt \to 0$, any term in $\left(dt\right)^n$, with $n > 1$, goes to zero faster than dt and can thus be ignored.

Given these results let us next discuss the *geometric* Brownian motion (2.1). As we pointed out, this particular kind of stochastic process has the attracting characteristic that the change rate $\frac{d\Pi_t}{\Pi_t}$ is normally distributed, and therefore, any change in absolute value (i.e., in $d\Pi_t$) follows a log-normal distribution.

To understand the characteristics of this particular kind of Brownian motion let us study a function $F(\Pi_t, t)$, and assume that Π_t is a geometric Brownian motion. Function $F(\Pi_t, t)$ is also assumed to be at least twice differentiable with respect to Π_t and at least once with respect to t.

Given $F(\Pi_t, t)$ we can use Itô's Lemma, which is an application of Taylor series expansion. Differentiating $F(\Pi_t, t)$ with respect to Π_t and t gives

$$\begin{aligned} dF(\Pi_t, t) = F_{\Pi_t}(\Pi_t, t)\, d\Pi_t + F_t(\Pi_t, t)\, dt + \\ + \tfrac{1}{2} F_{\Pi_t\Pi_t}(\Pi_t, t)\,(d\Pi_t)^2 + \tfrac{1}{6} F_{\Pi_t\Pi_t\Pi_t}(\Pi_t, t)\,(d\Pi_t)^3 + .., \end{aligned} \tag{2.35}$$

with $F_{\Pi_t}(\Pi_t, t) \equiv \frac{\partial F(\Pi_t, t)}{\partial \Pi_t}$, $F_t(\Pi_t, t) \equiv \frac{\partial F(\Pi_t, t)}{\partial t}$, $F_{\Pi_t\Pi_t}(\Pi_t, t) \equiv \frac{\partial F^2(\Pi_t, t)}{\partial \Pi_t^2}$, and $F_{\Pi_t\Pi_t\Pi_t}(\Pi_t, t) \equiv \frac{\partial F^3(\Pi_t, t)}{\partial \Pi_t^3}$.[18] Given the properties of Brownian motions all the terms $(d\Pi_t)^n$ with $n > 2$ in (2.35) go to zero faster than dt and can thus be ignored. Therefore, the expansion (2.35) can be rewritten as

$$dF(\Pi_t, t) = F_{\Pi_t}(\Pi_t, t)\, d\Pi_t + F_t(\Pi_t, t)\, dt + \frac{1}{2} F_{\Pi_t\Pi_t}(\Pi_t, t)\,(d\Pi_t)^2, \tag{2.36}$$

with

$$(d\Pi_t)^2 = (\alpha\Pi_t dt + \sigma\Pi_t dz_t)^2 = \sigma^2\Pi_t^2 (dz_t)^2 = \sigma^2\Pi_t^2 dt.$$

Given Itô's Lemma the equation (2.36) reduces to

$$dF(\Pi_t, t) = F_t(\Pi_t, t)\, dt + F_{\Pi_t}(\Pi_t, t)\, d\Pi_t + \frac{\sigma^2}{2} F_{\Pi_t\Pi_t}(\Pi_t, t)\,\sigma^2\Pi_t^2 dt. \tag{2.37}$$

In what follows the differential equation (2.37) will be used to calculate value functions.

---

[18] For further details see e.g. Øksendal (1998).

2.4.2 The calculation of (2.3)

In order to find (2.3) let us first expand the RHS of (2.2). Omitting the time variable we obtain

$$O(\Pi) = wdt + (1 - rdt)\left[O(\Pi) + dO\left(\Pi\right)\right] + o(dt), \tag{2.38}$$

where $o(dt)$ is the summation of all terms that go to zero faster than dt.

Given (2.37), we apply Itô's Lemma and obtain

$$dO\left(\Pi\right) = \left[O_t\left(\Pi\right) + \alpha\Pi O_\Pi + \frac{\sigma^2}{2}\Pi^2 O_{\Pi\Pi}\right] dt, \tag{2.39}$$

with $O_t\left(\Pi\right) \equiv \frac{\partial O(\Pi)}{\partial t}$, $O_\Pi \equiv \frac{\partial O(\Pi)}{\partial \Pi}$, and $O_{\Pi\Pi} \equiv \frac{\partial^2 O(\Pi)}{\partial \Pi^2}$. Since $O_t\left(\Pi\right) = 0$, substituting (2.39) into (2.38) gives

$$O(\Pi) = wdt + (1 - rdt)\,O(\Pi) + \left[\alpha\Pi O_\Pi + \frac{\sigma^2}{2}\Pi^2 O_{\Pi\Pi}\right] dt. \tag{2.40}$$

Simplifying (2.40) gives

$$rO(\Pi) = w + \alpha\Pi O_\Pi + \frac{\sigma^2}{2}\Pi^2 O_{\Pi\Pi}. \tag{2.41}$$

As shown in Dixit and Pindyck (1994), equation (2.41) has the following general closed-form solution

$$O(\Pi) = A_0 + \sum_{j=1}^{2} A_j \Pi^{\beta_j}, \tag{2.42}$$

with

$$O_\Pi = \sum_{j=1}^{2} \beta_j A_j \Pi^{\beta_j - 1},$$
$$O_{\Pi\Pi} = \sum_{j=1}^{2} \beta_j\left(\beta_j - 1\right) A_j \Pi^{\beta_j - 2}.$$

In order to find the solution of (2.41), we substitute (2.42) into (2.41) and obtain

$$\begin{aligned} r(A_0 + \sum_{j=1}^{2} A_j \Pi^{\beta_j}) &= \\ = w + \alpha\left(\sum_{j=1}^{2} \beta_j A_j \Pi^{\beta_j}\right) &+ \tfrac{\sigma^2}{2}\left[\sum_{j=1}^{2} \beta_j\left(\beta_j - 1\right) A_j \Pi^{\beta_j}\right]. \end{aligned} \tag{2.43}$$

Equating the coefficients of (2.43) with w and $A_j \Pi^{\beta_j}$ gives[19]

$$rA_0 = w, \tag{2.44}$$

and

$$rA_j \Pi^{\beta_j} = \left[\alpha\beta_j + \frac{\sigma^2}{2} \beta_j \left(\beta_j - 1 \right) \right] A_j \Pi^{\beta_j} \text{ for } j = 1, 2, \tag{2.45}$$

respectively. Solving (2.44) and (2.45) gives

$$A_0 = \frac{w}{r},$$

and the quadratic equation

$$\Psi \left(\beta_j \right) \equiv \frac{\sigma^2}{2} \beta_j (\beta_j - 1) + \alpha\beta_j - r = 0. \tag{2.46}$$

Eq. (2.46) is usually known as the characteristic equation, and has the following roots

$$\beta_1 = \frac{1}{2} - \frac{\alpha}{\sigma^2} + \sqrt{\left(\frac{\alpha}{\sigma^2} - \frac{1}{2} \right)^2 + \frac{2r}{\sigma^2}} > 1,$$

and

$$\beta_2 = \frac{1}{2} - \frac{\alpha}{\sigma^2} - \sqrt{\left(\frac{\alpha}{\sigma^2} - \frac{1}{2} \right)^2 + \frac{2r}{\sigma^2}} < 0.$$

Given these results, we can next calculate A_2. It is worth noting that when Π goes to zero, in a geometric Brownian motion it will remain zero.[20] This means that $\Pi = 0$ is an absorbing barrier, and therefore, the worker's value function reduces to

$$O(0) = \frac{w}{r}. \tag{2.47}$$

Notice that, given $\beta_2 < 0$, if $A_2 \neq 0$ we would have

$$\lim_{\Pi \to 0} A_2 \Pi^{\beta_2} = \infty,$$

and the condition (2.47) would fail to hold. This implies that we must set $A_2 = 0$. Function (2.3) is thus obtained.

[19] For further details on this procedure see Abel (1983, 1984, 1985).

[20] Dixit and Pindyck (1994, ch. 5) provide further details on this point.

2.4.3 The calculation of (2.5)

To calculate (2.5), let us expand the RHS of (2.4), and apply Itô's Lemma so as to obtain the following differential equation

$$V(\Pi) = \Pi dt + (1 - rdt)\, V(\Pi) + \left[\alpha \Pi V_{\Pi} + \frac{\sigma^2}{2}\Pi^2 V_{\Pi\Pi}\right] dt + o(dt), \tag{2.48}$$

where $V_{\Pi} \equiv \frac{\partial V(\Pi)}{\partial \Pi}$, $V_{\Pi\Pi} \equiv \frac{\partial^2 V(\Pi)}{\partial \Pi^2}$. Simplifying (2.48) one obtains

$$rV(\Pi) = \Pi + \alpha \Pi V_{\Pi} + \frac{\sigma^2}{2}\Pi^2 V_{\Pi\Pi}, \tag{2.49}$$

whose general solution is

$$V(\Pi) = H_0 \Pi + \sum_{j=1}^{2} H_j \Pi^{\beta_j}. \tag{2.50}$$

Substituting (2.50) into (2.49) one obtains

$$r(H_0\Pi + \sum_{j=1}^{2} H_j \Pi^{\beta_j}) = \Pi + \alpha\Pi\left(H_0 + \sum_{j=1}^{2} \beta_j H_j \Pi^{\beta_j - 1}\right) + \\ + \tfrac{\sigma^2}{2}\Pi^2 \left[\sum_{j=1}^{2} \beta_j \left(\beta_j - 1\right) H_j \Pi^{\beta_j - 2}\right],$$

which gives $H_0 = \frac{1}{r-\alpha}$, and the characteristic equation (2.46). Therefore β_1 and β_2 are the same as those obtained in appendix 2.4.2. Given these results we can rewrite (2.50) as

$$V(\Pi) = \frac{\Pi}{r-\alpha} + \sum_{j=1}^{2} H_j \Pi^{\beta_j}.$$

Let us next calculate H_j for $j = 1, 2$. As regards H_2, we know that $\Pi = 0$ is an absorbing barrier and that the condition $V(0) = 0$ holds. This implies that $H_2 = 0$. To calculate H_1 we recall Dixit and Pindyck's (1994) explanation, according to which the term $H_1 \Pi^{\beta_1}$ may be referred to speculative bubbles. If, therefore, we assume that no bubble exists, we must set $H_1 = 0$. We have thus obtained (2.5).

2.4.4 An alternative approach to the optimal timing problem

In this appendix we show that the trigger point $\overline{\Pi}$ is the solution of a maximization problem. To do so, let us substitute (2.3) and (2.5) into the VMC (2.6). We thus have

$$\frac{w}{r} + A_1 \overline{\Pi}^{\beta_1} = V(\overline{\Pi}) - I. \tag{2.51}$$

Solving (2.51) for A_1 we obtain

$$A_1 = \left[V(\overline{\Pi}) - \left(\frac{w}{r} + I\right)\right] \overline{\Pi}^{-\beta_1}.$$

Thus we can rewrite (2.3) as

$$O(\Pi;\overline{\Pi}) = \frac{w}{r} + A_1 \overline{\Pi}^{\beta_1} = \frac{w}{r} + \left(\frac{\Pi}{\overline{\Pi}}\right)^{\beta_1} \left[V(\overline{\Pi}) - I - \frac{w}{r}\right]. \tag{2.52}$$

The intertemporal problem can be rewritten as

$$\max_{\overline{\Pi}} O(\Pi;\overline{\Pi}). \tag{2.53}$$

Using (2.52) we can next calculate the first order condition (2.53):

$$\frac{\partial O(\Pi;\overline{\Pi})}{\partial \overline{\Pi}} = \left(\frac{\Pi}{\overline{\Pi}}\right)^{\beta_1} \left[-\beta_1 \frac{V(\overline{\Pi}) - I - \frac{w}{r}}{\overline{\Pi}} + \left.\frac{\partial V(\Pi)}{\partial \Pi}\right|_{\Pi=\overline{\Pi}}\right] = 0. \tag{2.54}$$

Substituting (2.5) into (2.54), and solving for $\overline{\Pi}$ gives

$$\overline{\Pi} = \frac{\beta_1}{\beta_1 - 1} (r - \alpha) \left(\frac{w}{r} + I\right).$$

2.4.5 The calculation of (2.14)

Let us expand the RHS of (2.13), and apply Itô's Lemma. We obtain the following equation:

$$(r + \lambda) V^T(\Pi) = \Pi^N + \alpha \Pi V_\Pi^T + \frac{\sigma^2}{2} \Pi^2 V_{\Pi\Pi}^T, \tag{2.55}$$

whose general solution is

$$V^T(\Pi) = D_0 + H_0 \Pi + \sum_{j=1}^{2} H_j^T \Pi^{\beta_j(\lambda)}. \tag{2.56}$$

Substituting (2.56) into (2.55) and solving, gives

$$D_0^T = \tfrac{\rho}{r+\lambda}\tau I,$$

$$H_0^T = \tfrac{1-\tau}{r+\lambda-\alpha},$$

and the characteristic equation

$$\Psi\left(\beta_j(\lambda)\right) \equiv \frac{\sigma^2}{2}\beta_j(\lambda)\left(\beta_j(\lambda)-1\right)+\alpha\beta_j(\lambda)-(r+\lambda)=0. \quad (2.57)$$

Solving equation (2.57) one thus obtains the roots

$$\beta_1(\lambda) = \left(\tfrac{1}{2}-\tfrac{\alpha}{\sigma^2}\right)+\sqrt{\left(\tfrac{\alpha}{\sigma^2}-\tfrac{1}{2}\right)^2+\tfrac{2(r+\lambda)}{\sigma^2}} > 1,$$
$$\beta_2(\lambda) = \left(\tfrac{1}{2}-\tfrac{\alpha}{\sigma^2}\right)-\sqrt{\left(\tfrac{\alpha}{\sigma^2}-\tfrac{1}{2}\right)^2+\tfrac{2(r+\lambda)}{\sigma^2}} < 0.$$

Let us finally calculate H_j^T for $j=1,2$. As we know, the condition $V^T(0)=0$ must hold. This implies that $H_2^T=0$. Moreover, assuming the absence of speculative bubbles gives $H_1^T=0$. We therefore obtain (2.14).

3

The choice of the organizational form

Firms can take various organizational forms: they can be managed as sole-proprietorships, i.e., by an individual, or as companies. Companies can also have unlimited or limited liability in respect to their social obligations. In the former case we have a partnership, while in the latter case we have a corporation.

Assuming unlimited liability means that partners will have to answer completely from their own personal wealth that could be potentially very risky. This type of company has much common ground with sole-proprietorship, since in both cases there is a close relationship between control and ownership.

It is worth noting that partners are usually restricted by law or even forbidden to sell shares to third parties. The reason is straightforward: selling shares to third parties might become an unacceptable risk for the other partners. If indeed third parties were unreliable, given unlimited liability, rash behavior by one of them could have serious repercussions on the property of the old partners.[1]

Under limited liability, shareholders do not need to answer with their own personal wealth: this means that business risk is reduced.

[1] This is the well-known Latin principle of *intuitus personae*, according to which the identity and, above all, reliability of partners is a necessary condition for doing business together.

Moreover public trading of shares is usually allowed. As MacKie-Mason and Gordon (1997) point out, share trading is an important factor that may help to reduce principal-agent problems between managers and shareholders.

Non-tax features of companies are fairly helpful to understand their tax status. In particular, partnerships are characterized by the significant involvement of partners in the business activity. In this case, it is difficult, if not impossible, to distinguish between labor income and capital income, received by partners in recognition for their work and for their partnership, respectively. To solve this informational problem, therefore, many tax systems directly impute business income to partners at the personal level (in proportion to their participation share).[2] Imputation is made regardless of whether the profit is distributed or retained to finance the activity.

Given the potentially large number of shareholders, the partnership approach is not a satisfactory solution for corporations. If corporate income were directly imputed to shareholders, it would be very difficult to calculate the personal tax base of shareholders, given that the taxable income of all companies would need to be calculated in advance. We know indeed that a corporation could be held by thousands of shareholders, who could equally hold shares in other companies. Thus, to find the exact tax base for each tax payer, all companies' balance sheets would be needed. If then (as is now becoming common) taxpayers held foreign shares and the Residence Principle were applied, there would be an exponential increase in the data needed, making the whole tax system less manageable.

To solve information problems arising from the potentially high number of shareholders, modern tax systems introduced the corporation tax. One of the first applications of corporate income tax occurred in Prussia, where, from 1891, separate tax treatment of corporate income was justified given the fact that companies were juridical subjects distinct from shareholders. This motivation was subsequently taken up by many authors, including Griziotti (1928) and Studenski (1940). In particular, Studenski (1940, p. 623) noted that "modern business enterprise is, to a large extent, no longer the personal venture of an individual producer, inseparable from his per-

[2] In chapter 6 we will discuss the Dual Income Tax system, which splits income into labor and capital income by means of a presumptive method.

sonality, but is a complex organisation or group venture having an organic unity and collective personality of its own."[3]

Corporate taxation can be justified by means of the Benefit Principle, according to which taxation should be understood in regard to the benefits connected to the typical juridical status of a person. The benefits that a corporation enjoys are not only juridical. As Mintz (1995) points out, corporation tax can also be considered as the price paid to enjoy public goods and services provided by the government.[4]

3.1 MacKie-Mason and Gordon's (1997) model

MacKie-Mason and Gordon (1997) have devoted considerable effort in studying the effects of taxation and the choice on organizational form.[5]

Using our notation, we can rewrite their model as follows. We denote Π as the payoff earned by a non-corporate firm. If, instead, the firm is a corporation, its payoff is Ψ times Π. Parameter Ψ measures the effect of non-tax factors on the firm's profitability. In particular $\Psi > 1$ (< 1) entails that incorporation raises (reduces) the firm's before-tax payoff. This means that, without taxation, incorporation is a feasible option only if $\Psi > 1$.

[3] In Studenski's words we can see the influence of Coase (1937, pp. 392-393), who argued that "The entrepreneur has to carry out his functions at less cost, taking into account the fact that he may get factors of production at a lower price than the market transactions which he supersedes ... A firm, therefore, consists of the system of relationships which comes into existence when the direction of resources is dependent on an entrepreneur". Coase also pointed out that management "merely reacts to price changes rearranging the factors of production under its control" (p. 404). In particular, business men are constantly comparing the marginal cost of organizing within their firm, the marginal cost of organizing in another firm and the marginal cost of leaving transactions "to be 'organized' by the price mechanism". As can be seen, Coase was fully aware of the organization form problem involved in managing a firm. It is worth noting that a similar point was previously raised by Nitti (1912). He argued that if shareholders separately undertook the same activity as their company, they would achieve worse results, as the corporation's effectiveness in terms of pursuing business objectives is greater than that of the sum of shareholders themselves

[4] For a discussion on this point see also Gravelle (1995) and Slemrod (2004).

[5] A preliminary discussion of the effects of taxation on organizational choices was provided by Gordon and MacKie-Mason (1990), who analyzed the effects of the US Tax Reform Act implemented in 1986.

Let us define τ_p and τ_c as the non-corporate and the corporate tax rate, respectively. Given these assumptions we can write the net benefit of incorporating as the difference between the after-tax corporate and non-corporate payoff, namely

$$NB \equiv (1-\tau_c)\,\Psi\Pi - (1-\tau_p)\,\Pi. \tag{3.1}$$

Using (3.1) we can show that incorporation is profitable if the non-tax benefit of incorporation is high enough, i.e.,

$$\Psi > \frac{1-\tau_p}{1-\tau_c} = 1 + \frac{\tau_c - \tau_p}{1-\tau_c}. \tag{3.2}$$

It is worth noting that the tax rate differential $(\tau_c - \tau_p)$ is ambiguous. On the one hand, MacKie-Mason and Gordon (1997) argue that non-corporate firms are usually taxed at a personal level, whereas corporations are taxed at both a corporate and a personal level. In principle, this would lead to the inequality $\tau_c > \tau_p$. On the other hand, there are at least three reasons which explain why the converse may be true. Firstly, MacKie-Mason and Gordon themselves argue that corporate and non-corporate tax income may differ as long as corporations have greater opportunities to avoid taxation, e.g., by means of debt financing.[6] Secondly, corporate taxation is usually proportional whereas personal taxation may be progressive. Thirdly, over the last decade, many countries dramatically cut their corporate tax rates and also reduced effective tax rates on capital income (including dividends). In many cases, therefore, tax reforms made effective corporate tax rates lower than non-corporate ones. If therefore these factors dominate the double-tax effect discussed by MacKie-Mason and Gordon, we have $\tau_c < \tau_p$. In this case incorporation may be profitable even if non-tax factors have a negative impact on the corporate firm's profitability (i.e., $\Psi < 1$). It is indeed sufficient that inequality (3.2) holds.[7]

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[6] Tax avoiding practices will be analyzed in chapters 4 and 5.

[7] In the second part of their article, MacKie-Mason and Gordon (1997) showed that the model is supported by the US empirical evidence. Further evidence on tax-motivated incorporation is provided by Goolsbee (2004) and Romanov (2006). The former uses a cross-country approach and shows that the impact of the relative taxation of corporate to personal income is much larger than that found in previous empirical literature. The latter analyzes recent Israeli's tax changes and finds that an increase in the personal income tax rates, implemented in 2002, caused a sharp increase in the number of new corporations in the following year.

3.2 The option to incorporate

MacKie-Mason and Gordon's (1997) model disregards limited liability. In order to introduce this important determinant we assume that, during each short interval dt, the firm may face a loss L with probability λdt. This means that the firm is subject to a Poisson process, that describes a sudden event in its activity.[8]

Moreover we assume that a given percentage Ω_L of loss L is deductible against other incomes earned by the partners of the unlimited company. Therefore the net loss faced by the unlimited company's partners is

$$(1 - \Omega_L \tau_p) L.$$

Given these assumptions we have two alternative cases:

Case 1 *Inequality* $\Psi > 1 + \frac{\tau_c - \tau_p}{1 - \tau_c}$ *holds.*

Case 2 *Inequality* $\Psi < 1 + \frac{\tau_c - \tau_p}{1 - \tau_c}$ *holds.*

Case 1 is in line with MacKie-Mason and Gordon's (1997) model: if Ψ is high enough, indeed, corporations are more profitable than non-corporate firms. *A fortiori* the allowance for limited liability makes corporations even more attractive. Therefore incorporation is always and *immediately* optimal.

In case 2, however, we have a trade-off. On the one hand, the low value of Ψ entails that, *coeteris paribus*, the corporation's expected after-tax operating profit is lower than that earned by a partnership. On the other hand, limited liability reduces business risk, thereby raising the expected return. If therefore the former effect dominates the latter, partnership is the optimal organizational choice and vice versa.

In what follows we will focus on case 2, which implies that the difference between the non-corporate and the corporate operating profit, i.e., $[(1 - \tau_p) - (1 - \tau_c)\Psi]\Pi$, is increasing in Π. This also means that the firm's net benefit of being non-corporate is increasing in Π, and hence incorporating is never optimal when Π is high enough. By dealing with case 2, we can study a common life story,

[8] For further details on this process see e.g. chapters 5 and 6 of Dixit and Pindyck (1994).

where firms start non-corporate and then can decide whether and when to incorporate.[9]

To generalize the model we also assume that incorporation requires a transaction cost equal to I.[10] Defining Ω_I as the percentage of deductibility allowed for the cost I, the net cost of incorporating is thus equal to $(1 - \Omega_I \tau_c) I$.[11] Of course, incorporation is a feasible option if $(1 - \Omega_I \tau_c) I$ is low enough. For simplicity we finally assume that incorporation is an irreversible choice.[12]

3.2.1 The value functions

As shown in chapter 2, dynamic programming allows us to write the value function of a company as a summation between the current after-tax payoff in the short interval dt, i.e.,

$$(1 - \tau_p) \Pi dt,$$

and its expected present value after dt has passed. This latter term is contingent on future events, namely on whether, after the short time interval dt, the firm still operates or not. We know that with probability $(1 - \lambda dt)$ the firm survives and its expected value is therefore $\xi \left[O^T(\Pi + d\Pi)\right]$. With probability λdt, instead, it stops production and faces the after-tax loss $(1 - \Omega_L \tau_p) L$, where $\Omega_L \in [0, 1]$ is the percentage of deductibility related to the loss L. Applying the relevant discount factor e^{-rdt}, we obtain the contingent value of the firm at time $t + dt$, i.e.,

$$e^{-rdt} \left\{(1 - \lambda dt) \xi \left[O^T(\Pi + d\Pi)\right] - \lambda dt (1 - \Omega_L \tau_p) L\right\}.$$

---

[9] It is worth noting that the entrepreneurial decision (discussed in chapter 2) and the organizational choice could be jointly analyzed as a two-stage process. In this case, the individual would own a compound option: in other words, in the first stage the individual would exercise the entry call option and, at the same time, would acquire an option to incorporate.

[10] Klapper, Laeven and Rajan (2006) provide cross-country evidence regarding the effects of entry regulation on entry rates. In line with our argument, they show that entry regulations hamper entry, especially in industries that should have high entry.

[11] Notice that a fairly high transaction cost would also introduce a trade-off in case 1. In this model we assume that I is low enough.

[12] Of course, the model would be more realistic if we assumed that the decision to incorporate is partially reversible. In this case, however, we would have no closed-form solution.

Adding the above terms we thus calculate the value function of the unlimited company:

$$O^T(\Pi) = (1-\tau_p)\,\Pi dt + \\ + e^{-rdt}\left\{(1-\lambda dt)\,\xi\left[O^T(\Pi+d\Pi)\right] - \lambda dt\,(1-\Omega_L\tau_p)\,L\right\}. \tag{3.3}$$

As shown in appendix 3.4.1 the solution of (3.3) is

$$O^T(\Pi) = \frac{(1-\tau_p)\,\Pi}{r+\lambda} - \frac{\lambda}{r+\lambda}(1-\Omega_L\tau_p)\,L + A_2^T\Pi^{\beta_2(\lambda)}, \tag{3.4}$$

where $A_2^T\Pi^{\beta_2(\lambda)}$ measures the value of the firm's option to incorporate, and A_2^T is an unknown to be found. This option allows the firm to switch from a riskier activity (characterized by unlimited liability) to a less risky one (i.e., with limited liability). This entails that $A_2^T\Pi^{\beta_2(\lambda)}$ is a put option. Since the firm can decide to change its organizational form whenever it likes, then we can say that this option is an American one.

Let us next calculate the corporate firm's value, which consists of two terms. The first term is represented by the after-tax payoff

$$(1-\tau_c)\,\Psi\Pi dt,$$

earned in the short interval dt. The second term is contingent on future events. Namely, after dt has passed, the firm survives with a probability $(1-\lambda dt)$: its expected value is thus equal to

$$\xi\left[V^T(\Pi+d\Pi)\right].$$

With probability λdt, instead, the firm stops production but, given limited liability, shareholders do not face the loss L. Therefore the corporate firm's value is equal to

$$V^T(\Pi) = (1-\tau_c)\,\Psi\Pi dt + (1-\lambda dt)\,e^{-rdt}\xi\left[V^T(\Pi+d\Pi)\right] + \\ + \lambda dt e^{-rdt}\max\left\{-(1-\Omega_L\tau_c)\,L, 0\right\}, \tag{3.5}$$

where the term $\max\{-(1-\Omega_L\tau_c)\,L, 0\}$ measures the benefit of limited liability. As shown in appendix 3.4.2, solving (3.5) gives

$$V^T(\Pi) = \frac{(1-\tau_c)\,\Psi\Pi}{r+\lambda-\alpha}. \tag{3.6}$$

As can be seen the value function is given by a perpetual rent. This is due to the fact that, after incorporation, the firm owns no real option.

3.2.2 The exercise of the option to incorporate

Given these results we can now study the decision to incorporate. Substituting (3.4) and (3.6) into the VMC (2.6), gives

$$\begin{aligned}\tfrac{(1-\tau_p)\Pi^*}{r+\lambda} - \tfrac{\lambda}{r+\lambda}\left(1-\Omega_L\tau_p\right)L + A_2^T {\Pi^*}^{\beta_2(\lambda)} &= \\ = \tfrac{(1-\tau_c)\Psi\Pi^*}{r+\lambda-\alpha} - \left(1-\Omega_I\tau_c\right)I,&\end{aligned} \tag{3.7}$$

where Π^* is the trigger point to be found. Solving (3.7) for A_2^T one obtains

$$\begin{aligned}A_2^T = \Bigg[\tfrac{\lambda}{r+\lambda}\left(1-\Omega_L\tau_p\right)L- \\ -\tfrac{(1-\tau_p)-(1-\tau_c)\Psi}{r+\lambda-\alpha}\Pi^* - \left(1-\Omega_I\tau_c\right)I\Bigg]{\Pi^*}^{-\beta_2(\lambda)}.\end{aligned}$$

Therefore we can rewrite the value of the unlimited company value as

$$\begin{aligned}O^T(\Pi;\Pi^*) = \tfrac{(1-\tau_p)\Pi}{r+\lambda-\alpha} - \tfrac{\lambda}{r+\lambda}\left(1-\Omega_L\tau_p\right)L+ \\ +\left[\tfrac{\lambda}{r+\lambda}\left(1-\Omega_L\tau_p\right)L - \tfrac{(1-\tau_p)-(1-\tau_c)\Psi}{r+\lambda-\alpha}\Pi^* - \left(1-\Omega_I\tau_c\right)I\right]\left(\tfrac{\Pi}{\Pi^*}\right)^{\beta_2(\lambda)}.\end{aligned} \tag{3.8}$$

Given (3.8) the firm's problem is the one of choosing the value of Π^* that maximizes the non-corporate firm value

$$\max_{\Pi^*} O^T(\Pi;\Pi^*). \tag{3.9}$$

Solving (3.9) (see appendix 3.4.3) one obtains

$$\Pi^* = \frac{\beta_2(\lambda)}{\beta_2(\lambda)-1}\frac{(r+\lambda-\alpha)\left[\frac{\lambda}{r+\lambda}\left(1-\Omega_L\tau_p\right)L - \left(1-\Omega_I\tau_c\right)I\right]}{(1-\tau_p)-(1-\tau_c)\Psi} > 0, \tag{3.10}$$

if

$$L > L^* \equiv \frac{r+\lambda}{\lambda}\frac{1-\Omega_I\tau_c}{1-\Omega_L\tau_p}I \geq 0 \text{ for } I \geq 0.$$

This means that if L is high enough we have a positive trigger point. Otherwise, incorporation is never optimal for $\Pi > 0$.[13]

[13] Remember that we focused on case 2, which implies that the difference between the non-corporate and the corporate operating profit, i.e. $[(1-\tau_p)-(1-\tau_c)\Psi]\Pi$ is positive.

As can be seen, the threshold point is increasing in L. In other words, the greater the expected loss, the higher the threshold point is and the earlier the firm incorporates. Not surprisingly, the threshold point is negatively affected by the after-tax cost of incorporation $(1 - \Omega_I \tau_c) I$.

Let us next analyze the impact of taxation on the option to incorporate. We can prove the following:

Proposition 2 *If the cost of incorporation is positive, we have:*

$$\frac{\partial \Pi^*}{\partial \tau_p} > 0 \text{ if } L > L_1 \equiv \frac{r+\lambda}{\lambda} \frac{(1-\Omega_I \tau_c)}{(1-\Omega_L)+(1-\tau_c)\Psi\Omega_L} I > L^*,$$

$$\frac{\partial \Pi^*}{\partial \tau_c} < 0 \text{ if } L > L_2 \equiv \frac{r+\lambda}{\lambda} \frac{(1-\tau_p)\Omega_I+(1-\Omega_I)\Psi}{\Psi(1-\Omega_L \tau_p)} I > L^*,$$

and vice versa.

Proof. See appendix 3.4.4. ■

According to proposition 2 the effect of taxation on the decision to incorporate is ambiguous as long as transition costs are positive.

To understand this ambiguity let us assume an increase in τ_p. On the one hand, a higher rate τ_p raises the current net benefit of incorporation (3.1), i.e., $NB \equiv [(1 - \tau_c) \Psi - (1 - \tau_p)] \Pi$. On the other hand it reduces the expected after-tax loss $(1 - \Omega_L \tau_p) L$. As shown in appendix 3.4.4, the former effect dominates the latter if the expected loss is $L > L_1$: in this case, an increase in τ_p raises the trigger point Π^* thereby encouraging incorporation. If $L^* < L < L_1$ the converse is true.

A similar trade-off arises when τ_c is reduced. On the one hand, a decrease in τ_c raises the current net benefit of incorporation NB. On the other hand, the decrease in τ_c raises the expected after-tax cost of incorporation $(1 - \Omega_I \tau_c) I$. If $L > L_2$ the decrease in τ_c raises the trigger point thereby encouraging incorporation.[14]

It is worth noting that the ambiguity of comparative statics analysis disappears if we set $I = 0$. Given proposition 2, it is easy to show that:

Corollary 1 *If the cost of incorporation I is nil, we have $\frac{\partial \Pi^*}{\partial \tau_p} > 0$ and $\frac{\partial \Pi^*}{\partial \tau_c} < 0$.*

[14] Notice that the sign of $(L_1 - L_2)$ is ambiguous.

Proposition 2 and corollary 1 imply that transaction costs are crucial determinants of the effects of taxation on organizational choices. MacKie-Mason and Gordon (1997) find that in the US transaction costs have a negligible impact on the organizational choices. However, this does not necessarily hold in other countries. Empirical investigation should thus focus on the size of transaction costs in order to understand the effects of both τ_p and τ_c.

3.3 Organizational neutrality

Organizational neutrality holds when $\tau_p = \tau_c$. This equality can be achieved either with radical reforms or with *ad hoc* rules. On the one hand, McLure (1979, 1987) and Feldstein (1988) proposed the abolition of corporate taxation and the full imputation of all capital income to the company's shareholders.[15] On the other hand, some tax systems have implemented milder changes by introducing *ad hoc* classes of taxpayers, which are between partnerships (with unlimited liability and small ownership base) and standard corporations (with limited liability and a wider shareholder base). Two examples of these taxpayers can be found in the US and the Italian tax system. In the US we have so-called S corporations, that begin their existence as standard for-profit corporations (namely "C corporations"). After the corporation has been formed, however, it may elect "S Corporation Status", on condition that:

1. all shareholders of the corporation are US Citizens or have US Residency Status;

2. the corporation never has more than 75 shareholders.

In this case the S corporation is taxed like a partnership or sole-proprietorship. This means that income is directly imputed to the shareholders, who will then report income or loss generated by an S corporation.

A similar device, known as Fiscal Transparency, was introduced in Italy in 2004. Under Italy's tax system, corporate income is directly imputed to shareholders in proportion to their percentage of ownership, provided that:

[15] For further details see chapter 6.

1. shareholders are all natural persons;
2. the volume of revenue does not exceed the threshold of € 5,164,569;
3. the corporation has no more than 10 shareholders (20 for co-operative companies).

In principle both the US and Italian case imply the equality $\tau_p = \tau_c$ and therefore entail that the organizational choice is unaffected by taxation. It is worth noting however that neutrality in terms of organizational choices may fail to hold if different kinds of corporations have a different tax base, as well as different tax avoidance opportunities. As we have pointed out, this hybrid tax treatment is allowed only for small corporations, that usually have less opportunities for avoiding taxation than larger corporations.

3.4 Appendix

3.4.1 The calculation of (3.4)

Let us rewrite (3.3) as follows

$$\begin{aligned} O^T(\Pi) = \; & (1-\tau_p)\,\Pi dt + \\ & + (1-\lambda dt)(1-rdt)\left\{\xi\left[O^T(\Pi+d\Pi)\right]\right\} - \\ & -\lambda d\,(1-rdt)(1-\Omega_L\tau_p)\,L. \end{aligned} \tag{3.11}$$

Remember that the term $(dt)^2$ goes to zero faster than dt. This means that

$$(1-\lambda dt)(1-rdt) = 1-(\lambda+r)\,dt+\lambda r\,(dt)^2 \approx 1-(\lambda+r)\,dt,$$

$$-\lambda dt\cdot(1-rdt) = -\lambda dt+\lambda r\,(dt)^2 \approx -\lambda dt.$$

Expanding the RHS of (3.11), and applying Itô's Lemma we thus have

$$\begin{aligned} O^T(\Pi) = (1-\tau_p)\,\Pi dt + (r+\lambda)\,dtO^T(\Pi) - \lambda dt\,(1-\Omega_L\tau_p)\,L + \\ + \left[\alpha\Pi O^T_\Pi(\Pi) + \tfrac{\sigma^2}{2}\Pi^2 O^T_{\Pi\Pi}(\Pi)\right] dt. \end{aligned} \tag{3.12}$$

Simplifying (3.12) gives

$$(r+\lambda)\, O^T(\Pi) = (1-\tau_p)\,\Pi - \\ -\lambda\,(1-\Omega_L\tau_p)\,L + \alpha\Pi O^T_{\Pi}(\Pi) + \tfrac{\sigma^2}{2}\Pi^2 O^T_{\Pi\Pi}(\Pi). \tag{3.13}$$

The general solution of (3.13) is

$$O^T(\Pi) = D_0 + A_0\Pi + \sum_{j=1}^{2} A_j \Pi^{\beta_j(\lambda)}. \tag{3.14}$$

Substituting (3.14) into (3.13) we obtain

$$(r+\lambda)\left[D_0 + A_0\Pi + \sum_{j=1}^{2} A_j\Pi^{\beta_j(\lambda)}\right] =$$
$$= (1-\tau_p)\,\Pi - \lambda\,(1-\Omega_L\tau_p)\,L +$$
$$+\alpha\Pi\left[A_0 + \sum_{j=1}^{2}\beta_j(\lambda)\,A_j\Pi^{\beta_j(\lambda)-1}\right] +$$
$$+\tfrac{\sigma^2}{2}\Pi^2\left\{\sum_{j=1}^{2}\beta_j(\lambda)\left[\beta_j(\lambda)-1\right]A_j\Pi^{\beta_j(\lambda)-2}\right\},$$

which gives

$$D_0 = -\tfrac{\lambda}{r+\lambda}\,(1-\Omega_L\tau_p)\,L,$$

$$A_0 = \tfrac{1-\tau_p}{r+\lambda},$$

and the roots

$$\beta_1(\lambda) = \left(\tfrac{1}{2} - \tfrac{\alpha}{\sigma^2}\right) + \sqrt{\left(\tfrac{\alpha}{\sigma^2} - \tfrac{1}{2}\right)^2 + \tfrac{2(r+\lambda)}{\sigma^2}} > 1,$$
$$\beta_2(\lambda) = \left(\tfrac{1}{2} - \tfrac{\alpha}{\sigma^2}\right) - \sqrt{\left(\tfrac{\alpha}{\sigma^2} - \tfrac{1}{2}\right)^2 + \tfrac{2(r+\lambda)}{\sigma^2}} < 0,$$

of the characteristic equation

$$\Psi\left(\beta_j(\lambda)\right) \equiv \frac{\sigma^2}{2}\beta_j(\lambda)\left(\beta_j(\lambda)-1\right) + \alpha\beta_j(\lambda) - (r+\lambda) = 0.$$

The general-form solution can thus be rewritten as

$$O^T(\Pi) = \left[\frac{(1-\tau_p)\,\Pi}{r+\lambda} - \frac{\lambda}{r+\lambda}\,(1-\Omega_L\tau_p)\,L\right] + \sum_{j=1}^{2} A_j\Pi^{\beta_j(\lambda)}, \tag{3.15}$$

where the term in square brackets is a perpetual rent which accounts for the risk of facing the loss L, and the terms $A_j \Pi^{\beta_j(\lambda)}$, for $j = 1, 2$, measure the value of the non-corporate firm's option to incorporate.

In the absence of financial bubbles, we obtain $A_1^T = 0$ and the firm's value reduces to (3.4).

3.4.2 The calculation of (3.6)

Given $[-(1-\Omega_L \tau_c) L] < 0$ we can simplify (3.5) as follows

$$V^T(\Pi) = (1-\tau_c)\Psi\Pi dt + (1-\lambda dt)\, e^{-rdt}\left\{\xi\left[V^T(\Pi + d\Pi)\right]\right\} \approx$$
$$\approx (1-\tau_c)\Pi dt + (1-\lambda dt)(1-rdt)\left\{\xi\left[V^T(\Pi+d\Pi)\right]\right\}. \tag{3.16}$$

Applying Itô's Lemma to (3.16) we obtain

$$(r+\lambda) V^T(\Pi) = (1-\tau_c)\Pi + \alpha\Pi V_\Pi^T(\Pi) + \frac{\sigma^2}{2}\Pi^2 V_{\Pi\Pi}^T(\Pi). \tag{3.17}$$

As we know, the general-form solution of (3.17) is

$$V^T(\Pi) = \frac{(1-\tau_c)\Psi\Pi}{r+\lambda-\alpha} + \sum_{j=1}^{2} F_j^T \Pi^{\beta_j(\lambda)}. \tag{3.18}$$

As we pointed out, in case 2 incorporation is a viable solution if Π is low enough. This means that we can apply the boundary condition

$$V^T(0) = 0. \tag{3.19}$$

Given condition (3.19), therefore, equality $F_2^T = 0$ holds. Moreover, in the absence of financial bubbles we also have $F_1^T = 0$. Consequently, the corporation's value (3.18) reduces to (3.6).

3.4.3 The trigger point (3.10)

Let us substitute (3.8) into (3.9), and differentiate with respect to Π^*. We obtain the following f.o.c.

$$\frac{\partial O^T(\Pi;\Pi^*)}{\partial \Pi^*} = \frac{\Pi^{\beta_2(\lambda)}}{\Pi^{*\beta_2(\lambda)+1}} \cdot \left\{\left[\beta_2(\lambda) - 1\right] \frac{(1-\tau_p)-(1-\tau_c)\Psi}{r+\lambda-\alpha}\Pi^* - \right.$$
$$\left. -\beta_2(\lambda)\left[\frac{\lambda}{r+\lambda}(1-\Omega_L\tau_p)L - (1-\Omega_I\tau_c)I\right]\right\} = 0. \tag{3.20}$$

Solving for Π^* one easily obtains (3.10). To show that Π^* is an optimum, we rewrite the f.o.c. (3.20) as

$$\begin{aligned}\frac{\partial O^T(\Pi;\Pi^*)}{\partial \Pi^*} &= \frac{\Pi^{\beta_2(\lambda)}}{\Pi^{*\beta_2(\lambda)+1}} \cdot \Big\{ \left[\beta_2(\lambda) - 1\right] \frac{(1-\tau_p)-(1-\tau_c)\Psi}{r+\lambda-\alpha}\Pi^* - \\ &-\beta_2(\lambda)\Big[\frac{\lambda}{r+\lambda}(1-\Omega_L\tau_p)L - (1-\Omega_I\tau_c)I\Big]\Big\} = 0.\end{aligned} \tag{3.21}$$

Differentiating (3.21) gives the second order condition

$$\begin{aligned}\frac{\partial^2 O^T(\Pi;\Pi^*)}{\partial {\Pi^*}^2} = & -\left[\beta_2(\lambda)+1\right]\frac{\Pi^{\beta_2(\lambda)}}{\Pi^{*\beta_2(\lambda)+1}} \cdot \\ & \cdot \Big\{\left[\beta_2(\lambda)-1\right]\frac{(1-\tau_p)-(1-\tau_c)\Psi}{r+\lambda-\alpha} - \\ & -\beta_2(\lambda)\Big[\frac{\lambda}{r+\lambda}(1-\Omega_L\tau_p)L-(1-\Omega_I\tau_c)I\Big]\Big\} + \\ & + \left(\frac{\Pi}{\Pi^*}\right)^{\beta_2(\lambda)} \cdot \frac{\beta_2(\lambda)-1}{\Pi^*} \cdot \frac{(1-\tau_p)-(1-\tau_c)\Psi}{r+\lambda-\alpha}.\end{aligned} \tag{3.22}$$

Substituting (3.21) into condition (3.22) we have

$$\frac{\partial^2 O^T(\Pi;\Pi^*)}{\partial {\Pi^*}^2} = \frac{\Pi^{\beta_2(\lambda)}}{\Pi^{*\beta_2(\lambda)+1}} \cdot \left[\beta_2(\lambda)-1\right]\frac{(1-\tau_p)-(1-\tau_c)\Psi}{r+\lambda-\alpha} < 0.$$

The negative sign of $\frac{\partial^2 O^T(\Pi;\Pi^*)}{\partial {\Pi^*}^2}$ proves that Π^* is an optimum.

3.4.4 *Proof of proposition 2*

Let us differentiate (3.10) with respect to τ_p and τ_c. We thus have

$$\frac{\partial \Pi^*}{\partial \tau_p} \propto \frac{(1-\Omega_L)L + (1-\tau_c)\Psi\Omega_L L - \frac{r+\lambda}{\lambda}(1-\Omega_I\tau_c)I}{\left[(1-\tau_p)-(1-\tau_c)\Psi\right]^2}.$$

It is easy to ascertain that $\frac{\partial \Pi^*}{\partial \tau_p} > 0$ if $L > L_1$, where

$$L_1 \equiv \frac{r+\lambda}{\lambda}\frac{(1-\Omega_I\tau_c)}{(1-\Omega_L)+(1-\tau_c)\Psi\Omega_L}I > 0.$$

To show that the inequality $L_1 > L^* \equiv \frac{r+\lambda}{\lambda}\frac{1-\Omega_I\tau_c}{1-\tau_p\Omega_L}I$ holds let us rewrite L_1 as

$$L_1 = \frac{r+\lambda}{\lambda}\frac{(1-\Omega_I\tau_c)}{(1-\Omega_L)+\tau_p\Omega_L-\tau_p\Omega_L+(1-\tau_c)\Psi\Omega_L}I.$$

Given $[(1-\tau_p)-(1-\tau_c)\Psi]>0$, we obtain:

$$L_1=\frac{r+\lambda}{\lambda}\frac{(1-\Omega_I\tau_c)}{(1-\tau_p\Omega_L)-\Omega_L\left[(1-\tau_p)-(1-\tau_c)\Psi\right]}I>L^*.$$

Differentiating (3.10) with respect to τ_c gives

$$\frac{\partial\Pi^*}{\partial\tau_c}\propto\frac{\frac{r+\lambda}{\lambda}I\left[(1-\tau_p)\Omega_I+(1-\Omega_I)\Psi\right]-\Psi(1-\Omega_L\tau_p)L}{\left[(1-\tau_p)-(1-\tau_c)\Psi\right]^2}.$$

Therefore we have $\frac{\partial\Pi^*}{\partial\tau_c}<0$ if $L>L_2$, where

$$L_2\equiv\frac{r+\lambda}{\lambda}\frac{(1-\tau_p)\Omega_I+(1-\Omega_I)\Psi}{\Psi(1-\Omega_L\tau_p)}I, \tag{3.23}$$

and vice versa. Rewrite (3.23) as follows

$$L_2=\frac{r+\lambda}{\lambda}\frac{(1-\Omega_I\tau_c)+\frac{\Omega_I}{\Psi}\left[(1-\tau_p)-(1-\tau_c)\Psi\right]}{(1-\Omega_L\tau_p)}I.$$

Given $[(1-\tau_p)-(1-\tau_c)\Psi]>0$, therefore, we can show that $L_2>L^*$. This concludes the proof.■

4

The tax treatment of debt financing

Debt financing usually ensures the tax benefit of interest deductibility. In this chapter we deal with the trade-off between tax benefits and default costs. We will first introduce a standard deterministic model and then show how operating and default risk affect firms' financial choices under taxation.

In the second part of this chapter we will deal with the interactions between tax avoiding practices and financial policies by multinational companies (MNCs).

4.1 The standard model

The article by Modigliani and Miller (1958) is one of the pillars of modern corporate finance. These authors wanted to understand "[w]hat is the "cost of capital" to a firm in a world in which funds are used to acquire assets whose yields are uncertain..." (p. 261). In their subsequent contribution (Modigliani and Miller, 1963) they analyzed the relationships between corporate taxation and firms' capital structure.

In order to summarize Modigliani and Miller's findings we will focus on a representative entrepreneur that has two alternative investment opportunities: risky capital, denoted as K, and risk-free bonds (e.g., treasury bonds). If he decides to undertake a business investment, he bears a risky return that depends on the amount of capital accumulated.

The entrepreneur can either borrow or use his own resources to finance the business activity. In the first case, the entrepreneur must pay an interest rate, thereby facing an effective cost. If, on the other hand, the entrepreneur self-finances his own activity, he faces an opportunity cost equal to the risk-free return r. We also assume that:

1. the risk-free return is tax-exempt;
2. the representative firm employs only capital to produce one good;
3. the price of both the good produced and capital is equal to 1 Euro;
4. capital can be bought and sold without limitations and it becomes productive as soon as it is bought;
5. it maintains its characteristics unchanged in time;
6. marginal product is decreasing in K.

These assumptions are in line with Jorgenson's (1963) neoclassical model, and thus do not need any particular comment. It is sufficient to say that the marginal product of capital (MPK) defines the demand for capital, while the exogenously given interest rate determines an infinitely elastic supply curve. The optimal quantity of capital, defined as K^*, is obtained by equating the marginal product of capital, denoted as π, to its marginal cost (i.e., r), so that equality

$$\pi = r \tag{4.1}$$

holds. Condition (4.1) means that the user cost of capital is equal to r. In figure 4.1 we draw the capital accumulation process. The optimal amount of capital K^* is given by the intersection point, where condition (4.1) holds.

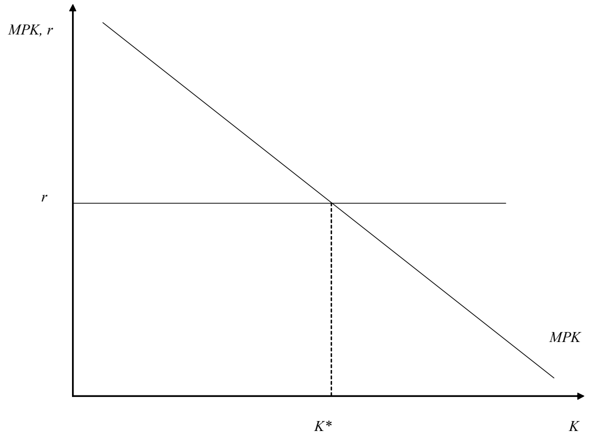

FIGURE 4.1. Capital accumulation without taxation.

It is worth noting that as long as the capital market is perfectly efficient[1] and there are no default costs, both the effective cost and the opportunity cost are equal to r. This means that condition (4.1) holds irrespective of the firm's financial strategy: this is the well-know Modigliani and Miller's Indifference Theorem.[2]

In their correction note, Modigliani and Miller (1963) improved their analysis on tax determinants of financial strategies.[3] The underlying idea is that tax systems usually ensure the deductibility of interest payments on debt. This means that, under debt financing, the marginal tax base is equal to $(\pi - r)$ and, thus, the after-tax marginal return is $(1 - \tau)(\pi - r)$. Since under debt financing the

[1] Modigliani and Miller (1958, p. 268) maintain that "the term perfect is to be taken in its usual sense as implying that any two commodities which are perfect substitutes for each other must sell in equilibrium at the same price".

[2] As proven by Modigliani and Miller (1958) this indifference result holds even under uncertainty. In a subsequent article, Miller and Modigliani (1961) assume that capital markets are complete and are charactized by the absence of transaction costs and by symmetric information.

[3] In their joint contributions Modigliani and Miller did not deal with personal taxation. Subsequently, Miller (1977) introduced personal taxation and analyzed the effect of it on firms' capital structure.

opportunity cost is nil, the marginal condition is

$$(1-\tau)(\pi - r) = 0.$$

Given $(1-\tau) \geq 0$, the *laissez-faire* condition (4.1), i.e.,

$$(\pi - r) = 0$$

holds even under taxation. We can therefore write the following:

Proposition 3 *Under debt financing, corporate taxation is neutral from the point of investment choice.*

It is worth noting that the result of proposition 3, discussed in Stiglitz (1973), holds if interest payments are fully deductible.[4] If, instead, the interest rate is only partially deductible,[5] corporate taxation has a distortive impact on investment strategies. It is easy to show that partial deduction of interest rates raises the user cost of capital, thereby discouraging investment: thus, neutrality fails to hold.

Let us next analyze the effects of taxation under equity financing. Under most tax systems, the opportunity cost of equity financing is non-deductible. This means that capital accumulation is optimal when the after-tax marginal product $(1-\tau)\pi$ is equal to the opportunity cost r, i.e., $(1-\tau)\pi = r$. Solving for π one obtains

$$\pi = \frac{r}{1-\tau}. \tag{4.2}$$

As can be seen in (4.2), the user cost of capital $\frac{r}{1-\tau}$ is higher than the rate r. As the marginal product of capital is decreasing, the higher the user cost and the lower the optimal investment is. This implies that, under equity financing, taxation leads to underinvestment, namely the optimal amount of capital is less than K^*.

If we compare (4.1) with (4.2), Modigliani and Miller's (1958) Indifference Theorem fails to hold: given the different tax treatment,

[4] As pointed out by Stiglitz (1973, pp. 26-27) "[i]n the absence of uncertainty, the corporate profits tax with the interest deductibility provision is completely nondistortionary. It does not shift resources (at the margin) from the corporate to the noncorporate sector. It is an infra-marginal tax on the return to capital (or pure profits) in the corporate sector". He also adds that "[i]f we ignore bankruptcy, the same result, that the corporate profits tax is non-distortionary, obtains in the presence of uncertainty".

[5] As will be discussed, the deductibility of interest payments may be prevented whenever thin capitalization rules, aimed at contrasting tax avoidance, are applied.

debt has a lower user cost than equity. We can thus write the following:

Proposition 4 *Under interest deductibility debt is preferable to equity.*

Modigliani and Miller (1963) show the result of proposition 4 in two different ways: both by using the cost of capital formulae[6] and by referring to a firm's value. In this latter case, they show that the value of the levered firm is equal to

$$V = V_U + \tau D, \tag{4.3}$$

where V_U is the value of the unlevered firm and D is the value of debt. As shown in (4.3), therefore, interest deductibility raises the firm's value by an amount equal to τ times the value of debt.

4.2 Default risk and optimal leverage

As pointed out by Modigliani and Miller (1963), debt can be the least burdensome form of finance. If this is true, then we need to ask why companies are not entirely debt-financed. The answer is that the model so far analyzed does not consider market imperfections (such as default costs) which can dramatically affect a company's financial strategy.[7] Branch (2002) classifies default costs in four categories:

1. costs borne directly by the bankrupt firm;
2. costs faced directly by the claimants;
3. losses to the bankrupt firm that are offset by gains to other entities;
4. costs born by third-party entities.

[6] Notice that equations (4.1) and (4.2) are the same as those obtained by Modigliani and Miller (1963) on p. 440.

[7] Modigliani and Miller (1963, p. 442) were aware of capital market imperfections. They argued that "the existence of a tax advantage for debt financing ... does not necessarily mean that corporations should at all time seek to use the maximum possible amount of debt in their capital structures. For one thing, other forms of financing, notably retained earnings, may in some circumstances be cheaper ... More important, there are ... limitations imposed by lenders, ... as well as many other dimensions (and kinds of costs) in real-world problems of financial strategy ...".

By accounting for these categories Branch (2002) estimates a total default-related cost ranging between 12.7% and 20.5%.[8]

Given the fact that default is costly, the evidence shows that as leverage rises, the premium asked by the creditor also increases to cover the default risk. Defining D and E as the value of debt and equity, respectively, we obtain the interest rate on debt as a function of the leverage ratio $\left(\frac{D}{D+E}\right)$, i.e.,

$$r_D = r + f\left(\frac{D}{D+E}\right), \tag{4.4}$$

where $f\left(\frac{D}{D+E}\right)$ measures risk premium, which is increasing in the leverage ratio $\left(\frac{D}{D+E}\right)$. If, therefore, a firm decides to expand its activity by using debt, the interest rate r_D is expected to grow because of the higher risk premium required by the lender.[9]

In figure 4.2 we compare equity and debt financing, when the default cost is accounted for. Up to point $K^{'}$, it is preferable to accumulate capital by resorting to debt financing. After this point equity is preferable, although its opportunity cost is non-deductible. Accumulation thus concludes once point $K^{''}$ has been reached.

The model depicted in figure 4.2 does not take into consideration asymmetric information. Agency costs, analyzed in the pioneering articles by Jensen and Mecklin (1976) and Myers (1977), lead to a trade-off even in the absence of taxation. It is well known that debt can lead to an improvement as it ensures a reduction in agency conflicts between managers and shareholders. As argued by Jensen (1986), the payment of a coupon to debtholders reduces the amount of free cash flow available for managers. Harris and Raviv (1991) state that, under debt financing, the possibility of any liquidation reduces managers' propensity to undertake negative NPV projects in order to build their own empire.[10]

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[8] It is worth noting that Goldstein, Ju and Leland (2001) criticize the existing literature in that it usually assumes unreasonably high default costs. They argue that overall default costs are about 5%.

[9] The trade-off between tax benefits and default costs was studied by Kraus and Litzenberger (1973) and Scott (1976).

[10] Agency problems are particularly important whenever there is a separation between control and property. In this case, managers are autonomous and often answer to shareholders only during annual meetings. For this reason, resorting to the market for borrowing can be extremely important for shareholders, as it lowers agency costs. As Kanniainen

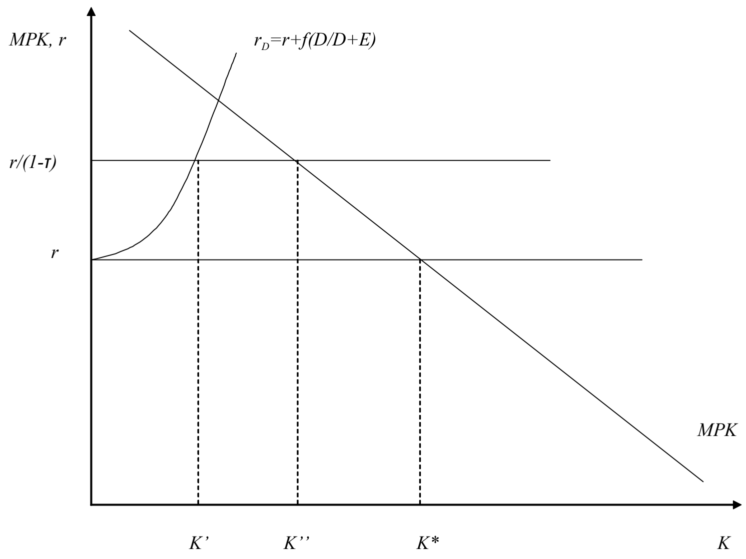

FIGURE 4.2. Capital accumulation under taxation and default risk.

It is worth noting that the introduction of non-tax factors, such as agency problems, is an interesting generalization. However, it is beyond the scope of this chapter. In what follows, we will thus limit our analysis to the trade-off between interest deductibility and the cost of default.

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and Södersten (1994, 1995) noted, shareholders are aware that lenders will monitor a company before giving a loan. Lenders will therefore substitute the shareholders from control of the management, thereby saving resources that otherwise would be needed for monitoring their company. Sørensen (1994, 1995) proposed a similar line of argument for new equity issues. He argued that issuing new shares can ensure a benefit to old shareholders if new shareholders are institutional investors (such as banks, investment funds, financing companies). In this case, they will carry out an in-depth control of the economic-financial situation of the company. Given that the controls of these new institutional partners will benefit all shareholders, the cost of the capital is reduced by savings in monitoring costs. For a comprehensive analysis of agency problems see e.g. Tirole (2006). See also Rossi (2003), who provides an interesting discussion of clash of interests in an international setting.

4.3 The trade-off model

In this section we apply Leland's (1994) continuous-time model to analyze the trade-off between tax benefits and default costs. This framework describes the financial strategies of a representative firm, that can borrow from a perfectly competitive credit sector, which is characterized by a given risk-free interest rate r.

We assume that the firm's Earning Before Interest and Taxes (EBIT), defined as Π, follows a geometric Brownian motion

$$\frac{d\Pi}{\Pi} = \sigma dz, \text{ with } \Pi_0 \geq 0, \tag{4.5}$$

where, as we know, σ is the instantaneous standard deviation of $\frac{d\Pi}{\Pi}$, and dz is the increment of a Wiener process.[11] Moreover we introduce the following assumptions:

Assumption 4 *At time 0, the firm borrows some resources and pays a coupon, which is not renegotiable.*

Assumption 5 *If the firm does not meet its debt obligations, default occurs, namely the firm is expropriated by the lender.*

Assumption 6 *The cost of default is proportional to the coupon received.*

These assumptions deserve some comments. In line with Leland (1994), assumption 4 means that the firm sets a coupon and then computes the market value of debt. In the absence of arbitrage, this is equivalent to first set the value of debt and then calculate the effective interest rate. Moreover, we assume that debt cannot be renegotiated: this means that we apply a *static* trade-off approach where the firm's financial policy cannot be reviewed later.[12]

Assumptions 5 and 6 introduce the risk and the cost of default, respectively. Given (4.5), it is assumed that if the firm's EBIT falls

[11] As shown in chapter 2, the general form of the geometric Brownian motion is $d\Pi = \alpha\Pi dt + \sigma\Pi dz$ where α is the expected rate of growth. If shareholders are risk neutral, in equilibrium we have $\alpha = r - \delta$, where δ is the convenience yield (see e.g. McDonald and Siegel, 1985). With no loss of generality, in (4.5) we set $\alpha = r - \delta = 0$.

[12] Of course the absence of debt renegotiation is not realistic, although it does not affect the qualitative properties of the model. For a detailed analysis of *dynamic* trade-off strategies, with costly debt renegotiation, see e.g. Goldstein, Ju and Leland (2001), and Hennessy and Whited (2005).

to a given threshold value, the firm is expropriated by the lender (assumption 5). In the event of default, the lender faces a sunk cost, which is proportional to the coupon paid (assumption 6).

Following Leland (1994) we introduce two alternative definitions of default:[13]

Definition 1 *Under protected debt financing, default occurs when* Π *falls to an exogenously given threshold point* $\overline{\Pi}^{p}$*.*

Definition 2 *Under unprotected debt financing, the threshold point* $\overline{\Pi}^{u}$ *is chosen optimally by shareholders at time 0.*

According to definition 1, default may be triggered when the firm's payoff falls to the exogenously given threshold point $\overline{\Pi}^{p}$. This former definition refers to protected debt, where default takes place when the firms' asset value falls to the debt's value.

Under the definition 2, when the firm's net cash flow is negative, shareholders can decide whether to inject further equity capital in order to meet the firm's debt obligations or to default. As long as they issue new capital and pay the interest rate they can exploit future recoveries in the firm's profitability. Under unprotected debt financing, shareholders behave as if they owned a put option, whose exercise leads to default.

As pointed out by Leland (1994) both protected and unprotected debt are widely used. In particular, minimum net-worth requirements, implied by protected debt, are common in short-term debt financing, whereas long-term debt instruments are usually unprotected or only partially protected.

Given the above assumptions, we therefore set the cost of default equal to υC^{j}, where the parameter $\upsilon > 0$ measures the impact of default on the lender's profitability, and C^{j} is the coupon paid when debt is either protected ($j = p$) or unprotected ($j = u$).[14] The framework so far obtained accounts for the use of debt for tax-motivated financial strategies. Given the tax rate τ the firm's net profit function is thus equal to

$$\Pi^{N} = (1 - \tau)\left(\Pi - C^{j}\right). \tag{4.6}$$

[13] For further details on default conditions see Brennan and Schwartz (1978), and Smith and Warner (1979).

[14] The quality of results does not change if, like Leland (1994), we assume that default costs are proportional to the firm's value.

As regards the treatment of the lender's receipts it is well-known that effective tax rates on capital income are fairly low. With no loss of generality, therefore, we assume that the lender's pre-default tax burden is nil. When, however, in the event of default, the lender becomes shareholder, it is subject to corporate taxation.

Given the above assumptions, we can now calculate the firm's value function

$$V^j(\Pi) = D^j(\Pi) + E^j(\Pi), \text{ with } j = p, u, \tag{4.7}$$

where $D^j(\Pi)$ and $E^j(\Pi)$ are, respectively, the value of debt and equity, under either protected or unprotected debt financing.

We will next calculate the value of debt, for a given default threshold point $\overline{\Pi}^j$ with $j = p, u$. Then we will calculate $\overline{\Pi}^j$ and the value of equity.

4.3.1 The debt value

Using dynamic programming, we can write the value of debt as follows:

$$D^j(\Pi) = \begin{cases} (1-\tau)\,\Pi dt + e^{-rdt}\xi\left[D^j(\Pi + d\Pi)\right] & \text{after default,} \\ C^j dt + e^{-rdt}\xi\left[D^j(\Pi + d\Pi)\right] & \text{before default.} \end{cases} \tag{4.8}$$

Applying Itô's Lemma to (4.8), gives

$$rD^j(\Pi) = L + \frac{\sigma^2}{2}\Pi^2 D^j_{\Pi\Pi}(\Pi), \tag{4.9}$$

where $L = (1-\tau)\,\Pi, C^j$, and $D^j_{\Pi\Pi}(\Pi) \equiv \frac{\partial^2 D^j(\Pi)}{\partial \Pi^2}$. The general closed-form solution of function (4.9) is

$$D^j(\Pi) = \begin{cases} \frac{(1-\tau)\overline{\Pi}^j}{r} + \sum_{i=1}^2 B_i^j \Pi^{\beta_i} & \text{after default,} \\ \frac{C^j}{r} + \sum_{i=1}^2 D_i^j \Pi^{\beta_i} & \text{before default,} \end{cases} \tag{4.10}$$

where $\beta_1 = \frac{1}{2} + \sqrt{\left(\frac{1}{2}\right)^2 + \frac{2r}{\sigma^2}} > 1$, and $\beta_2 = \frac{1}{2} - \sqrt{\left(\frac{1}{2}\right)^2 + \frac{2r}{\sigma^2}} < 0$ are the two roots of the characteristic equation

$$\Psi(\beta) \equiv \frac{1}{2}\sigma^2\beta(\beta-1) - r = 0.$$

To calculate B_i^j and D_i^j for $i = 1, 2$, we need three boundary conditions. Firstly, we assume that whenever Π goes to zero the lender's claim is nil, namely condition $D^j(0) = 0$ holds: this implies that $B_2^j = 0$. Secondly, we assume that financial bubbles do not exist: this means that $B_1^j = D_1^j = 0$. Thirdly, we must consider that at point $\Pi = \overline{\Pi}^j$, the pre-default value of debt must be equal to the post-default one, net of the default cost. Using the two branches of (4.10) we thus obtain

$$\frac{(1-\tau)\,\overline{\Pi}^j}{r} - \upsilon C^j = \frac{C^j}{r} + D_2^j \overline{\Pi}^{j\beta_2}.$$

Solving for D_2^j gives

$$D_2^j = \left[\frac{(1-\tau)\,\overline{\Pi}^j - C^j}{r} - \upsilon C^j\right] \overline{\Pi}^{j^{-\beta_2}},$$

and, therefore, the value of debt is

$$D^j(\Pi) = \begin{cases} \frac{(1-\tau)\overline{\Pi}^j}{r} & \text{after default,} \\ \frac{C^j}{r} + \left[\frac{(1-\tau)\overline{\Pi}^j - C^j}{r} - \upsilon C^j\right]\left(\frac{\Pi}{\overline{\Pi}^j}\right)^{\beta_2} & \text{before default.} \end{cases} \tag{4.11}$$

As shown in (4.11), before default the value of debt consists of two terms. The first one, $\frac{C^j}{r}$, is a perpetual rent which measures the value of debt when the default risk is nil. The second term accounts for any future expected change in profitability caused by default. In particular, the term $\left(\frac{\Pi}{\overline{\Pi}^j}\right)^{\beta_2}$ measures the present value of 1 Euro contingent on the event default. After default, the lender becomes shareholder and the value of his claim is equal to $\frac{(1-\tau)\overline{\Pi}^j}{r}$.

4.3.2 The equity value

Using (4.6) and applying dynamic programming we can write equity as

$$E^j(\Pi) = \begin{cases} 0 & \text{after default,} \\ \begin{array}{l}(1-\tau)\left(\Pi - C^j\right)dt + \\ +e^{-rdt}\xi\left[E^j(\Pi + d\Pi)\right]\end{array} & \text{before default.} \end{cases} \tag{4.12}$$

As can be seen in (4.12), under default the value of equity goes to zero: this is in line with assumption 5. Using (4.12) we obtain the following non-arbitrage condition:

$$rE^j(\Pi) = (1-\tau)\left(\Pi - C^j\right) + \frac{\sigma^2}{2}\Pi^2 E^j_{\Pi\Pi}(\Pi). \tag{4.13}$$

Solving (4.13) gives

$$E^j(\Pi) = \begin{cases} 0 & \text{after default,} \\ (1-\tau)\left(\frac{\Pi - C^j}{r}\right) + \sum_{i=1}^{2} A_i^j \Pi^{\beta_i} & \text{before default.} \end{cases} \tag{4.14}$$

Let us next calculate A_1^j and A_2^j. In the absence of any financial bubbles, A_1^j is nil. To calculate A_2^j, we recall that default occurs when $\Pi = \overline{\Pi}^j$. In this case the value of equity falls to zero, namely

$$E^j\left(\overline{\Pi}^j\right) = 0. \tag{4.15}$$

Substituting (4.14) into (4.15), and solving for A_2^j gives

$$A_2^j = -\frac{(1-\tau)\left(\overline{\Pi}^j - C^j\right)}{r} \cdot \overline{\Pi}^{j^{-\beta_2}},$$

and therefore the pre-default value of equity is equal to

$$E^j(\Pi) = \frac{(1-\tau)\left(\Pi - C^j\right)}{r} - \frac{(1-\tau)\left(\overline{\Pi}^j - C^j\right)}{r}\left(\frac{\Pi}{\overline{\Pi}^j}\right)^{\beta_2}, \tag{4.16}$$

with $j = p, u$. Given (4.16), we can now calculate the default threshold points under protected and unprotected debt financing.

Protected debt

According to definition 1, full debt protection means that the default threshold point $\overline{\Pi}^p$ must be such that the firm's profit is nil, i.e.,

$$\overline{\Pi}^p = C^p. \tag{4.17}$$

Under debt protection it is easy to ascertain that $A_2^p = 0$, and therefore the value of equity reduces to the present value of a perpetual rent:

$$E^p(\Pi) = \frac{(1-\tau)(\Pi - C^p)}{r}. \tag{4.18}$$

Unprotected debt

Let us next calculate the threshold value under unprotected debt financing. Following Leland (1994), $\overline{\Pi}^u$ is obtained by maximizing the value of equity, i.e.,

$$\max_{\overline{\Pi}^u} E^u(\Pi). \tag{4.19}$$

Substituting (4.16) into (4.19) and differentiating gives the following f.o.c.

$$\begin{aligned} \tfrac{\partial E^u(\Pi)}{\partial \overline{\Pi}^u} = -\tfrac{(1-\tau)}{r}\left(\tfrac{\Pi}{\overline{\Pi}^u}\right)^{\beta_2} + \\ +\beta_2 \tfrac{(1-\tau)\left(\overline{\Pi}^u - C^u\right)}{r}\left(\tfrac{\Pi}{\overline{\Pi}^u}\right)^{\beta_2} \overline{\Pi}^{u^{-1}} = 0. \end{aligned} \tag{4.20}$$

Re-arranging (4.20) we obtain

$$\overline{\Pi}^u = \frac{\beta_2}{\beta_2 - 1} C^u. \tag{4.21}$$

Substituting (4.21) into (4.16) gives

$$E^u(\Pi) = \frac{(1-\tau)(\Pi - C^u)}{r} + f^u\left(\overline{\Pi}^u\right), \tag{4.22}$$

where

$$f^u\left(\overline{\Pi}^u\right) \equiv \left(\frac{1}{1-\beta_2}\right)\left[\frac{(1-\tau)C^u}{r}\right]\left(\frac{\Pi}{\overline{\Pi}^u}\right)^{\beta_2}.$$

Let us next compare the trigger points and the equity values under the two alternative default conditions. Using (4.17) and (4.21) it is straightforward to show that $\overline{\Pi}^p$ and $\overline{\Pi}^u$ are proportional to the coupon paid. It is easy to show that, *coeteris paribus* (i.e., given the same coupon), we have $\overline{\Pi}^u < \overline{\Pi}^p$. Under unprotected debt financing, the firm can inject equity in order to meet the firm's debt obligations. This means that, relative to the protected case, the firm postpones default.

As can be seen in (4.18) and (4.22), the pre-default value of equity depends on the perpetual rent $\frac{(1-\tau)\left(\Pi - C^j\right)}{r}$, that measures the static NPV of equity. Under unprotected debt financing we have the additional term $f^u\left(\overline{\Pi}^u\right)$, which measures the value of financial flexibility. Moreover, it is easy to show that $E^u(\Pi) > E^p(\Pi)$. Such a difference is due to the fact that, under unprotected debt financing, the firm is endowed with a put option (i.e., the option to default). This makes equity more valuable.[15]

4.3.3 The optimal coupon

In order to calculate the firm's value we substitute (4.11), (4.18) and (4.22) into (4.7) thereby obtaining the value of the levered firm:

$$V^j(\Pi) = \frac{(1-\tau)\Pi}{r} + \tau\frac{C^j}{r} - (\tau + rv)\frac{C^j}{r}\left(\frac{\Pi}{\overline{\Pi}^j}\right)^{\beta_2}. \tag{4.23}$$

If we compare (4.23) with Modigliani and Miller's (1963) formula (4.3) we can say that $\frac{(1-\tau)\Pi}{r}$ is equivalent to the value of the unlevered firm V_U. As regards debt financing, however, there is a crucial difference: while Modigliani and Miller's (1963) formula only accounts for the tax benefit arising from debt financing, i.e., τD (which is equivalent to $\tau\frac{C^j}{r}$),[16] in (4.23) there is the additional term $(\tau + rv)\frac{C^j}{r}\left(\frac{\Pi}{\overline{\Pi}^j}\right)^{\beta_2}$, that measures the contingent value of default cost.

Using (4.23) we can now find the coupon that maximizes the firm's value function, namely,[17]

$$\max_{C^j} V^j(\Pi). \tag{4.24}$$

Differentiating (4.24) with respect to C^j gives the f.o.c.

$$\frac{\partial V^j(\Pi)}{\partial C^j} = \frac{\tau}{r} - \left(\frac{\tau}{r} + v\right)\left(\frac{\Pi}{\overline{\Pi}^j}\right)^{\beta_2} + \beta_2\left(\frac{\tau}{r} + v\right)\left(\frac{\Pi}{\overline{\Pi}^j}\right)^{\beta_2}\frac{C^j}{\overline{\Pi}^j}\frac{\partial\overline{\Pi}^j}{\partial C^j} = 0, \tag{4.25}$$

[15] Given the inequality $E^u(\Pi) > E^p(\Pi)$ one might wonder why firms also use protected debt. As pointed out by Leland (1994), protected debt may be preferable if agency costs are assumed. In particular this kind of debt might induce shareholders not to increase firm risk at the expense of the lender.

[16] Notice that $\frac{C^j}{r}$ measures the value of default-free debt.

[17] The maximization of the firm's overall value (i.e., equity plus debt) implicitly means that we rule out any agency conflict between shareholders and the lender. As we pointed out, strategic interactions, à la Myers (1977), are not dealt with in this book.

with $\frac{C^j}{\overline{\Pi}^j}\frac{\partial\overline{\Pi}^j}{\partial C^j} = 1$. Re-elaborating (4.25) we have

$$\left(\frac{\Pi}{\overline{\Pi}^j}\right)^{\beta_2} = \frac{1}{1-\beta_2}\frac{\tau}{\tau + r\upsilon}. \tag{4.26}$$

Substituting (4.17) and (4.21) into (4.26) gives the optimal coupon

$$C^j = \left(m^j\right)^{-1}\left(\frac{1}{1-\beta_2}\frac{\tau}{\tau + r\upsilon}\right)^{-\frac{1}{\beta_2}}\Pi, \tag{4.27}$$

with $m^p \equiv 1 > m^u \equiv \frac{\beta_2}{\beta_2 - 1}$.

As shown in (4.27), C^j is proportional to the current EBIT, and is also affected by taxation. Moreover, given $m^p > m^u$, we have $\left(\frac{C^u}{\Pi}\right) > \left(\frac{C^p}{\Pi}\right)$. The reasoning behind this inequality is straightforward: under unprotected debt financing the firm can decide when to default. Thanks to its higher financial flexibility, the firm can choose a higher leverage ratio.

Let us next provide some comparative statics analysis. It is easy to ascertain that $\frac{\partial C^j}{\partial \tau} > 0$, namely the greater the benefit arising from borrowing, i.e., τ, the higher the optimal coupon is. Not surprisingly, therefore, an increase in τ stimulates borrowing. On the other hand, we have $\frac{\partial C^j}{\partial \upsilon} < 0$. This means that an increase in the sunk cost of default (i.e., in υ) reduces the propensity to borrow.[18]

Let us finally analyze the impact of risk on the firm's financial strategy. Given the above results we can write the following:

Proposition 5 *The derivative* $\frac{d\log\left(\frac{C^p}{\Pi}\right)}{d\sigma^2} < 0$ *holds, and, if* υ *is high enough, we also have* $\frac{d\log\left(\frac{C^u}{\Pi}\right)}{d\sigma^2} < 0$.

Proof- See appendix 4.5.1.

The intuition behind proposition 5 is straightforward: an increase in volatility makes the costly event of default more likely and thus discourages debt financing. This result is supported, above all, by empirical evidence based on cross-country comparisons.[19]

[18] More detailed discussions on these results can be found in Leland (1994) and Goldstein, Ju and Leland (2001).

[19] For a survey on this evidence see Graham (2003, 2004).

4.4 Financial strategies and tax avoidance

Financial strategies can help MNCs to alter transfer prices and thus shift income from high- to low-tax jurisdictions. The literature on MNCs has provided interesting evidence on the interactions between financing decisions and tax planning activities. In particular, Hines (1999) and Mills and Newberry (2004), for the US, and Mintz and Smart (2004), for Canada, showed that income can be shifted by means of debt policies, and that the amount of income shifted depends on tax rate differentials. As regards Europe, Mintz and Weichenrieder (2005) analyzed a sample of German-owned subsidiaries and found that a 10% increase in the host country's corporate tax rate causes a 5.6% increase in the debt-assets ratio of wholly-owned manufacturing firms. They also showed that, contrary to the US evidence, tax rate differentials explain intra-group debt but do not affect third-party debt financing.[20]

It is worth pointing out that debt policies are affected not only by tax factors but also by other determinants, such as distress costs and risk. In particular, Desai, Foley and Hines (2004) showed that political risk encourages MNCs to use greater debt, while Fan, Titman and Twite (2003) made a cross-country analysis and showed that business risk discourages debt issues.

So far the literature on tax avoidance by MNCs has mainly focused on financial strategies in a deterministic context, so disregarding default risk and its consequences on financial strategies. In this section we follow Panteghini (2006a) by introducing business, default and policy risk, as well as default costs. We thus obtain a theoretical framework that is in line with the above-mentioned evidence, and that allows us to describe the effects of income shifting on MNCs' financing strategies.

Let us focus on a representative MNC resident in country A, that owns a subsidiary located in country B. Given assumptions 5 and 6 we improve the model of section 4.3 by introducing the following:

[20] Income shifting activities are also dealt with by Mintz (2000), Altshuler and Grubert (2003), Graham and Tucker (2006). Moreover, the reader will find in Hespel and Mignolet (2000) an interesting analysis of financial services companies and their tax-motivated location. Finally, Huizinga, Laeven and Nicodeme (2006) provide interesting evidence on a broad sample of European companies. They find that debt policies are affected by both national tax rates and tax rate differentials.

Assumption 7 *The parent company produces a given amount* Ψ_A *of operating profits in its home country.*

Assumption 8 *The foreign subsidiary's EBIT, denoted as* Π_B*, follows a geometric Brownian motion*

$$\frac{d\Pi_B}{\Pi_B} = \sigma dz_B, \ \ \textit{with}\ \Pi_B\left(0\right) \geq 0. \tag{4.28}$$

Assumption 9 *At time 0, the subsidiary can borrow from a perfectly competitive credit sector, which is characterized by a given risk-free interest rate* r*, and by symmetric information.*

Assumption 10 *The subsidiary pays a non-renegotiable constant coupon for borrowing.*

Assumption 11 *The parent company believes that there is some positive probability* λdt *that the foreign government expropriates its subsidiary during the short interval* dt*.*

These assumptions deserve some comments. Assumption 7 states that the operating profits of the parent company (Ψ_A) are exogenously given, whereas, according to assumption 8, the subsidiary's EBIT is stochastic.[21] These two hypotheses introduce a risk asymmetry, according to which operating in the home country is less risky than operating abroad.[22]

Desai and Foley (2004) have shown that rates of return and investment rates of subsidiaries are highly correlated with the rates of return and investment of the parent and other subsidiaries within the same group. This means that MNCs are an important channel for the transmission of country-specific shocks. In line with their findings, therefore, assumptions 7 and 8 allow us to deal with the effects of foreign business risk on the parent company.

As pointed out in the previous section, assumptions 9 and 10 entail that the MNC sets a coupon and then computes the market value of debt. Given the absence of debt renegotiation, the model is a static one. Moreover, assumption 11 describes the MNC's beliefs on the credibility of future government policy. In particular, it is assumed

[21] Again, with no loss of generality we assume that the drift parameter in (4.28) is nil.

[22] This looks realistic since parent companies are more aware of the characteristics of their own country and thus can more easily predict and offset changes in their domestic business environment.

that the MNC fears that the foreign government may expropriate its subsidiary. Since such an expropriation is a sudden event, we model policy risk as a Poisson process, where λdt is the instantaneous *a priori* probability that expropriation occurs in the short interval dt.[23]

Let us next introduce the default conditions dealt with in section 4.3. Default conditions are fairly important in an international setting. Under protected debt financing, default may be triggered when the MNC's overall profit, net of the after-tax domestic income, is nil. Under unprotected debt financing, instead, default timing is optimally chosen by the parent company. When the subsidiary's net cash flow is negative, the parent company can decide to inject further equity capital in order to meet the subsidiary's debt obligations and delay default. As long as the parent company issues new capital and pays the interest rate it can thus exploit future recoveries in the firm's profitability. These assumptions allow us to analyze the realistic case of a parent company that can decide to convert intra-group debt into equity in order to prevent the subsidiary's default.

According to assumptions 5 and 6, default occurs when the subsidiary's EBIT falls to a threshold level. In the event of default, the lender faces a sunk cost, which is proportional to the coupon paid.

Notice that we make the simplifying assumption that all the external debt is borrowed by the subsidiary. In doing so we emphasize the role played by this foreign subsidiary in tax avoidance practices. In particular, we focus on a trade-off arising from foreign activities: on the one hand, the existence of a subsidiary allows international tax avoidance. On the other hand, debt-financed foreign activities may lead to default costs. International financial strategies are thus the solution of this trade-off problem.[24]

Let us next focus on tax avoidance. Here we make the plausible assumption that income is shifted by means of intra-group debt policies. As we know, in most countries the amount of interest owed to related parties is considered at arm's length, i.e., the transfer price of debt must be in line with interest rates paid to unrelated parties.

[23] The qualitative properties of the model do not change if we assume partial expropriation, that can be caused either by unfavorable law changes or by tighter regulation. If, therefore, we assume that only a percentage $\vartheta \in (0,1)$ is expropriated, then we can rewrite the sudden event of partial expropriation as a Poisson process with a probability $\vartheta\lambda dt < \lambda dt$.

[24] The quality of results does not change if we assume that default also involves the parent company.

However, financial engineering[25] as well as the widespread use of cash pooling devices within MNCs allow them to avoid taxation.[26] The amount of income shifted is equal to the intra-group interest rate differential times the amount of debt. Therefore the higher the MNC's leverage the greater the amount of income shifted is. It is therefore plausible to assume that the amount of income shifted is proportional to the coupon paid. In line with this reasoning we will therefore assume that the MNC can shift a percentage γ_A of the coupon paid by the foreign subsidiary. Therefore we analyze the case, depicted in figure 4.3, where the subsidiary borrows from the capital market and pays a coupon C_B^j where the term $j = p, u$ stands for protected and unprotected, respectively. In turn the parent company can shift γ_A times C_B^j by means of intra-firm debt financing.

It is worth noting that shifting income by means of intra-firm borrowing and lending is costly. The cost of income shifting is due to two main factors: one is related to advising activities and transaction costs and the other is due to anti-avoidance rules. On the one hand, shifting income usually requires the costly advice of tax and financial experts. On the other hand, countries try to prevent tax-avoiding practices by introducing *ad hoc* rules that restrict interest deductions.[27] For this reason we introduce the following:

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[25] On this point see e.g. Desai (2003, 2005). In particular, Desai (2005, p. 172) argues that: "... financial engineering that transforms the nature and timing of receipts, the growing importance of contractual arrangements and the attendant ambiguity over the timing of receipts, and the increased accessibility of offshore tax havens all have contributed to the increasingly discretionary nature of corporate profits. In short, managers have a variety of tools available to them to recharacterize and manufacture profits—through the wedges created by the dual reporting system—that were not available previously".

[26] Cash pooling is a widespread technique which offsets debit and credit balances within a group of firms. In other words firms with excess cash lend to other firms of the same group, needing additional resources. This intra-group cash management not only can optimize the use of excess cash but also allows MNCs to shift income from high-tax to low-tax countries by means of tax-motivated interest rate differentials. Moreover the location of the cash pooler can be affected by taxation as well. In any case, tax authorities can punish these transactions as long as they find evidence of a bias between intra-group interest payments and transfer prices.

[27] In relation to the limitation to the deduction on interest, the following devices can be applied:

1. the tax treatment of thin capitalization, which entails that if the debt/equity ratio exceeds a given threshold, the exceeding interest remuneration is deemed as constructive dividends. In this case the debtor cannot deduct interest paid on loans granted by qualified shareholders and/or related parties;

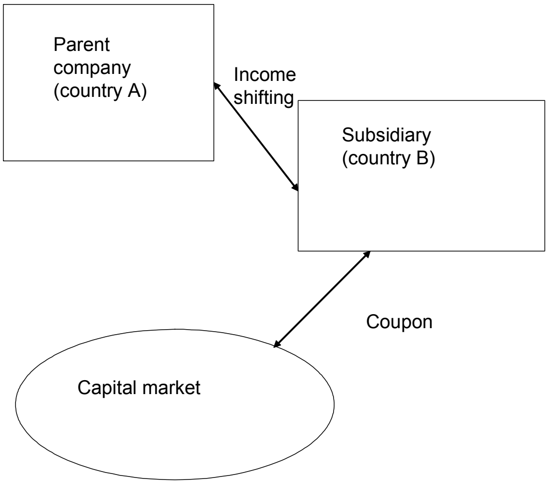

FIGURE 4.3. The relationship between the MNC and capital market

Assumption 12 *Income shifting entails a cost* $\nu(\gamma_A, n)$ *which is convex in* γ_A *and is positively related to the parameter* $n \geq 0$, *that measures how costly it is for the MNC to shift income from one country to the other.*

With assumption 12, the convexity in γ_A allows us to find an internal solution. Moreover parameter n allows us to deal with both institutional determinants and tax and financial advising activities. On the one hand, indeed, the introduction of thin capitalization and

2. the re-characterization of interest as non-deductible expenses, according to which interest is re-characterized as non-deductible expenses in so far as the underlying financial source meets crucial requirements of equity rather than of debt;
3. the "arm's length" approach, which entails the non-deductibility of interests paid between affiliated companies that is in excess of what would be paid between unconnected parties dealing at arm's length;
4. the assets dilution ratio, according to which certain expenses related to acquisition of participations generating non-taxable income (capital gains or dividend) are non-deductible for the acquiring company, either by way of a ratio between taxable and non-taxable income or by a ratio between financial and non-financial assets.

For a discussion on the application of these devices in the EU see Garbarino and Panteghini (2007).

Controlled-Foreign-Company devices, aiming to prevent tax avoiding activities, raises n and, hence, the costs of income shifting. On the other hand, the decrease in the cost of tax sheltering operations, which is linked to the degradation of book and tax profits, leads to a decrease in n.

In line with Panteghini and Schjelderup (2006) we also assume that the cost of income shifting is non-deductible.[28]

For simplicity we assume that the corporate tax system is fully symmetric and follows the Source Principle.[29] Defining τ_A and τ_B as the tax rate of country A and B, respectively, we can write the overall profit function of the MNC as

$$\begin{aligned} \Pi_A^N(\Pi_B) = (1-\tau_A)\left(\Psi_A - \gamma_A C_B^j\right) + \\ + (1-\tau_B)\left(\Pi_B - C_B^j + \gamma_A C_B^j\right) - \nu(\gamma_A, n)\, C_B^j. \end{aligned} \tag{4.29}$$

According to Desai and Foley's (2004) empirical findings, therefore, the profit function (4.29) allows us to describe the transmission of the country B's specific shock described in (4.28).

4.4.1 Optimal income shifting

Given this model we can study the MNC's income shifting strategy. Its problem is one of choosing

$$\phi(\gamma_A^*, n) \equiv \max_{\gamma_A}\left[(\tau_A - \tau_B)\gamma_A - \nu(\gamma_A, n)\right], \tag{4.30}$$

namely the optimal percentage of γ_A^*, which equates at the margin the tax saving from income shifting to its cost.[30] Substituting (4.30) into (4.29) and re-arranging gives the MNC's overall after-tax cash flow

$$\Pi_A^N(\Pi_B) = (1-\tau_A)\Psi_A + (1-\tau_B)\Pi_B - (1-\widetilde{\tau})\, C_B^j,$$

[28] The quality of results would not change if we assumed partial or full deductibility of such costs. For further details on this point see also Haufler and Schjelderup (1999, 2000).

[29] Notice that the existence of deferral possibilities and limited credit rules leads to the application of the Source Principle (see e.g. Keen, 1993).

[30] Given (4.30), it is easy to show that $\frac{\partial \phi(\gamma_A^*, n)}{\partial n} < 0$. Namely an increase in n reduces the tax avoidance benefit. See also chapter 5, where we will assume that the function $\phi(\gamma_A, n)$ is quadratic.

where

$$\widetilde{\tau} \equiv \tau_B + \phi\left(\gamma_A^*, n\right)$$

is the effective tax benefit arising from the deduction of the coupon. As can be seen, $\widetilde{\tau}$ accounts for the net benefit of income shifting. Since the tax benefit $\widetilde{\tau}$ depends on income reporting strategies, i.e., on $\phi\left(\gamma_A^*, n\right)$, it follows that, whenever tax avoidance is allowed, we have $\widetilde{\tau} > \tau_B$. This means that the greater the benefit arising from borrowing, i.e., $\widetilde{\tau}$, the higher the optimal coupon is. Not surprisingly, therefore, an increase in $\widetilde{\tau}$ stimulates borrowing.

4.4.2 The optimal capital structure

Let us next focus on the MNC's financial policy. To find its optimal strategy we must first calculate its value function:

$$V_A^j\left(\Pi_B\right) = D_A^j\left(\Pi_B\right) + E_A^j\left(\Pi_B\right), \text{ with } j = p, u, \tag{4.31}$$

where $D_A^j\left(\Pi_B\right)$ and $E_A^j\left(\Pi_B\right)$ are the value of debt and equity, respectively.

Let us first calculate the value of debt, under the assumption that before default the lender is tax exempt.[31] When, in the event of default, the lender becomes shareholder, however, it is subject to the source-based tax levied on the subsidiary.

Given the default threshold point $\overline{\Pi}_B^j$ and the default cost υC_B^j, we can calculate the value of debt (see appendix 4.5.2):

$$D_A^j\left(\Pi_B\right) = \begin{cases} \frac{(1-\tau_B)\overline{\Pi}_B^j}{r+\lambda} & \text{after default,} \\ \frac{C_B^j}{r+\lambda} + \left[\frac{(1-\tau_B)\overline{\Pi}_B^j}{r+\lambda} - \right. & \\ \left. - \frac{C_B^j}{r+\lambda} + \upsilon C_B^j\right]\left(\frac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2(\lambda)} & \text{before default,} \end{cases} \tag{4.32}$$

where $\beta_2\left(\lambda\right) = \frac{1}{2} - \sqrt{\left(\frac{1}{2}\right)^2 + \frac{2(r+\lambda)}{\sigma^2}} < 0$. As shown in (4.32), the risk of expropriation is embodied in the discount factor. In other words, the lender's claim is regarded as an infinitely-lived one; however, the relevant discount rate is raised from r to $(r + \lambda)$.

[31] As pointed out in section 4.3 effective capital income taxes are fairly low.

Before default, $D_A^j(\Pi_B)$ consists of two terms. The first one, $\frac{C_B^j}{r+\lambda}$, is a perpetual rent calculated with the increased discount rate $(r+\lambda)$. The second term accounts for any future expected change in profitability caused by default. As explained in section 4.3, the term $\left(\frac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2(\lambda)}$ measures the present value of 1 Euro contingent on the event of default. After default, the lender becomes shareholder and the value of his claim is

$$\frac{(1-\tau_B)\,\overline{\Pi}_B^j}{r+\lambda}, \text{ with } j = p, u.$$

Let us next calculate the value of equity. We must consider that when default occurs the parent company loses its subsidiary and receives a net operating profit equal to $(1-\tau_A)\,\Psi_A$, namely it operates as a domestic firm. Thus the value of equity is simply equal to a perpetual rent $\frac{(1-\tau_A)\Psi_A}{r}$.[32] Before default, the MNC must account for the risk of expropriation of its subsidiary. As shown in appendix 4.5.3, therefore, we have:

$$E_A^j(\Pi_B) = \begin{cases} \frac{(1-\tau_A)\Psi_A}{r} & \text{after default,} \\ \frac{(1-\tau_A)\Psi_A}{r} + \\ + \frac{(1-\tau_B)\Pi_B - (1-\widetilde{\tau})C_B^j}{r+\lambda} + f^j\left(\overline{\Pi}_B^j\right) & \text{before default,} \end{cases} \tag{4.33}$$

where

$$f^p\left(\overline{\Pi}_B^p\right) = 0,$$

$$f^u\left(\overline{\Pi}_B^u\right) \equiv \left(\frac{1}{1-\beta_2}\right)\left[\frac{(1-\widetilde{\tau})C_B^u}{r+\lambda}\right]\left(\frac{\Pi_B}{\overline{\Pi}_B^u}\right)^{\beta_2(\lambda)}.$$

The term $\frac{(1-\tau_B)\Pi_B-(1-\widetilde{\tau})C_B^j}{r+\lambda}$ measures the net benefit arising from the ownership of the subsidiary. As can be seen, this term is equal to the present value of the net cash flow with discount rate $(r+\lambda)$. The term $f^u\left(\overline{\Pi}_B^u\right)$ measures the MNC's option to inject equity (or

[32] Notice that the perpetual rent $\frac{(1-\tau_A)\Psi_A}{r}$ is obtained by using r as the relevant discount rate. This implies that the MNC assumes that the risk of expropriation in its home country is null.

equivalently, to convert intra-debt into equity) and thus delay default.

We can now calculate the default threshold points under protected and unprotected debt financing. According to definition 1, protected debt financing means that the default threshold point $\overline{\Pi}_B^p$ is such that the MNC's overall profit, net of the domestic cash flow, is nil, namely it is such that the following equality

$$\Pi_A^N\left(\overline{\Pi}_B^p\right) = (1-\tau_A)\,\Psi_A + (1-\tau_B)\,\overline{\Pi}_B^p - (1-\widetilde{\tau})\,C_B^p = (1-\tau_A)\,\Psi_A$$

holds. Solving for $\overline{\Pi}_B^p$ we therefore have

$$\overline{\Pi}_B^p \equiv \frac{(1-\widetilde{\tau})}{(1-\tau_B)}C_B^p. \tag{4.34}$$

Let us next calculate the threshold value $\overline{\Pi}_B^u$, which is obtained by solving the following problem:

$$\max_{\overline{\Pi}_B^u} E_A^u\left(\Pi_B\right). \tag{4.35}$$

Substituting (4.33) into (4.35) we can find the MNC's default trigger point (see appendix 4.5.3)

$$\overline{\Pi}_B^u = \frac{\beta_2\left(\lambda\right)}{\beta_2\left(\lambda\right)-1}\frac{(1-\widetilde{\tau})}{(1-\tau_B)}C_B^u. \tag{4.36}$$

Given (4.34) and (4.36) we next analyze the effects of tax avoidance on default. We can see that, whenever $\widetilde{\tau} > \tau_B$, namely tax avoidance is exploited, the inequality $\frac{1-\widetilde{\tau}}{1-\tau_B} < 1$ holds. Therefore, we can write the following:

Proposition 6 *Tax avoidance leads to a postponement of default.*

The reasoning behind proposition 6 is straightforward: tax savings due to tax avoidance raise the MNC's profitability. *Coeteris paribus*, therefore, the EBIT that triggers default is lower under tax avoidance. This induces a delay in default.

Let us next calculate the optimal coupon. Substituting (4.32) and (4.33) into (4.31) we obtain the overall value of the MNC

$$\begin{aligned} V_A^j\left(\Pi_B\right) = \tfrac{(1-\tau_A)\Psi_A}{r} + \tfrac{(1-\tau_B)\Pi_B + \widetilde{\tau}C_B^j}{r+\lambda} - \\ -\left(\tfrac{\widetilde{\tau}}{r+\lambda} + \upsilon\right)C_B^j\left(\tfrac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2(\lambda)}. \end{aligned} \tag{4.37}$$

Using (4.37) we can next find the optimal coupon by solving the following problem:

$$\max_{C_B^j} V_A^j (\Pi_B) . \tag{4.38}$$

As shown in appendix 4.5.4 we obtain

$$\frac{C_B^j}{\Pi_B} = \left(m^j (\lambda)\right)^{-1} \frac{1-\tau_B}{1-\widetilde{\tau}} \left[\frac{1}{1-\beta_2(\lambda)} \frac{\widetilde{\tau}}{\widetilde{\tau}+(r+\lambda)\upsilon}\right]^{-\frac{1}{\beta_2(\lambda)}}, \tag{4.39}$$

with

$$m^p(\lambda) \equiv 1 > m^u(\lambda) \equiv \frac{\beta_2(\lambda)}{\beta_2(\lambda)-1}.$$

Using (4.39), we can show that $\left(\frac{C_B^u}{\Pi_B}\right) > \left(\frac{C_B^p}{\Pi_B}\right)$. The explanation for this result is straightforward: under unprotected debt financing the MNC can decide when to default. Therefore, its higher flexibility allows it to raise leverage.

Let us next analyze the effects of risk on the MNC's debt strategy. We can write the following:

Proposition 7 *If υ is high enough, we have $\frac{d\log\left(\frac{C_B^p}{\Pi_B}\right)}{d\lambda} > 0$ for $j = p, u$.*

Proof- See appendix 4.5.5.

According to proposition 7, if the cost of default is high enough, an increase in λ rises $\left(\frac{C_B^j}{\Pi_B}\right)$. This is due to the fact that a rise in λ increases the relevant discount rate $(r+\lambda)$. Thus the present value of 1 Euro contingent on the event of default is reduced. The decrease in the expected cost of default induces the MNC to borrow more resources (or equivalently, to pay a higher coupon).

Proposition 7 provides a rationale for the positive effect of policy risk on debt financing, found by Desai, Foley and Hines (2004). It is worth noting that there are other possible (not necessarily conflicting) explanations for the positive effect of policy risk on the subsidiaries' leverage. For instance, Brealey and Myers (2001) argue that debt can be used as a threat against governments aiming to expropriate. In their recommendation to readers who want to set up a mine in the Republic of Costaguana they maintain (p. 810): "No contract can restrain sovereign power. But you can arrange project financing to make these acts as painful as possible for the foreign government. For example, you might set up the mine as a subsidiary corporation, which then borrows a large fraction of the required investment from a consortium of major international banks. If your firm guarantees the loan, make sure the guarantee stands only if the Costaguanan governments honors its contract. The government will be reluctant to break the contract if that causes a default on the loans and undercuts the country's credit standing with the international banking system".

Let us finally analyze the impact of income shifting on the capital structure. We can prove the following:

Proposition 8 *If* $\tau_A \neq \tau_B$ *a decrease in* n *raises the optimal coupon* C_B^j.

Proof- See appendix 4.5.6.

As shown by proposition 8, a decrease in n, namely a reduction in the cost of income shifting, caused either by less strict anti-avoidance rules or by less expensive techniques, raises the net benefit $\phi(\gamma_A^*, n)$. The increase in the tax benefit of debt financing, i.e., in $\widetilde{\tau}$, thus stimulates the MNC to pay a higher coupon in order to rise its leverage.

4.5 Appendix

4.5.1 Proof of proposition 5

Taking the log of (4.27) and differentiating with respect to σ^2 we obtain

$$\frac{d\log\left(\frac{C^j}{\Pi}\right)}{d\sigma^2} = \frac{\partial\log\left(\frac{C^j}{\Pi}\right)}{\partial\beta_2} \cdot \frac{\partial\beta_2}{\partial\sigma^2},$$

where

$$\frac{\partial\log\left(\frac{C^j}{\Pi}\right)}{\partial\beta_2} = \underbrace{\left(-\frac{1}{m^j}\frac{\partial m^j}{\partial\beta_2}\right)}_{\geq 0} + \tag{4.40}$$
$$+\underbrace{\left\{\frac{1}{\beta_2^2}\left[-\log(1-\beta_2) + \frac{\beta_2}{\beta_2 - 1}\right]\right\}}_{<0} + \underbrace{\frac{1}{\beta_2^2}\log\left[\frac{\tau}{\tau + rv}\right]}_{<0},$$

with $\frac{\partial \beta_2}{\partial \sigma^2} > 0$, and $\frac{\partial m^u}{\partial \beta_2} < \frac{\partial m^p}{\partial \beta_2} = 0$. Given (4.40) we have

$$\frac{\partial \log\left(\frac{C^p}{\Pi}\right)}{\partial \beta_2} < 0.$$

Moreover, if υ is high enough, we also have $\frac{\partial \log\left(\frac{C^u}{\Pi}\right)}{\partial \beta_2} < 0$. This is sufficient to say that if υ is high enough, we have:

$$\frac{d \log\left(\frac{C^j}{\Pi}\right)}{d\sigma^2} < 0 \text{ for } j = p, u.$$

This proves proposition 5.■

4.5.2 Derivation of (4.32)

Using dynamic programming, debt can be written as

$$D_A^j(\Pi_B) = \begin{cases} (1-\tau_B)\,\Pi_B dt + (1-\lambda dt)\cdot \\ \cdot e^{-rdt}\xi\left[D_A^j(\Pi_B + d\Pi_B)\right] & \text{after default,} \\ \\ C_B^j dt + (1-\lambda dt)\cdot \\ \cdot e^{-rdt}\xi\left[D_A^j(\Pi_B + d\Pi_B)\right] & \text{before default.} \end{cases} \tag{4.41}$$

Function (4.41) can be rewritten as

$$D_A^j(\Pi_B) = \begin{cases} (1-\tau_B)\,\Pi_B dt + \\ +(1-\lambda dt)(1-rdt)\cdot & \text{after default,} \\ \cdot\xi\left[D_A^j(\Pi_B + d\Pi_B)\right] \\ \\ C_B^j dt + \\ +(1-\lambda dt)(1-rdt)\cdot & \text{before default.} \\ \cdot\xi\left[D_A^j(\Pi_B + d\Pi_B)\right] \end{cases} \tag{4.42}$$

Applying Itô's Lemma to (4.42), one obtains

$$(r+\lambda)\, r D_A^j(\Pi_B) = L + \frac{\sigma^2}{2}\Pi_B^2 D^j_{A_{\Pi_B \Pi_B}}(\Pi_B), \tag{4.43}$$

where $L = (1-\tau_B)\Pi_B, C_B^j$, and $D^j_{A_{\Pi_B \Pi_B}}(\Pi_B) \equiv \frac{\partial^2 D_A^j(\Pi_B)}{\partial \Pi_B^2}$. The general closed-form solution of function (4.43) is

$$D_A^j(\Pi_B) = \begin{cases} \frac{(1-\tau_B)\overline{\Pi}_B^j}{r+\lambda} + \sum_{i=1}^2 B_i^j \Pi_B^{\beta_i(\lambda)} & \text{after default,} \\ \frac{C_B^j}{r+\lambda} + \sum_{i=1}^2 D_i^j \Pi_B^{\beta_i(\lambda)} & \text{before default,} \end{cases} \tag{4.44}$$

where

$$\beta_1(\lambda) = \frac{1}{2} + \sqrt{\left(\frac{1}{2}\right)^2 + \frac{2(r+\lambda)}{\sigma^2}} > 1,$$

and

$$\beta_2(\lambda) = \frac{1}{2} - \sqrt{\left(\frac{1}{2}\right)^2 + \frac{2(r+\lambda)}{\sigma^2}} < 0$$

are the two roots of the characteristic equation

$$\Psi(\beta) \equiv \frac{\sigma^2}{2}\beta(\beta-1) - (r+\lambda) = 0.$$

Following the procedure of section 4.3 we calculate B_i^j and D_i^j for $i = 1, 2$, by introducing the well-known boundary conditions. Firstly, whenever Π_B goes to zero the lender's claim is nil, and we have $D_A^j(0) = 0$: this implies that $B_2^j = 0$. Secondly, the absence of financial bubbles implies that $B_1^j = D_1^j = 0$. Thirdly, at point $\Pi_B = \overline{\Pi}_B^j$, the pre-default value of debt must be equal to the post-default one, net of the default cost. Using the two branches of (4.44) we thus obtain

$$\frac{(1-\tau_B)\overline{\Pi}_B^j}{r+\lambda} - \upsilon C_B^j = \frac{C_B^j}{r+\lambda} + D_2^j \overline{\Pi}_B^{j\,\beta_2(\lambda)}.$$

Solving for D_2^j gives

$$D_2^j = \left[\frac{(1-\tau_B)\overline{\Pi}_B^j - C_B^j}{r+\lambda} - \upsilon C_B^j\right] \overline{\Pi}_B^{j\,-\beta_2(\lambda)}.$$

Given the above results we obtain (4.32).

4.5.3 Derivation of (4.33) and (4.36)

To derive the value of equity we must remember that default causes the expropriation of the subsidiary. This means that, whenever we have $\Pi_B = \overline{\Pi}_B^j$, the value of equity reduces to

$$E_A^j\left(\overline{\Pi}_B^j\right) = \frac{(1-\tau_A)\,\Psi_A}{r}, \tag{4.45}$$

that is the fair market value of the parent company when operating as a domestic firm.

Applying dynamic programming we next write the added value arising from the ownership of a foreign subsidiary. Given the additional after-tax cash flow due to holding the subsidiary, namely

$$\left[\Pi_A^N(\Pi_B) - (1-\tau_A)\,\Psi_A\right],$$

the added value is equal to

$$S_A^j(\Pi_B) = \begin{cases} 0 & \text{after default,} \\ \left[\Pi_A^N(\Pi_B) - (1-\tau_A)\,\Psi_A\right]dt + \\ +(1-\lambda dt)\,e^{-rdt}\xi\left[S_A^j(\Pi_B + d\Pi_B)\right] & \text{before default.} \end{cases} \tag{4.46}$$

As can be seen, (4.46) embodies the net benefit arising from income shifting, and accounts for the risk of expropriation (i.e., the MNC's fear that the foreign government expropriates its subsidiary). Using Itô's Lemma, eliminating all the terms multiplied by $(dt)^2$ and dividing by dt, we can rewrite the pre-default value of (4.46) as

$$\begin{aligned}(r+\lambda)\,S_A^j(\Pi_B) &= \\ = \left[(1-\tau_B)\,\Pi_B - (1-\widetilde{\tau})\,C_B^j\right] &+ \tfrac{\sigma^2}{2}\Pi_B^2 S_{A_{\Pi_B\Pi_B}}^j(\Pi_B),\end{aligned} \tag{4.47}$$

where $S_{A_{\Pi_B\Pi_B}}^j(\Pi_B) \equiv \frac{\partial^2 S_A^j(\Pi_B)}{\partial \Pi_B^2}$. Solving (4.47) we have

$$S_A^j(\Pi_B) = \begin{cases} 0 & \text{after default,} \\ \frac{(1-\tau_B)\Pi_B - (1-\widetilde{\tau})C_B^j}{r+\lambda} + \sum_{i=1}^2 A_i^j \Pi_B^{\beta_i(\lambda)} & \text{before default.} \end{cases} \tag{4.48}$$

Let us next calculate A_i^j with $i = 1, 2$. In the absence of financial bubbles, we have $A_1^j = 0$ for $j = p, u$. Moreover to calculate A_2^j we let the two branches of (4.48) meet at point $\Pi_B = \overline{\Pi}_B^j$ thereby obtaining

$$S_A^j\left(\overline{\Pi}_B^j\right) = \frac{(1-\tau_B)\,\overline{\Pi}_B^j - (1-\widetilde{\tau})\,C_B^j}{r+\lambda} + A_2^j \overline{\Pi}_B^{j^{\beta_2(\lambda)}} = 0.$$

Solving for A_2^j gives

$$A_2^j = -\frac{(1-\tau_B)\,\overline{\Pi}_B^j - (1-\widetilde{\tau})\,C_B^j}{r} \cdot \overline{\Pi}_B^{j^{-\beta_2(\lambda)}}.$$

The pre-default value of equity is thus equal to

$$\begin{aligned} E_A^j(\Pi_B) &= \tfrac{(1-\tau_A)\Psi_A}{r} + S_A^j(\Pi_B) = \\ &= \tfrac{(1-\tau_A)\Psi_A}{r} + \tfrac{(1-\tau_B)\Pi_B - (1-\widetilde{\tau})C_B^j}{r+\lambda} - \\ &- \left[\tfrac{(1-\tau_B)\overline{\Pi}_B^j - (1-\widetilde{\tau})C_B^j}{r+\lambda}\right]\left(\tfrac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2(\lambda)}, \end{aligned} \tag{4.49}$$

with $j = p, u$.

Equity value under protected debt

Recall that under full debt protection, we have

$$\overline{\Pi}_B^p = \frac{1-\widetilde{\tau}}{1-\tau_B} C_B^p.$$

In this case we have therefore $A_2^p = 0$, and the value of equity reduces to

$$E_A^p(\Pi_B) = \frac{(1-\tau_A)\,\Psi_A}{r} + \frac{(1-\tau_B)\,\Pi_B - (1-\widetilde{\tau})\,C_B^p}{r+\lambda}. \tag{4.50}$$

Equity value under unprotected debt

Under unprotected debt, the MNC must solve (4.35). Using (4.49) one obtains the following f.o.c.

$$\begin{aligned} \tfrac{\partial E_A^u(\Pi_B)}{\partial \overline{\Pi}_B^u} &= -\tfrac{(1-\tau_B)}{r+\lambda}\left(\tfrac{\Pi_B}{\overline{\Pi}_B^u}\right)^{\beta_2(\lambda)} + \\ &\quad + \beta_2(\lambda)\left(\tfrac{(1-\tau_B)\overline{\Pi}_B^u - (1-\widetilde{\tau})C_B^u}{r+\lambda}\right)\left(\tfrac{\Pi_B}{\overline{\Pi}_B^u}\right)^{\beta_2(\lambda)} \overline{\Pi}_B^{u^{-1}} = 0. \end{aligned}$$

Solving for $\overline{\Pi}_B^u$ thus gives (4.36), i.e.,

$$\overline{\Pi}_B^u = \frac{\beta_2(\lambda)}{\beta_2(\lambda)-1}\frac{(1-\widetilde{\tau})}{(1-\tau_B)}C_B^u.$$

Substituting (4.36) into (4.49) gives

$$\begin{aligned} E_A^u(\Pi_B) &= \tfrac{(1-\tau_A)\Psi_A}{r} + \tfrac{(1-\tau_B)\Pi_B-(1-\widetilde{\tau})C_B^u}{r+\lambda} + \\ &+ \tfrac{1}{1-\beta_2(\lambda)}\left[\tfrac{(1-\widetilde{\tau})C_B^u}{r+\lambda}\right]\left(\tfrac{\Pi_B}{\overline{\Pi}_B^u}\right)^{\beta_2(\lambda)}. \end{aligned} \tag{4.51}$$

Finally, using (4.50) and (4.51) we obtain (4.33).

4.5.4 The optimal coupon (4.39)

Let us solve problem (4.38). Using (4.37) and differentiating with respect to C_B^j, one easily obtains the f.o.c.

$$\begin{aligned} \tfrac{\partial V_A^j(\Pi_B)}{\partial C_B^j} &= \tfrac{\widetilde{\tau}}{r+\lambda} - \left(\tfrac{\widetilde{\tau}}{r+\lambda}+\upsilon\right)\left(\tfrac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2(\lambda)} + \\ &+\beta_2(\lambda)\left(\tfrac{\widetilde{\tau}}{r+\lambda}+\upsilon\right)\left(\tfrac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2(\lambda)}\tfrac{C_B^j}{\overline{\Pi}_B^j}\tfrac{\partial\overline{\Pi}_B^j}{\partial C_B^j} = 0, \end{aligned} \tag{4.52}$$

with $\frac{C_B^j}{\overline{\Pi}_B^j}\frac{\partial\overline{\Pi}_B^j}{\partial C_B^j} = 1$. Re-arranging (4.52) one obtains

$$\left(\frac{\Pi_B}{\overline{\Pi}_B^j}\right)^{\beta_2(\lambda)} = \frac{1}{1-\beta_2(\lambda)}\frac{\widetilde{\tau}}{\widetilde{\tau}+(r+\lambda)\upsilon}. \tag{4.53}$$

Substituting (4.34) and (4.36) into (4.53), and re-elaborating gives (4.39).

4.5.5 Proof of proposition 7

Taking the log of (4.39) and differentiating with respect λ we obtain

$$\frac{d\log\left(\frac{C_B^j}{\Pi_B}\right)}{d\lambda} = \frac{\partial\log\left(\frac{C_B^j}{\Pi_B}\right)}{\partial\beta_2(\lambda)}\cdot\frac{\partial\beta_2(\lambda)}{\partial\lambda} + \underbrace{\frac{1}{\beta_2(\lambda)}\frac{\upsilon}{\widetilde{\tau}+(r+\lambda)\upsilon}}_{<0},$$

where

$$\begin{aligned}\frac{\partial \log\left(\frac{C_B^j}{\Pi_B}\right)}{\partial \beta_2(\lambda)} &= \underbrace{\left(-\frac{1}{m^j(\lambda)}\frac{\partial m^j(\lambda)}{\partial \beta_2(\lambda)}\right)}_{\geq 0}+ \\ &+\underbrace{\left\{\frac{1}{\beta_2^2(\lambda)}\left[-\log\left(1-\beta_2(\lambda)\right)+\frac{\beta_2(\lambda)}{\beta_2(\lambda)-1}\right]\right\}}_{<0}+ \\ &+\underbrace{\frac{1}{\beta_2^2(\lambda)}\log\left[\frac{\widetilde{\tau}}{\widetilde{\tau}+(r+\lambda)\upsilon}\right]}_{<0},\end{aligned} \tag{4.54}$$

with $\frac{\partial \beta_2(\lambda)}{\partial \lambda}<0$, and $\frac{\partial m^u(\lambda)}{\partial \beta_2(\lambda)}<\frac{\partial m^p(\lambda)}{\partial \beta_2(\lambda)}=0$. Given (4.54) we have

$$\frac{\partial \log\left(\frac{C_B^p}{\Pi_B}\right)}{\partial \beta_2(\lambda)}<0,$$

and, if υ is high enough,

$$\frac{\partial \log\left(\frac{C_B^u}{\Pi_B}\right)}{\partial \beta_2(\lambda)}<0.$$

Since

$$\lim_{\upsilon\to+\infty}\frac{\partial \log\left(\frac{C_B^j}{\Pi_B}\right)}{\partial \beta_2(\lambda)}\frac{\partial \beta_2(\lambda)}{\partial \lambda}=+\infty$$

we can say that $\frac{d\log\left(\frac{C_B^j}{\Pi_B}\right)}{d\lambda}>0$ if the default cost is high enough. This concludes the proof of proposition 7.■

4.5.6 Proof of proposition 8

Take the log of (4.39):

$$\begin{aligned}\log\left(\frac{C_B^j}{\Pi_B}\right) &= -\log m^j(\lambda)+\log\left(1-\tau_B\right)-\log\left(1-\widetilde{\tau}\right)- \\ &-\tfrac{1}{\beta_2(\lambda)}\log\tfrac{1}{1-\beta_2(\lambda)}-\tfrac{1}{\beta_2(\lambda)}\log\left[\tfrac{\widetilde{\tau}}{\widetilde{\tau}+(r+\lambda)\upsilon}\right].\end{aligned} \tag{4.55}$$

Differentiating (4.55) with respect to $\widetilde{\tau}$ gives

$$\frac{\partial \log\left(\frac{C_B^j}{\Pi_B}\right)}{\partial \widetilde{\tau}} = \frac{1}{1-\widetilde{\tau}} - \frac{1}{\beta_2\left(\lambda\right)} \frac{\left(r+\lambda\right)\upsilon}{\left[\widetilde{\tau}+\left(r+\lambda\right)\upsilon\right]\widetilde{\tau}} > 0.$$

Given

$$\frac{\partial \widetilde{\tau}}{\partial \phi\left(\gamma_A^*, n\right)} = 1,$$

and, according to assumption 12,[33]

$$\frac{d\phi\left(\gamma_A^*, n\right)}{dn} < 0,$$

we thus have

$$\underbrace{\frac{\partial \log\left(\frac{C_B^u}{\Pi_B}\right)}{\partial \widetilde{\tau}} \frac{\partial \widetilde{\tau}}{\partial \phi\left(\gamma_A^*, n\right)}}_{>0} \cdot \frac{d\phi\left(\gamma_A^*, n\right)}{dn} < 0.$$

Proposition 8 is thus proven.■

[33] Differentiating $\phi\left(\gamma_A^*, n\right)$ with respect to n gives:

$$\frac{d\phi\left(\gamma_A^*, n\right)}{dn} = \frac{\partial \phi\left(\gamma_A^*, n\right)}{\partial \gamma_A^*} \frac{\partial \gamma_A^*}{\partial n} + \frac{\partial \phi\left(\gamma_A^*, n\right)}{\partial n}.$$

Applying the Envelope Theorem we have:

$$\frac{d\phi\left(\gamma_A^*, n\right)}{dn} = \frac{\partial \phi\left(\gamma_A^*, n\right)}{\partial n} = -\frac{\partial \nu\left(\gamma_A^*, n\right)}{\partial n} < 0.$$

5

Foreign Direct Investment and tax avoidance

Foreign Direct Investment (FDI) is at least partially sunk. Moreover, imperfect information concerning market conditions, national rules and regulations means that there is uncertainty related to the true cost of FDI and its payoff. Finally, managers are aware that investment presents opportunities and is not an obligation. Thus, they behave as if they owned option-rights thereby computing the optimal investment (exercise) timing. The fact that FDI is often characterized by irreversibility, uncertainty, and the ability to choose its optimal timing makes the real-option approach quite suitable for its analysis.[1]

In this chapter we first show how transfer pricing affects the timing of investment decisions. Moreover, we apply the real-option approach to the study of international competition between small open countries to attract investments.

In the second part of the chapter we deal with the "capital levy problem", which arises when the governments have the urge to tax

[1] The literature on management science is also aware of the importance of real-option techniques in international business. As argued by Rugman and Li (2002) in their edited book, real options "will make existing theories in international business ... dynamic and more realistic" (p. ix).

irreversible investment and firms are aware of possible tax commitment failures.

5.1 FDI activities and tax competition

In this section we use the two-period model developed by Panteghini and Schjelderup (2006) to study the effects of tax avoidance on FDI strategies.[2] We then apply this model to analyze international tax competition to attract FDI.[3]

5.1.1 FDI and tax avoidance

Let us focus on a firm that is initially located only in country A, and assume that:

Assumption 13 *The firm produces a constant after-tax profit equal to* $(1-\tau_A)\,\Pi_A$*, where* τ_A *is the statutory tax rate and* Π_A *is gross profits.*

Assumption 14 *The firm has an option to expand production in country B: in this case, it must pay a non-deductible sunk cost I.*

Assumption 15 *Investing abroad is risky. Let* $(1+x)\Pi_B$ *be gross profits in country B. At time 0, x is zero. At time 1, however, it will change: with probability q, it will be* $x=u$ *and with probability* $(1-q)$ *it will be* $x=-d$*, where parameters* $u>0$ *and* $d>0$ *measure the upward and downward profit jump, respectively.*

Assumption 16 *The shock x is mean-preserving, i.e.,*

$$q(1+u)+(1-q)\,(1-d)=1. \tag{5.1}$$

Assumption 17 *At time 1, uncertainty vanishes and foreign gross profits will remain at the new level forever.*

In line with the model discussed in section 4.4, assumptions 13 and 14 allow us to describe a realistic setup where operating in the home

[2] Using a similar approach, in Panteghini (2000) we analyzed the effects of tax evasion on a domestic firm's investment strategies.

[3] The tax competition literature is reviewed by, among others, Wilson (1999), and Wilson and Wildasin (2004). For a survey on MNCs' taxation see also Gresik (2001).

country is less costly than investing abroad. This asymmetry is due to the firm's familiarity with the legal and cultural factors in the domestic economy. According to assumption 14 the representative firm can decide whether to invest I immediately (thereby exercising its option to expand) or wait until new information on the state of the world has been gathered. Given this assumption, FDI is mobile *ex ante* and immobile *ex post*. Moreover, assumption 14 entails that I is non-deductible.

According to assumption 15, FDI may yield either profits or losses. With assumption 16 we let any change in one parameter be offset by changes in the other parameters. This implies that any change in volatility does not affect the expected value, which remains equal to the firm's payoff earned at time 0.

In line with the two-period model introduced in chapter 1, we assume that the second period lasts to infinity (assumption 17). Of course, the quality of results would not change if we assumed a finitely-lived project: what matters is the relative weight of the two periods (namely the relevant discount factor) rather than their length.

As we pointed out, a firm can shift profits to low-tax countries by transfer pricing. Given this assumption we can thus say that the attractiveness of FDI is driven by the ease by which a firm can shift profits to low-tax countries, thereby raising its after-tax profitability. According to chapter 4, we denote the percentage of profits shifted by $\gamma_A \lesseqgtr 0$, and assume that it is costly to shift income for tax saving purposes. With no loss of generality, we also assume that the concealment cost function (already discussed in chapter 4) is quadratic in γ_A, i.e.,

$$\nu\left(\gamma_A, n\right) = \frac{n}{2}\gamma_A^2. \tag{5.2}$$

Again, parameter $n \geq 0$ indicates how costly it is for the firm to shift income from one country to another.[4]

With no loss of generality, we normalize overall tax savings with respect to Π_B. Given the cost function $\nu\left(\gamma_A, n\right)$, we can thus write the MNC's overall after-tax net operating profit (if FDI is under-

[4] As argued in chapter 4, the more stringent the anti-avoidance rules and/or the higher the tax sheltering costs, the higher the parameter n is.

taken) as

$$\Pi_A^N(x) = (1-\tau_A)\,\Pi_A + (1+x)\left[(1-\tau_B) + \phi(\gamma_A^*, n)\right]\Pi_B, \quad (5.3)$$

where τ_B is country B's tax rate.[5]

As shown in chapter 4, the MNC finds its optimal income shifting policy by solving problem (4.30), namely by computing

$$\phi(\gamma_A^*, n) \equiv \max_{\gamma_A}\left[(\tau_A - \tau_B)\,\gamma_A - \nu(\gamma_A, n)\right].$$

Using (5.2) we find the optimal percentage of income shifting:

$$\gamma_A^* = \frac{\tau_A - \tau_B}{n}. \quad (5.4)$$

As shown in (5.4), if $\tau_A < \tau_B$ then $\gamma_A^* < 0$ and vice versa; the firm thus shifts profits to the low-tax country. Given (5.2) and (5.4) we can obtain the net benefit of income shifting, i.e.,

$$\phi(\gamma_A^*, n) = \frac{(\tau_A - \tau_B)^2}{2n}. \quad (5.5)$$

We also make the reasonable assumption that it is prohibitively costly to shift all profits to the low-tax country. This implies that the following inequalities

$$(1-\tau_A)\,\Pi_A + (1+x)\phi(\gamma_A^*, n)\,\Pi_B > 0,$$

$$(1+x)\left[(1-\tau_B) + \phi(\gamma_A^*, n)\right]\Pi_B > 0,$$

hold.[6] Let us finally qualify bad news according to the following:

Assumption 18 *If at time 1 the firm faces bad news, the present discounted value of future profits is less than the net discounted cost of investment, that is:*

$$\sum_{t=1}^{\infty}\frac{\Pi^N(-d, \gamma_A^*)}{(1+r)^t} - \frac{I}{1+r} < 0, \quad (5.6)$$

where $\Pi_A^N(-d, \gamma_A^*) \equiv \max_{\gamma_A} \Pi_A^N(-d)$.

---

[5] As we have pointed out in chapter 4, in principle repatriated profits are taxed according to the Residence Principle. However, deferral possibilities, as well as limited credit rules *de facto* lead to the application of the Source Principle.

[6] It is worth noting that γ_A^* is not state-contingent due to the convexity of the cost function $\phi(\gamma_A, n)$. If we relaxed this assumption so that one of the profit expressions could be zero, a corner solution would be obtained. In this case, the optimal percentage γ_A^* would be state-contingent.

Assumption 18 states that the bad state of nature inflicts a loss on the firm. If this were not the case, all news would be good in the sense that any news would generate positive profits. Given (5.6), rational firms do not invest at time 1 under the bad state.

Let us next calculate the NPV of the representative firm. If it invests at time 0 it will be equal to:

$$
\begin{aligned}
NPV_{0,A} &= (1-\tau_A)\,\Pi_A + \\
&+q\sum_{t=1}^{\infty}\frac{\Pi^N\left(u,\gamma_A^*\right)}{(1+r)^t} + (1-q)\sum_{t=1}^{\infty}\frac{\Pi^N\left(-d,\gamma_A^*\right)}{(1+r)^t} - I = \\
&= \tfrac{1+r}{r}(1-\tau_A)\,\Pi_A + \left[(1-\tau_B)+\phi\left(\gamma_A^*,n\right)\right]\tfrac{1+r}{r}\Pi_B - I.
\end{aligned} \tag{5.7}
$$

If, otherwise, the firm waits until time 1, we have:

$$
\begin{aligned}
NPV_{1,A} &= (1-\tau_A)\,\Pi_A + q\left[\sum_{t=1}^{\infty}\frac{\Pi^N\left(u,\gamma_A^*\right)}{(1+r)^t} - \frac{I}{1+r}\right] = \\
&= \tfrac{1+r}{r}(1-\tau_A)\,\Pi_A + q\left\{\frac{(1+u)\left[(1-\tau_B)+\phi\left(\gamma_A^*,n\right)\right]\Pi_B}{r} - \frac{I}{1+r}\right\}.
\end{aligned} \tag{5.8}
$$

Using (5.7) and (5.8), setting

$$
NPV_{0,A} - NPV_{1,A} = 0,
$$

and solving for Π_B gives the optimal trigger point above which immediate FDI is undertaken, namely

$$
\Pi_B^* = \eta\frac{r}{1+r}\tilde{I}, \tag{5.9}
$$

with $\eta \equiv \frac{r+(1-q)}{r+(1-q)(1-d)}$, and $\tilde{I} \equiv \frac{1}{\left[1-\tau_B+\phi\left(\gamma_A^*,n\right)\right]}I$. As usual, in order for the firm to invest abroad at time 0, profits must cover the effective tax-inclusive cost of investing abroad $\tilde{I}$ plus the value of the call option to expand.[7]

[7] As pointed out in chapter 1, the wedge $(\eta-1)\frac{r}{1+r}$ is the additional return which is required by the firm to exercise its call option and invest at time 0.

Let us next analyze the impact of volatility on the trigger point. To do so, let us recall assumption 16. Re-arranging (5.1) gives

$$d = \frac{q}{1-q}u.$$

Thus we have $\frac{\partial \eta}{\partial d} \propto \frac{\partial \eta}{\partial u} > 0$, where the positive sign follows immediately from the definition of the variables r, d and q. Since $\frac{\partial \Pi_B^*}{\partial \eta} > 0$, we can prove that an increase in volatility (i.e., with $\Delta d > 0$ and $\Delta u > 0$) raises the trigger point Π_B^*, namely

$$\Delta \Pi_B^* = \underbrace{\frac{\partial \Pi_B^*}{\partial \eta}}_{>0} \cdot \underbrace{\left(\frac{\partial \eta}{\partial d} \Delta d + \frac{\partial \eta}{\partial u} \Delta u \right)}_{>0} > 0. \tag{5.10}$$

As pointed out in chapter 2, the effect of volatility shown in (5.10) does not depend on risk aversion, but rather is due to the BNP.[8] In other words, an increase in volatility means that good news gets better and bad news gets worse: since good news does not matter, increased volatility affects profitability in an adverse way and must be compensated by higher profits. This leads to a higher trigger point.

The above result is in line with the empirical evidence, which shows a negative relationship between uncertainty and FDI. In particular, Chen and So (2002) showed that the 1997 Asian financial crisis (which caused an increase in exchange rate variability) discouraged FDI undertaken by US MNCs. Further evidence is provided by Aizenman and Marion (2004), who focused on the foreign operations of US MCNs since 1989. They showed that uncertainty affects both vertical and horizontal FDI. In particular, they showed that greater supply uncertainty reduces the expected income from vertical FDI but increases the expected income from horizontal FDI. Greater demand uncertainty adversely affects the expected income under both production modes. Moreover, volatility and sovereign risk are shown to have a greater adverse impact on vertical FDI than on horizontal FDI.[9]

[8] Notice that the now-or-never case (where the value of the option to expand is nil) is equivalent to a deterministic setup. We can indeed find it as a special case by setting $d = u = 0$. In this case, the opportunity cost of losing flexibility is zero, and the firm's trigger point is lower.

[9] Further evidence is discussed in Markusen (2002, ch. 1).

Using (5.9), we can also show that an increase in the profit shifting benefit $\phi(\gamma_A^*, n)$ (or equivalently, a decrease in the cost of income shifting n) reduces the effective tax rate on foreign tax profits. As the trigger point Π_B^* drops, investment is stimulated.

5.1.2 The effects of income shifting on tax competition

A common feature of the standard theoretical tax competition literature is that capital investment is fully reversible or, alternatively, that capital investment is irreversible, although it is characterized by exogenous investment timing. Moreover, most of the contributions on tax competition disregard risk.[10]

However, the evidence indicates that risk is a crucial feature of international activities[11] and, therefore, policy makers should deal with it. It is thus necessary to investigate how taxes are set in order to attract FDI when firms can time their investment decisions and countries compete to attract resources. Following Panteghini and Schjelderup (2006) we model tax competition between two identical small open countries called A and B.

Let us assume the existence of two country-specific shocks: namely the shock faced by firms resident in country A when investing in country B and that faced by firms with their headquarter in country B when investing in country A.[12] Moreover, we assume that:

1. in each country, there exists a continuum of firms that can invest abroad;

2. each firm is characterized by its own starting profit level Π arising from investing abroad and the firm-specific profits are distributed according to a linear density function $f(\Pi)$ with $\Pi \in \left[\underline{\Pi}, \overline{\Pi}\right]$;

[10] A few exceptions are Gordon and Varian (1989) and Lee (2004).

[11] As pointed out in chapter 4, Desai and Foley (2004) found that country-specific shocks are transmitted across borders as a consequence of multinational firm's worldwide network of subsidiaries. Moreover, Rodrik (1997) found a positive relationship between market openness and government expenditures. He explained such a result by stressing the importance of social insurance and the role of government in covering against external risk, caused by increased economic integration.

[12] It is worth noting that the quality of results does not change if we assume correlation between these shocks.

3. denoting Π_i^* as country i's trigger point[13] we have the following inequalities:

   a) $\underline{\Pi} < \Pi_i^*$;
   b) $\underline{\Pi} < \frac{r}{1+r} I < (1+u)\underline{\Pi}$;
   c) $\overline{\Pi} > \Pi_i^*$.

Inequalities a) and b) are necessary to rule out the closed-economy case. Without these inequalities, indeed, FDI would be unfeasible for low-income firms, i.e. for those firms who incur losses from international activities irrespective of the quality of the news received.[14] Inequality c) implies that high-income firms invest abroad at time 0 irrespective of the existence of the option to delay. Therefore, it allows us to examine tax competition in a realistic setting, where FDI occurs both at time 0 and time 1.

In constructing the social welfare function for each country, note that since firms incur additional costs by investing abroad relative to home investments, they exploit home investment opportunities at time 0. Furthermore, there are no economies of scale or scope in our model. Therefore we can disregard domestic profit and focus on the sum of profits (or equivalently, the producer surplus) generated by FDI plus tax revenue from foreign firms' FDI in the home country.[15] Hence, each government maximizes the welfare function

$$\max_{\tau_i} W_i \qquad i = A, B, \tag{5.11}$$

where W_i is the intertemporal sum of overall gross profits for MNCs with a home base in country i plus tax revenues from subsidiaries located in i of MNCs with home base in country $j \neq i$. The maximization of (5.11) is part of a sequential game, where at stage 1 each government sets its tax rate; at stage 2, the firms in country A and B decide whether to invest at time 0 or at time 1.

Given these assumptions, Panteghini and Schjelderup (2006) find that there is a unique symmetric Nash equilibrium tax rate $\tau^* \epsilon$

[13] Notice that, given equation (5.9), all firms resident in country i (with $i = A, B$) have the same trigger point Π_i^*.

[14] In the limit case $I \to \infty$, there are no opportunities to invest abroad.

[15] With no loss of generality we also disregard profits faced by domestic firms that cannot exploit FDI opportunities.

$(0, 1)$, which equates at the margin the social cost of taxation to its social benefit. The interested readers will find the full derivation of problem (5.11), as well as the proofs of the following propositions in Panteghini and Schjelderup (2006). Here we will try to give the reasoning behind the effects of market openness and volatility on the equilibrium tax rate τ^*.

Market openness is negatively affected by the size of sunk investment cost I and is positively affected by the average profitability of firms, i.e., by the ratio $\frac{\overline{\Pi}+\underline{\Pi}}{2}$. A fall in I may be related to globalization if tighter economic integration is characterized by a reduction in technical barriers such as national standards and other factors that lower investment costs. A rise in average profitability may also be linked to globalization and more specifically to the decrease in transportation costs as well as the formidable rise in skill-biased technology and information systems such as the Internet.[16] It is thus reasonable to expect that such factors have a positive effect on profits. A further argument which deserves attention is that if I falls and/or $\frac{\overline{\Pi}+\underline{\Pi}}{2}$ rises, the number of firms that undertake FDI will increase.[17] The effects of these changes on the tax rate and tax revenue are summarized in the following:

Proposition 9 *A decrease in I and/or an increase in $\frac{\overline{\Pi}+\underline{\Pi}}{2}$ leads to a rise in the equilibrium tax rate τ^*, and, if $\overline{\Pi}$ is high enough, an increase in tax revenue.*

The reasoning behind proposition 9 is straightforward: a rise in $\frac{\overline{\Pi}+\underline{\Pi}}{2}$ and/or a decrease in I encourages FDI activities. This allows the two competing countries to set a higher tax without deterring FDI. Moreover, an improvement in business profitability raises the number of MNCs and thus widens the overall tax base. Hence, higher tax rates combined with wider tax bases in both countries yield larger tax revenue.

[16] In particular, information technology has allowed firms to outsource tasks to low costs suppliers and has improved communications (with HQs) and thus decision making.

[17] It is useful to recall that the liberalization of foreign exchange laws in most OECD countries, occurred in the mid and late 80s, implied free mobility of capital. The empirical evidence shows that the period after foreign exchange liberalization laws usually coincided with a sharp rise in FDI and multinational firm activity (see e.g. Markusen, 2002).

Let us next examine the effect of income shifting on the equilibrium tax rate. We find that:

Proposition 10 *A decrease in the cost of shifting profit (i.e., a drop in n) decreases the equilibrium tax rate τ^* and vice versa.*

According to proposition 10, a decrease in n makes income shifting less costly and thus stimulates tax competition:[18] this induces the governments to set a lower tax rate.[19] This result has an interesting policy implication as it helps to explain the widespread introduction of anti-avoidance rules: as long as governments can offset avoidance by raising n, indeed, they can set a higher tax rate.[20]

The empirical evidence shows that FDI and MNCs constitute significant fractions of economic output and investment in many countries. For this reason, the transmission of country-specific shocks by means of MNCs' activities is a phenomenon that deserves particular attention. Let us therefore analyze the effects of volatility on the tax equilibrium. It can be shown that:

Proposition 11 *An increase in the volatility of the two country-specific shocks lowers the equilibrium tax rate τ^*, and reduces tax revenue.*

The reasoning behind proposition 11 is as follows. As shown in (5.10), an increase in volatility raises the investment trigger point (5.9), say from Π^*_{i0} to Π^*_{i1} with $i = A, B$. This induces firms whose profits at time 0 are in the $\left(\Pi^*_{i0}, \Pi^*_{i1}\right)$ interval to delay. At time 1, however, only a fraction q of the firms who delayed will receive good news and then invest. The remaining $(1-q)$ firms will decide not

[18] Devereux, Lockwood and Redoano (2004) showed that countries compete over both the statutory tax rate and the tax base. In line with proposition 10, they also showed that the relaxation of capital controls stimulates tax competition and thus reduces both statutory and effective tax rates.

[19] Notice that if n goes to infinity, tax competition vanishes, and tax revenue reaches its maximum.

[20] A similar point is made by Panteghini (2006a), who analyzes the relationship between MNCs' policies and governments' tax strategies. Assuming that MNCs can shift income to low-tax countries by means of financial strategies, he shows that MNCs can affect the tax strategies of two governments competing to attract income. In particular he shows that a reduction in the cost of income shifting encourages tax avoidance. In turn this raises the tax benefit of debt financing and thus stimulates leverage. As long as an increase in leverage raises the MNCs' benefit from tax sheltering activities, the governments are forced to reduce the tax rate, in order to offset income shifting.

to invest. Therefore volatility reduces the overall number of firms involved in FDI activities. The governments' policy response is thus to lower the tax rate in order to partially alleviate the negative impact of increased volatility. Moreover, the reduction in the number of MNCs leads to a drop in the sum of all firms' tax bases. Therefore, both the reduced tax rate and the narrower aggregate tax base leads to lower tax revenue.

These findings may help to explain why, despite the fact that tax rates for large samples of countries are declining,[21] it is however possible to find countries where the tax on capital has risen. The fall in tax rates fits with the interpretation that, under some circumstances, the globalization process may raise volatility (proposition 11). However, the hypothesis that profits have become more volatile leads to a fall in tax revenue and thus fails to explain the empirical findings of stable tax revenue over time (as does the entire tax competition literature). Such stability may be due to the second possible explanation offered in Panteghini and Schjelderup (2006), namely the fall in trade barriers. As pointed out in proposition 9, foreign markets open up in the sense that more firms undertake FDI. This may offset the increase in volatility and make the net effect on tax revenue close to zero. A third determinant of tax rate changes is the cost of tax sheltering activities, which depend on anti-avoidance rules, consulting expenses, and transaction costs (proposition 10). Whenever the reduction in transaction and (tax and financial) consultancy costs overcomes the negative effect of more stringent anti-avoidance rules, it is natural to expect a tax rate cut.

5.2 The capital levy problem

Tax policy uncertainty arises either when a government announces a tax rate change which will not be implemented after (i.e., the future tax rate is unknown but remains constant) or when an unexpected

[21] This evidence has supported Gordon's (1986) forecast of a significant reduction in capital income taxation. For instance, Lee and Gordon (2005) found that in 1980-1989, the average top corporate tax rate was 41.3% (with standard deviation of 8.2%). In the 1990-1997 period, it decreased to 34.8% (with a standard deviation of 6.5%). Despite this generalized downward trend in tax rates, full exemption of capital income is still an improbable event. For a discussion on this point see Gordon (2000), Slemrod (2004), Sørensen (2006), and Garbarino and Panteghini (2007).

tax change takes place (i.e., the tax rate is unknown and variable). It is worth noting however that firms are usually aware that the government can undertake actions different from those initially planned and try to anticipate its tax choices. This commitment failure leads to the well-known "capital levy problem", which is related to the fear that a government can decide to raise taxes on capital already invested.

The capital levy problem deserves particular attention in an international setting. As pointed out by Mintz (1995, p. 61): "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". As pointed out by Eichengreen (1990), if the delay between proposal and implementation of the levy is substantial, capital mobility could make this additional tax burden ineffective. In a more recent article, however, Marceau and Smart (2003) showed that a more elaborate theory of political equilibrium with lobbying may lead to different results.[22] They pointed out that, when capital is mobile, there is little incentive to lobby. When, however, investment is sunk, lobbying can be used to protect short-term profitability in an industry. In this case, lobbying industries face a trade-off. On the one hand, they may succeed in reducing the overall tax burden on their sunk investment. On the other hand, political contributions, required by lobbying activities, entail additional costs. The net effect may be a mitigation or even reverse of the capital levy problem for lobbying industries, at the expense of other industries and of consumers. This implies that the capital levy problem distorts the allocation of capital in the economy.

[22] Evidence of the importance of lobbying activities is provided by Faccio (2006) who studied 541 politically connected firms, located in 47 countries. According to Faccio (2006) political connection occurs if one of the company's large shareholders or top officers is: member of parliament, a minister or the head of state, or closely related to a top official. In line with the relevant literature (see e.g. Shleifer and Vishny, 1994) she found that politicians extract rents from companies they manage. Such a phenomenon is quite relevant as these 541 firms represent almost 8% of the world's stock market capitalization.

It is worth noting that the existing literature accounts for both investment irreversibility[23] and (policy) uncertainty. However, the third pillar of the real-option pricing, i.e., timing, is not dealt with. The lack of an intertemporal perspective regarding investment decisions is a limit of the existing literature: using Pindyck's (2004, p. 12) words we must consider "the basic fact that sunk costs *do matter* in decision-making when those costs *have yet to be sunk*". For this reason we enrich the analysis by studying tax policy uncertainty from an *ex-ante* perspective.[24]

For simplicity we assume that policy risk in the foreign country is the only source of uncertainty for a representative MNC that can decide whether and when to invest abroad. Moreover, we assume that before-tax operating profits are constant. Given the initial foreign tax rate τ_B^0, we also assume that:

Assumption 19 *At time 1 the foreign tax rate will either rise to τ_B^u with probability $(1-q)$, or remain unchanged with probability q.*

Assumption 20 *At time 1 uncertainty vanishes and the tax rate will remain at the new level forever.*

Moreover we let the representative MNC under study shift income in order to avoid taxation. As usual, income shifting is costly. For this reason we introduce the following:

Assumption 21 *The cost of income shifting is given by (5.2), i.e., $\nu\left(\gamma_A^x, n\right) = \frac{n}{2}\left(\beta^x\right)^2$.*

Given (5.2) we can calculate the tax benefit

$$\phi\left(\overline{\gamma}_A^x, n\right) = \frac{\left(\tau_A - \tau_B^x\right)^2}{2n}, \tag{5.12}$$

and then can write the MNC's after-tax operating profit (if it invests in B) as

$$\Pi_A^N\left(x\right) = \left(1-\tau_A\right)\Pi_A + \left(1-\widetilde{\tau}_B^x\right)\Pi_B, \text{ for } x = 0, u, \tag{5.13}$$

[23] For instance, Marceau and Smart (2003) focused on capital already invested. They assumed that firms choose the initial level of capital and, after the government has announced its tax policy, can adjust their capital accumulation. Given the existence of investment adjustment costs, capital is partially irreversible.

[24] This point is somehow related to that discussed by Cherian and Perotti (2001). Applying option pricing techniques they showed that a gradual increase in reputation allows governments to attract a greater amount of FDI.

where

$$\widetilde{\tau}_B^x \equiv \tau_B^x - \phi\left(\overline{\gamma}_A^x, n\right) \tag{5.14}$$

is the effective tax rate. Moreover, we use the reasonable assumption that the cost of income shifting is sufficiently high to have $\widetilde{\tau}_B^x \geq 0$.

Let us finally re-interpret bad news as follows:

Assumption 22 *If at time 1 the firm faces bad news, the after-tax present value of future profits is less than the net discounted cost of investment, that is:*

$$\sum_{t=1}^{\infty} \frac{\left(1-\widetilde{\tau}_B^u\right)\Pi_B}{\left(1+r\right)^t} - \frac{I}{1+r} < 0. \tag{5.15}$$

Assumption 22 thus states that the tax rate increase makes investment non-profitable.

Given these assumptions we can calculate the MNC's expected NPV when investing at time 0, namely

$$\begin{aligned} NPV_{0,A} = &\sum_{t=0}^{\infty} \tfrac{(1-\tau_A)\Pi_A}{(1+r)^t} + \left(1-\widetilde{\tau}_B^0\right)\Pi_B + \\ &+ \sum_{t=1}^{\infty} \tfrac{q\left(1-\widetilde{\tau}_B^0\right)+(1-q)\left(1-\widetilde{\tau}_B^u\right)}{(1+r)^t}\Pi_B - I, \end{aligned} \tag{5.16}$$

and when investing at time 1, namely

$$NPV_{1,A} = \sum_{t=0}^{\infty} \frac{\left(1-\tau_A\right)\Pi_A}{\left(1+r\right)^t} + q\left[\sum_{t=1}^{\infty} \frac{\left(1-\widetilde{\tau}_B^0\right)\Pi_B}{\left(1+r\right)^t} - \frac{I}{1+r}\right]. \tag{5.17}$$

Let us next calculate the MNC's investment strategies. In the now-or-never case, the firm's problem is one of choosing whether to operate as a domestic firm or to expand abroad at time 0. Its problem can be written as

$$\max\left\{NPV_{0,A} - \sum_{t=0}^{\infty} \frac{\left(1-\tau_A\right)\Pi_A}{\left(1+r\right)^t}, 0\right\}. \tag{5.18}$$

Using (5.16) and solving (5.18) thus gives the now-or-never trigger point:

$$\Pi_B' = \frac{r}{\left(r+q\right)\left(1-\widetilde{\tau}_B^0\right) + \left(1-q\right)\left(1-\widetilde{\tau}_B^u\right)} I. \tag{5.19}$$

In the now-or-later case, the MNC's problem is as follows:

$$\max\left\{NPV_{0,A}-\sum_{t=0}^{\infty}\tfrac{(1-\tau_A)\Pi_A}{(1+r)^t},NPV_{1,A}-\sum_{t=0}^{\infty}\tfrac{(1-\tau_A)\Pi_A}{(1+r)^t},0\right\}. \tag{5.20}$$

Using (5.16) and (5.17), and solving (5.20) thus gives the now-or-later trigger point

$$\Pi_B^*=\frac{r}{1+r}\frac{r+1-q}{r\left(1-\widetilde{\tau}_B^0\right)+(1-q)\left(1-\widetilde{\tau}_B^u\right)}I. \tag{5.21}$$

Given the trigger points (5.19) and (5.21) we can now study how the capital levy problem changes when the MNC is endowed with an option to delay. It is straightforward to show that:

Proposition 12 *The relation* $\Pi_B^*-\Pi_B^{'}\propto\left(\widetilde{\tau}_B^u-\widetilde{\tau}_B^0\right)$ *holds.*

Proof. See appendix 5.3.1. ■

According to proposition 12, the difference $\left(\Pi_B^*-\Pi_B^{'}\right)$ depends on the effective tax rate differential rather than on the statutory one. In particular, if $\widetilde{\tau}_B^u>\widetilde{\tau}_B^0$, the inequality $\Pi_B^*>\Pi_B^{'}$ holds and vice versa. This means that as long as the effective tax rate is expected to grow, the existence of an option to delay discourages FDI and thus exacerbates the capital levy problem.

It is worth noting that an increase in the statutory tax rate does not necessarily lead to an increase in the effective tax rate. Using (5.12) and (5.14) it is straightforward to show that, given the inequality $\tau_B^u>\tau_B^0$, we have $\widetilde{\tau}_B^0>\widetilde{\tau}_B^u$ if

$$n<\frac{\tau_B^u+\tau_B^0}{2}-\tau_A. \tag{5.22}$$

Given (5.22) we can therefore write the following:

Proposition 13 *If* $\frac{\tau_B^u+\tau_B^0}{2}-\tau_A>0$ *and the cost of income shifting (n) is low enough, an increase in the statutory tax rate causes a decrease in the effective tax rate.*

According to proposition 13, as long as country B's tax rate is high enough (i.e., $\frac{\tau_B^u+\tau_B^0}{2}>\tau_A$), and the cost of shifting income is low enough, the increase in the statutory tax rate stimulates tax avoiding practices. As a consequence, the net effect of this tax change is a reduction in the effective tax rate.

Propositions 12 and 13 allow us to understand tax commitment failures in an international setting. On the one hand, the ownership of an option to delay exacerbates the capital levy problem. This means that the reverse result found by Marceau and Smart (2003) is less likely whenever MNCs can time their investment decisions. On the other hand, income shifting can reduce effective taxation even if statutory tax rates are expected to rise. In this case FDI is stimulated even in the absence of lobbying activities.

5.3 Appendix

5.3.1 Proof of proposition 12

Using (5.19) and (5.21) we can calculate the inequality

$$\begin{array}{c}\Pi_B^* = \frac{r}{1+r}\frac{r+1-q}{r\left(1-\widetilde{\tau}_B^0\right)+(1-q)(1-\widetilde{\tau}_B^u)}I > \\ > \Pi_B' = \frac{r}{(r+q)\left(1-\widetilde{\tau}_B^0\right)+(1-q)(1-\widetilde{\tau}_B^u)}I.\end{array} \tag{5.23}$$

Re-elaborating (5.23) gives

$$\frac{r+1-q}{1+r} > \frac{r\left(1-\widetilde{\tau}_B^0\right)+(1-q)\left(1-\widetilde{\tau}_B^u\right)}{(r+q)\left(1-\widetilde{\tau}_B^0\right)+(1-q)\left(1-\widetilde{\tau}_B^u\right)}. \tag{5.24}$$

Rewrite (5.24) as

$$1 > q + (1-q)\frac{1-\widetilde{\tau}_B^u}{1-\widetilde{\tau}_B^0}. \tag{5.25}$$

Given (5.25) we can see that $\Pi_B^* > \Pi_B'$, if $\frac{1-\widetilde{\tau}_B^u}{1-\widetilde{\tau}_B^0} < 1$, namely $\widetilde{\tau}_B^u > \widetilde{\tau}_B^0$, and vice versa.■

Part II

Policy issues

6

Corporate tax base options

6.1 The basic options

Corporate taxation can be based on two alternative schemes:

I. comprehensive income tax;

II. consumption-based tax.

Under the comprehensive income tax scheme, developed by Schanz (1896), Haig (1921) and Simons (1938), the tax base consists of two main elements:

1. consumption, including all expenditures, except those incurred in earning or producing income;
2. the increase in the taxpayer's economic wealth (stock of assets) in a given period.[1]

Therefore, according to this standard definition, the income tax base is the increase in the taxpayer's ability to consume in a given

[1] An interesting comparison between income and consumption taxation is provided by Auerbach (2006a, 2006b).

period. If the taxpayer is a corporation, the Schanz-Haig-Simons (hereafter, S-H-S) definition of income includes all income from production factors, such as labor, capital and non-reproducible factors (e.g., land, raw materials), net of expenses incurred in earning income. The idea underlying the S-H-S scheme is that the corporate tax base must be as close as possible to the true net income. Therefore, any change in the company's net worth must be taken into account.[2] Otherwise, we would fail to have a precise and fair measure of a taxpayer's ability to pay.

The concept of consumption tax derives from the pioneering work of John Stuart Mill (1848), who claimed that taxing total income produces discrimination between the income destined for consumption and that earmarked for saving.[3] The latter is taxed twice: both when it is produced and when the saving is remunerated.[4] Indeed, unlike the comprehensive income tax scheme, the consumption-based one exempts normal returns. Like the comprehensive income tax scheme, however, it taxes above-normal returns.[5]

As witnessed by the US Report of the President's Advisory Panel on Tax Reform (2005), the debate on these tax options is still lively after more than one century. The Panel proposed two alternative tax schemes: the Simplified Income Tax (SIT) Plan, in line with the S-H-S comprehensive income tax, and the Growth and Investment Tax (GIT) Plan, which is close a to consumption-based tax. However, the GIP Plan departs from a pure consumption-based tax, as it taxes

[2] For this reason the S-H-S tax base includes all capital income (e.g., interests, royalties, dividends, partnership income, and capital gains).

[3] A similar argument was raised by Kaldor (1955): to avoid the double taxation of savings, indeed, he agreed with the idea of taxing only consumption. A brief (but interesting) discussion on consumption tax is provided by Salanié (2003, ch. 9). See also McLure (1992), who provides a concise analysis of international implementation problems arising from the introduction of consumption-based direct taxation.

[4] The debate on the "right" definition of income has been particularly lively since the 1930s. For instance, Fisher (1937, p. 54) made the following proposal: "[j]ust as accountants speak of income "before taxes" are taken out and "after taxes" are taken out, so I now propose that, to avoid controversy, we speak of income "before savings" are taken out and income "after savings" are taken out; the latter evidently being what I call income proper". Two years later, Fisher (1939, p. 48) recommended to cast out the US capital-gains tax, which was "worse than haphazard". However, he claimed that other forms of capital income, such as dividends, interests and rents, should be included in the tax base.

[5] Above-normal returns (or extra-profits) may be due to innovation, entrepreneurial skills and effort, as well as to monopolistic rents (e.g., related to patents).

dividends, capital gains and interest received (thus including normal income) at a 15% rate.[6]

Advocates of comprehensive income tax argue that it offers a better picture of the taxpayer's ability to pay. In terms of fairness, therefore, it is desirable. However, most existing systems, which are in principle based on the S-H-S scheme, deviate from its purest version because of implementation difficulties.

The first problem involved with comprehensive income taxation is the timing of capital gains taxation. Indeed, capital gains can be taxed either at accrual or at realization. Of course, the former is preferable from a fairness point of view, as it taxes capital gains when they accrue, thereby providing a more precise measure of taxpayer's ability to pay. However, the accrual method has at least two limitations. First of all, the tax burden may occur in a period when the taxpayer matures but does not realize the capital gains. This could cause liquidity problems for the taxpayer, who might be forced to sell part of his assets, against his own wishes, in order to get the cash needed to pay the taxes. Moreover, it could be difficult to check the amount to be taxed with the accrual method. Under this system, the taxpayer should fill an income tax return accounting for all changes in the corporations' fair value. This would be easy if, during this period, shares were sold to other shareholders. Otherwise, the taxpayer or their substitutes (i.e., anyone held to pay the tax instead of the taxpayer) would have to calculate changes in their portfolio on the basis of data that is often imprecise. In particular, it is not always easy to estimate the value of a corporation, especially if it is not publicly traded. Given these limitations, many countries have therefore opted for a realization-based capital gains tax,[7] although under this

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[6] The debate on the US Panel's proposals is quite interesting, as it allows us to address the pros and cons of comprehensive income tax and consumption tax better. On implementation problems faced by the GIT option, see e.g. Auerbach (2005, 2006c) and Graetz (2005). In particular, Graetz (2005) argues that a third alternative, represented by the joint implementation of an income tax and a VAT, is preferable to both SIT and GIT. This combined system would make the US system closer to OECD countries' systems.

[7] Italy is one of the few exceptions. In 1998, it implemented the accrual method for the management of non-qualified shareholding in listed companies. According to the managed-portfolios system, the tax base includes dividends, interest and accrued capital gains, albeit not realized. The tax base is given by the difference between the market value of the managed portfolio at the end and that reckoned at the beginning of the period (see Bonzani, Panteghini and Venturi, 2002). However, the fact that most other countries apply a realization-based system induces tax arbitrage practices, at the

method the effective tax decreases as the time of realization period gets longer. This leads to the well-known "lock-in effect".[8]

A second limit of most existing comprehensive income tax systems is due to the fact that they usually tax nominal returns instead of real ones. If inflation rate is positive, indeed, a portion of capital income is nothing but compensation for losses in real purchasing power of taxpayers' wealth. This measurement problem is relevant for durable goods, as long as fiscal depreciation allowances are calculated on the basis of the historical cost. In this case, as the price of durable goods rises due to inflation, the gap between the assets' market and book value increases. Thus, fiscal depreciation allowances are less than economic (inflation-adjusted) depreciation. It is worth noting that the implementation of devices aimed at fully adjusting depreciation allowances for inflation is not easy. As Slemrod and Bakija (2004, p. 201) pointed out, "in an income tax, we would need to distinguish what portion of capital represented inflation and what portion didn't ... Accurately distinguishing the two would require not only a measure of the dollar amount of capital income, which is what we currently observe on the tax form, but also a measure of the value of the underlying wealth that generated the return, which can be administratively difficult to obtain".[9]

A consumption-based tax can be either indirect or direct. Indirect taxation can be based on the following alternative devices:

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expenses of Italian financial products. An alternative solution is the presumptive tax introduced in the Netherlands in 2001. As shown by Cnossen and Bovenberg (2001), however, this tax, which is in fact a net wealth tax, is distortive as it favors debt financing. Moreover, it is unique in the industrialized world. For this reason, Cnossen and Bovenberg (2001) maintain that the Dutch regime is in contrast with the EU's aim to coordinate capital income taxation.

[8] As proven by Constantinides (1983), under full loss offset, investors' optimal liquidation strategy is to realize losses immediately and to defer gains as long as possible. This would distort portfolio choices, as it would induce taxpayers to hold the shares for a longer period than without taxation. To offset the lock-in effect, Auerbach (1991) proposed a tax system that applies the realization method, but charges interest on past gains/losses when realization occurs. See also the tax proposal contained in Auerbach and Bradford (2004).

[9] Many existing systems permit accelerated depreciation to encourage investment. The *ratio* of the procedure is simple: deduction of investment expenses is allowed over a shorter period of time than the estimated lifetime of the asset. This means that as long as a company accumulates capital, it receives a tax benefit in terms of depreciation allowances. It is worth noting that accelerated depreciation, as well as investment tax credits, can eliminate the overstatement of income due to inflation.

(a) retail sales tax, under which the tax base is given by final sales of goods and services at the retail level, and revenues are collected from retailers;

(b) value-added tax (VAT), under which the tax base is given by the added value of each stage of the production and distribution process: in this case taxes are collected at each of these stages.

In what follows, however, we will focus on direct taxation. In this case, we have two alternative ways:

(c) consumption income tax, namely households' income less net savings;

(d) cash-flow tax.

Under the purest version of consumption income tax (option (c)), households should add up the net increase in bank accounts, the purchase of both financial and business assets, as well as the purchase of owner-occupied housing.[10] Since retained profits are a form of saving, there is no need for source-based business taxation. Such a radical change, which is in line with McLure's (1979) and Feldstein's (1988) proposals, would certainly ensure organizational neutrality, as it would treat corporate and non-corporate firms in the same way, and would also guarantee financial neutrality. As pointed out by Devereux and Sørensen (2005), however, this tax system would suffer from some practical difficulties. First of all, a full tax credit should be granted to foreign investors for taxes paid in the source country: this would cause a considerable revenue loss which would ensure a great benefit to foreign countries. Moreover, without an efficient international system of information sharing, it would be almost impossible to tax the foreign incomes of domestic taxpayers. Finally, taxing households' business income at accrual would probably lead to liquidity problems. For these reasons, there is still room for source-based business taxation.[11] We will therefore focus on option (d).

The cash-flow tax was proposed in Great Britain first by Brown (1948), and then by the Meade Committee (1978). As explained in

[10] To ensure progressivity, a certain level of consumption should be exempted and/or graduated tax rates should be applied.

[11] On this point see also Auerbach (2006b).

TABLE 6.1. Cash-flow taxation

Inflows/outflows
Sales of real goods, services and assets (R)
-
Purchase of real goods, services and
assets, and payments of wages ($\overline{R}$)
=
R-based
+
increase in borrowing (decrease in lending),
interest received etc. (F)
-
increase in lending (decrease in borrowing),
interest paid etc. ($\overline{F}$)
=
R+F-based

chapter 12 of the Meade Committee's Report, we could have either taxation of real cash flow, or financial cash flow (see table 6.1). Real cash flow (R-based system) is equal to the difference between sales of goods, services and assets and the outflow of payments from the costs of production (due to purchases of goods, services and assets, as well as payments of wages) and buying of investment goods. In the financial cash flow system, the tax base is given by the R-based cash flow plus the net flow of financial transactions. In this case, we have the R+F-based system, whose tax base consists of real transactions and financial transactions other than those involving corporate shares.

The Meade Committee (1978) accounted for a third alternative tax base: the S base. Under this tax, the base is given by the net amount of cash flowing out of the corporate sector. The relationship between this tax option and the other cash-flow devices can be understood by using the identity between total inflow and outflow:

$$R + F + S + T \equiv \overline{R} + \overline{F} + \overline{S} + \overline{T}, \qquad (6.1)$$

where S measures the inflow (i.e., increase in own shares issued, decrease in holding shares in other resident companies, and dividends received) and $\overline{S}$ is any outflow (i.e., decrease in own shares issued, increase in holding shares in other resident companies, and dividends paid) of resources due to transactions on shares. T and $\overline{T}$ are taxes paid and repaid, respectively. The rationale for the S base is simple: as pointed out by the Meade Committee (1978, p. 234), "any net receipt of funds from 'real' and 'financial' transactions must go to the advantage of shareholders $\left(S-\overline{S}\right)$ or of taxgatherer $\left(T-\overline{T}\right)$". Therefore the S-based tax is levied on "the total of dividends paid to outside shareholders less the amount of new share capital raised from them" (p. 234). Using (6.1) we can write

$$\left(\overline{S}-S\right)+\left(\overline{T}-T\right)\equiv(R+F)-\left(\overline{R}+\overline{F}\right). \tag{6.2}$$

Given (6.2), we can show that the R+F base and the S base are equivalent. We can thus focus on two options: the R-based and S-based cash-flow tax.

It is worth noting that taxing the sum of cash flow and wage is equivalent to taxing consumption. To prove this equivalence, we introduce the gross national product, defined as Y, that is given by the sum between wage income (W), and corporate income (Π), i.e.,

$$Y\equiv W+\Pi. \tag{6.3}$$

We also introduce the aggregate demand function (Z):

$$Z\equiv C+G+I, \tag{6.4}$$

where C is private consumption, G is public expenditure, I is investment. In equilibrium,[12] we have

$$Y=Z. \tag{6.5}$$

Substituting (6.3) and (6.4) into (6.5), and re-arranging we obtain

$$C+G=W+(\Pi-I). \tag{6.6}$$

[12] It is worth noting that, in equilibrium, the difference between net financial inflow and outflow is nil. Therefore, adding net financial flow to real cash flow does not change the overall tax base. However imposing a cash flow tax on all financial flow rather than only on real cash flow is likely to have a different impact on each individual taxpayer. In particular, the taxpayer's R base exceeds the S base if there is an excess of financial flow out of the company and vice versa. For further details on this problem see e.g. Auerbach (2006a) and Zee (2006).

Equation (6.6) shows that private and public consumption are equal to wage income plus the net cash flow.[13]

We can now compare the consumption tax and the cash flow tax, under the condition that the public budget constraint is in equilibrium, i.e.,

$$G = T. \tag{6.7}$$

Under the consumption-based system, tax revenues are calculated on a tax-exclusive basis, i.e.,

$$T = \theta C, \tag{6.8}$$

where θ is the relevant tax rate. Using (6.7), and substituting (6.8) into (6.6) gives:

$$(1 + \theta) C = W + (\Pi - I). \tag{6.9}$$

Let us next introduce a cash flow tax and a wage tax, such that tax revenues are equal to

$$T = T_W + T_{CF},$$

where

$$T_W = \tau_w W$$

is the wage tax bill, and

$$T_{CF} = \tau_{CF} (\Pi - I)$$

is the cash-flow tax one. The tax base obtained is in line with the X tax proposed by Bradford (1986, 2004) and the Flat tax proposed by Hall and Rabushka (1995). According to these proposals, a proportional tax should be levied on real cash flow (net of labor cost) of business firms, and another tax should be levied on workers' wages

[13] Notice that, in an open economy, we should wonder whether the Destination or the Origin Principle is applied. We know that origin- and destination-based taxation are equivalent provided that prices are flexible, perfect competition exists, and productive factors are mobile (see Lockwood, de Meza and Myles, 1994, and Lockwood, 2001). If any of these conditions fails to hold, equivalence may vanish. Moreover, equivalence may fail to hold if we do not account for tax avoiding practices. As pointed out by Devereux and Sørensen (2005), a destination-based cash-flow tax requires the distinction between costs incurred in the production of goods and services sold in the domestic country and those faced in the production of goods and services sold abroad. Under a destination-based system, only the former costs are deductible. However, the identification of these costs is fairly difficult in multinational companies with different activities and locations. For further details on consumption taxation see Zee (2006) and Zodrow (2003, 2006).

at a personal level. Under the X tax, however, labor income would be subject to a graduated-rate tax, whereas under the Hall-Rabushka scheme, a single tax rate would be applied and progressivity would be ensured by a tax-free allowance depending on the size and composition of family.[14]

To analyze equivalence between the different tax systems, we focus on the special case with $\tau_w = \tau_{CF} = \tau$. We can thus rewrite (6.6) as

$$C = (1-\tau)\left[W + (\Pi - I)\right]. \tag{6.10}$$

As can be seen in (6.10), $[W + (\Pi - I)]$ is a tax-inclusive base.

Comparing (6.9) with (6.10) we can say that the consumption tax is equivalent to the latter system (which taxes both labor income and business cash flow) if the tax rates are such that the equality

$$\tau = \frac{\theta}{1+\theta}$$

holds.

The cash-flow tax has at least three important merits. First of all, it allows taxpayers to avoid calculating depreciation allowances. As we know, depreciation of an asset is difficult, above all in the absence of efficient second-hand markets for durable goods.[15]

Investment neutrality is a second attracting characteristic of cash-flow taxation. To prove this property we assume that there are N firms of identical size. Each of these will decide to invest a sum equal to I/N, in order to obtain a gross income of Π/N. With no taxation, therefore, each of the N firms decides to invest when its payoff is

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[14] The Hall-Rabushka Flat tax differs from the flat taxes implemented in Eastern Europe (see Gaddy and Gale, 2006). Under the Hall-Rabushka scheme, the tax rate on capital income is zero. Conversely, Eastern European countries usually tax capital income, although tax rates are fairly low. As shown by Mitchell (2005), over the last ten years most Eastern European countries have also substantially reduced their overall tax rates. In 1994, Estonia moved first by adopting a flat tax of 26%, and exempting retained profits. The other two Baltic nations imposed flat taxes in the mid-1990s, with Latvia and Lithuania setting rates of 25% and 33%, respectively. Slovakia also introduced a rate of 19% and the Czech Republic further cut its rate by 2 percentage points at the beginning of 2006 (i.e., from 26% to 24%). This "race to the bottom" also involved many non-EU Eastern European countries. Following the example of the Baltic countries, Serbia (with a 14% tax rate), Romania (16%), Georgia (12%), and Russia (13%) introduced a flat tax.

[15] As pointed out by Masini (1979), depreciation is the result of a *guess* rather than an estimate. In other words, depreciation calculations come from subjective evaluations that are difficult or even impossible to verify *ex post*.

positive (see chapter 1), i.e.,

$$\max\left\{\frac{\Pi - I}{N}, 0\right\}. \tag{6.11}$$

Under cash-flow taxation, the firms' tax burden is equal to

$$\frac{T}{N} = \tau\frac{\Pi - I}{N}.$$

Hence, in evaluating the success of a business project, they should examine their net result. The investment rule is thus as follows:

$$\max\left\{(1-\tau)\frac{\Pi - I}{N}, 0\right\} = (1-\tau)\max\left\{\frac{\Pi - I}{N}, 0\right\}. \tag{6.12}$$

Comparing (6.11) with (6.12) we see that a firm's investment decision is unaffected by taxation. As shown in appendix 6.3.1, neutrality also holds when firms can time their investment strategies.

A third attracting characteristic of cash-flow taxation is highlighted by Sinn (2003). He maintains that cash flow taxes are not only "powerful revenues raisers" under tax competition, but also discourage capital outflow. Since a "flight of capital means that investors do not reinvest but use the funds freed through depreciation for foreign investment ..., the lack of reinvestment increases the tax base and the tax liability. The cash flow tax thus incorporates an exit fee that compensates the state for the foregone tax ..." (Sinn, 2003, pp. 53-54).

One might wonder why, despite these positive characteristics, cash-flow taxation is not yet widespread. The reason is that this tax system also has some limitations that we should not forget.

Its first limitation is linked to the risk of a lack of international coordination. If a country were to opt for this form of taxation, foreign taxpayers would risk having to pay double taxation. The example of Bolivia is indicative of this. Its government appointed two US experts, Charles McLure and George Zodrow (see McLure and Zodrow, 1998) to study the implementation of a cash-flow tax. As these authors pointed out, however, the US Internal Revenue Service (IRS) did not grant any tax credit to American companies operating in Bolivia. In other terms, the cash-flow tax, paid in Bolivia, did not guarantee any fiscal benefit, once the profits were repatriated and, according to the Residence Principle, subject to taxation also in the US. This double taxation and its deterring effects on capital inflow torpedoed the reform project. For this reason, Bolivia finally implemented a traditional S-H-S business income tax. As pointed out by McLure and Zodrow (1998, pp. 11-12) ... "by denying creditability for the CFT, the IRS is effectively precluding foreign countries from adopting a tax that may very well be in their best interest". This concluding remark is in line with Gordon's (1992) idea that the US plays as a Stackelberg-type leader and that other countries have to account for its leading role. For the same reason, we can also say that the implementation of the GIT Plan in the USA would certainly remove an important obstacle to the introduction of cash-flow taxation throughout the world.

Another problem related to the lack of international tax coordination are tax avoiding practices. Without any international agreement, taxpayers could easily avoid taxation, under a cash-flow tax. If a country were to introduce cash-flow taxation, it would be relatively easy for taxpayers to exploit the immediate deduction of investment, and shift income wherever taxation is less heavy.[16]

A second limitation to cash-flow taxation regards the pro-cyclical nature of its tax base.[17] As we know, investment is more volatile than GNP. To understand the consequences of volatility on fiscal policies let us look at the example of table 6.2, that describes a closed economy. Assume that, at time t, Y is equal to 100, while investment (I) is equal to 50. In the two following years, these variables oscillate due to the business cycle. In particular, these grow at time $t+1$, respectively by 2 and 4%. At time $t+2$, however, these fall by 2 and 4%, respectively. If we calculate the tax base ($Y-I$), we can see that it remains constant. Fixing the tax rate at 30%, therefore, tax revenues (T) will be equal to 15 each year. As we can see, however, the ratio T/Y drops during the recovery (at time $t+1$), and rises during the recession (at time $t+2$). Of course, this pro-cyclical effect

[16] International implementation problems are discussed by Shome and Schutte (1993). The pros and cons of destination-based and origin-based systems are dealt with by Bradford (2003) and Zee (2006).

[17] This point was raised by Vickrey (1939) when comparing the consumption tax (defined as "paid-income tax"), advocated by Fisher (1937), and the S-H-S one (that he called "accrued-income tax"). He maintained that "the paid-income tax assessed on a straight annual basis may have a much more severe effect in accentuating the business cycle through encouraging spending in times of prosperity, when taxes are low, and discouraging it in times of depression and fiscal need, when taxes are high, than in the case with the accrued-income tax" (p. 397).

TABLE 6.2. The pro-cyclical effect of cash flow taxation

	t	$t+1$	$t+2$
Y	100	102	98
I	50	52	48
$Y-I$	50	50	50
$T=\tau(Y-I)$	15	15	15
$\frac{T}{Y}$	0.150	0.147	0.153

may have extremely negative consequences on an economy under recession.[18]

Thirdly, transitional problems, due to a switch from a S-H-S to a consumption-based scheme, would draw a note of caution about its implementation. In particular, a consumption-based tax might cause a revenue loss and would have a negative impact on pre-existing wealth (including firms' assets). Empirical literature has addressed this problem in depth. Gordon and Slemrod (1988) showed that a switch to a modified R-based cash-flow tax would not have caused revenue losses in 1983. However, Gordon, Kalambokidis and Slemrod (2004) repeated the Gordon-Slemrod exercise and showed that, due to changes in the US economy and tax system, the same reform would have caused a relevant revenue loss in 1995 (about $ 100 billion). Furthermore, distributional effects would have been relevant, as the net gains would have had a U-shaped pattern, with taxpayers in the lowest and highest deciles with the largest gains.[19] Moreover, a move towards consumption-based taxation might distort investment timing. Consequently, transition should be carefully managed in order to reduce windfall losses.[20]

[18] Some evidence on the volatility of the cash-flow base was provided by Becker and Fuest (2005). By investigating the effects of a switch to a consumption-based system in Germany, they showed that it would make tax revenues more volatile, in particular under R-based taxation.

[19] Howitt and Sinn (1989) analyze intertemporal allocation effects of R-based cash-flow taxation in a general equilibrium model. They show that this tax system is more distortive than a comprehensive income one.

[20] For a discussion on transitional problems and their possible remedies, see e.g. Shome and Schutte (1993), Bradford (1998), and Slemrod and Bakija (2004).

6.2 The Nineties' tax proposals

In the early 90s, some interesting corporation tax systems were proposed: among these, we will focus on the US Comprehensive Business Income Tax (CBIT), the Italian Imposta Regionale sulle Attività Produttive (IRAP) and imputation tax schemes.

6.2.1 The US CBIT and the Italian IRAP

The CBIT was proposed by the US Treasury Department (1992). It aimed at widening the tax base for business, by disallowing interest payment deductibility from the profit tax base. Under CBIT, therefore, all kinds of capital income should be taxed at the level of the firm.

As Gravelle (1995) noted, CBIT is interesting for at least two reasons. Firstly, given that it is a real and proportional tax, it affects all capital income indiscriminately. Thus by applying a single tax rate, CBIT eliminates any possibility for fiscal bargaining. Secondly, this tax is easily manageable, given that it needs only simple calculations.

However, CBIT has some limitations. First of all, the implementation of CBIT may lead to cross-border problems, in particular when other countries apply standard S-H-S income taxes (see Gravelle, 1995 and 2005). Let us now consider a foreign investor, Mr. White, who has decided to lend 100 dollars in the US credit market and who receives a gross interest payment of 5 dollars. Given that CBIT is a real tax, these 5 dollars would be taxed in the US (that is in the source country). If there were no agreement between Mr. White's country of residence and the US, then he would risk also having to pay in his own country. Thus, it is obvious that Mr. White would be discouraged from lending in the US. To attract foreign investors, therefore, the US would have to offer them tax-breaks, such as, e.g., exemptions and/or tax credits. But this, in its turn, would also be a disadvantage. If, indeed, the US ensured benefits to foreign investors, US citizens might be induced towards tax avoidance. For example, they could attribute their own income to consenting foreigners, in order to enjoy the same benefits as foreign ones. As we can see, the introduction of a simple and innovative tax can become very complex, when considering international consequences.

A second limitation of CBIT is its distortive effect on debt financing. By making interest expenses non-deductible at the business level, it is expected to raise the cost of debt financing: this would cause a negative impact for firms with a pre-existing high leverage.[21]

IRAP is certainly one of the most innovative aspects of the Italian reform which came in force in 1998. Although there is nothing new in the idea to tax the added value,[22] there are very few other examples of real world applications.[23]

IRAP is a flat-rate tax levied on the value added generated by all types of business and self-employed activities. For most business activities the tax base is calculated annually from the taxpayers' accounts according to a direct subtraction method (see table 6.3). Specific rules are established for banks, financial intermediaries and insurance companies.

As can be seen in table 6.3, IRAP shares with CBIT the idea of taxing interest payments at the business level. Both profits, as traditionally calculated, and interests paid on debt would be taxed with a common rate at the business level. Relative to CBIT, however, IRAP goes further in widening the tax base, in so far as labor costs are also included.

Since neither labor costs, nor interest payments are deductible from the tax base, the IRAP base equals the sum of wages, profits, rents and interest payments at the business level. Contrary to

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[21] As pointed out by Devereux and Sørensen (2005), CBIT would also cause practical difficulties in terms of tax revenues. Since CBIT aims to eliminate personal taxation on shareholder income, it might cause considerable revenue losses, given the relatively low tax rate proposed by the US Treasury Department (1992), i.e., 31%.

[22] For instance, Studenski (1940, p. 648) stated that "... a far more accurate measure of the volume of activity of business enterprises, and hence also a fairer basis for the universal taxation thereof, is the so-called value-added, otherwise known also as net-value product. It can be described as the gross sales of a concern less the costs of materials and services procured from other enterprises for use in production. It represents the net value of the labors of the establishment itself without any admixtures of the labors of other establishments and includes, in the main, the costs of labor, management, and capital employed by the enterprise and the returns due to the entrepreneur as a reward for his contribution to production. A tax based on the value added is relatively free from pyramiding. Under it each business enterprise is taxed on its actual production, that is, in the final analysis, on the relative use made by it of the market and other facilities maintained by organized society". This idea was subsequently resumed by, among others, Gordon (2000), who recommended the adoption of value added taxes to replace traditional capital income taxes.

[23] The closest experiences are the Single Business Tax (SBT) applied in Michigan (US) since 1976 and the Business Enterprise Tax (BET) introduced in New Hampshire (US) in 1993. In Europe, the Hungarian local business tax is similiar to IRAP. For further details on local taxation see e.g. Bird (2005).

TABLE 6.3. Computation of the IRAP base

(A) Revenue:
from sales and services; changes to stocks of goods-in-progress; semi-finished and finished products; changes to work-in-progress on order; increases of fixed assets as a result of internal works; other revenue and proceeds.
(B) Expenses:
raw materials, subsidiary materials; consumable and goods; services; rent/lease; depreciation and value adjustments; provisions for risks; other provisions; miscellaneous running costs.
(A)-(B)=IRAP base

a subtraction-method VAT,[24] outlays for capital goods are not immediately expensed, but taxpayers may deduct fiscal depreciation allowances from the tax base.[25]

IRAP has some attractive characteristics:

1. like the CBIT, it guarantees an equal fiscal treatment of equity and debt financing, as profits and interest payments are taxed with the same tax rate;

2. it does not discriminate between different sources of equity capital (retained earnings and new subscriptions) either: all profits, independently of whether they are retained or distributed, are included in the tax base and no tax credit is given to the shareholders for the tax paid by the company;

[24] For details on the subtraction-method VAT, see Seidman (1997).

[25] Fiscal depreciation allowances include accelerated depreciation in the first three years.

3. it is levied on any type of productive activity: as it makes no distinction between taxable persons, it does not affect the organizational form of business;

4. in principle, it could be made neutral with respect to the use of different productive factors, namely capital and labor, since profits, interests and wages are all included in the same tax base and taxed at the same rate;

5. it has a wide basis and, therefore, ensures a significant tax revenue with a low rate;[26]

6. another interesting characteristic of IRAP is that, unlike the European VAT, it is levied according to the origin principle, on all value added produced within domestic boundaries. As it does not grant export exemptions, nor does it apply to imports, it requires no cross-border adjustments, and so IRAP is easy to manage.[27]

IRAP as well as CBIT, may be considered attempts to balance competing objectives: i.e., to attain neutrality with respect to the cost of capital across real and financial assets, on the one hand, and to reduce the statutory rate of profit taxation, on the other. However, IRAP suffers from at least two limitations that are linked to the non-deductibility of financial and labor costs, as well as to the fact that this tax is an almost isolated case in the international scenario.

By disallowing interest payments deductibility IRAP, like CBIT, introduces a positive tax wedge between gross and net returns on a debt-financed marginal investment. Therefore, both taxes are neutral with respect to financing decisions, but they are not neutral with respect to the cost of capital.[28] Furthermore, Italy's IRAP favors

[26] The standard IRAP rate is 4.25%, although Regions can change the rate up to a maximum of 1 percentage point. Since the tax base of IRAP is very large, however, it raised considerable revenue and thus allowed a significant reduction in the overall statutory tax rate. However, the decrease in average effective tax rates was not so dramatic (see Bordignon, Giannini and Panteghini, 2001).

[27] This characteristic makes IRAP quite different from EU VAT, at least in terms of tax base. According to the data provided by the Agenzia delle Entrate (Italy's Revenue Agency), in 2002 the overall VAT base (including imports of goods and services) was 288,046 million Euros, whereas IRAP (including exports) was 534,951 million Euros.

[28] For investment neutrality to hold, investment outlays should be made fully deductible under both taxes. This would transform CBIT into a R-based cash-flow tax and IRAP into a subtraction-method value added tax.

capital to labor in so far as depreciation deductions are extended to anticipated depreciation and are therefore likely to be larger than the economic depreciation rate (see Bordignon, Giannini and Panteghini, 1999). Another discouraging effect on labor demand is due to the fact that IRAP replaced social security contributions. Given the abolition of such contributions, characterized by a relatively high statutory rate (9.6%), the reform was expected to reduce the labor tax wedge. As shown by Rizzi and Zanette (1998), instead, the effective contributions abolished were substantially less than the statutory ones (on average less than 7%). Therefore, most taxpayers actually had an increase in the cost of labor. Gregorelli, Panteghini and Sonedda (2003) also showed that, given specific rules, IRAP may encourage a more intensive use of the existing labor force instead of leading to new employment.

The second limitation is the absence of similar taxes throughout the world that causes a lack of international coordination. To give an idea of the importance of this point, we can recall that, in 1998, US multinationals reacted strongly against the introduction of this tax, for a simple reason: due to the lack of similar taxes in the US system, the Italy/US double taxation treaty did not recognize IRAP. Upon the payment of US taxes, these companies could not deduct the IRAP paid in Italy, with an extra burden on them: thus US investors threatened to leave Italy for lower-tax jurisdictions. Finally, the two countries reached an agreement under which a part of (but not all) the IRAP is now creditable against income taxes due in the United States.[29] But the adversities of IRAP were far from being over: the European Court of Justice (ECJ) was called to pronounce on its compatibility with the EU VAT (case C-475/03). In fact, the ECJ had to assess whether the application of IRAP was detrimental to EU VAT. In October 2006, the ECJ held that IRAP is compatible with the EU VAT.[30] In doing so, the ECJ judgment has removed an important obstacle against IRAP-type schemes in the EU. Irrespective of this favorable judgment, however, the troubled story of

[29] While many other countries granted a 100% credit against the IRAP paid in Italy, the tax credit recognized for US tax purposes is equal to the tax rate (4.25%) times a modified IRAP tax base, that is given by current IRAP tax base less labor costs and financing costs. The adjusted tax base is thus close to a standard S-H-S one.

[30] This judgement was somehow unexpected as it came after two different Advocate Generals had claimed the incompatibility of IRAP with the EU VAT.

IRAP shows how the introduction of a new tax instrument, albeit interesting and innovative, may encounter relevant problems in an international setting.

6.2.2 The imputation methods

In the nineties, various cases of differentiated tax systems were proposed and/or introduced. According to these mechanisms, corporate income is split into two components, normal income and above-normal income.

The idea of taxing above-normal income is not new: during the first world war, many countries involved in that conflict introduced devices aimed at taxing "war-profiteering", that is profits that exceeded normal peace-time profits.[31] This tax was calculated on two main criteria:

1. as the difference between income made in war–time and the average of income produced previously;

2. as the excess compared with normal income calculated by multiplying the value of capital invested for a predefined percentage.

After the first world war, many economists were in favor of keeping this dual criteria, so much so that also during the second conflict, similar mechanisms were applied.

Although the aim was clearly different, the idea of splitting profits into two components and to tax above-normal profits more heavily by means of an imputation rate was an important precedent for the imputation tax schemes proposed in the nineties, i.e., the Nordic Dual Income Tax, the Allowance for Corporate Equity (ACE), and the Italian Dual Income Tax.

The Nordic DIT is applied to closely-held corporations, to partnerships, to sole traders and free-lance workers. Public corporations

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[31] Stamp (1917) described the widespread diffusion of the extra-profit tax. In March 1915, Denmark and Sweden aimed at striking "at the enormous profits made by exporters" (p. 26). Also in Italy and Germany, special taxation of war profits was demanded soon after the beginning of war. In 1916, many other countries (such as France, Austria, Australia, Russia, The Netherlands, New Zealand and the USA) introduced similar tax devices.

are thus excluded.[32] The rationale for dual taxation is based on the consideration that in small-medium sized enterprises, partners are often not only contributors of capital but also of labor. For fiscal reasons, this definition is particularly important, given that labor income is often taxed with progressive criteria and therefore taxation may be more burdensome. Thus, if income from labor is taxed more heavily, partners of small-medium sized businesses are more induced to have their income figure as capital income rather than labor income. To offset tax avoiding practices, the Nordic DIT introduced an imputation method (see table 6.4), which splits profits into labor and capital income. Capital income is calculated as the first component, by applying an imputed return on business assets. The imputed return is generally a market interest rate corrected to take into account the higher risk of equity capital (ρ).[33] Business assets (A) are either net (Finland and Sweden) or gross (Norway); moreover, they can either contain financial assets (Finland and Sweden) or not (Norway). Under the Nordic DIT, all types of capital income are taxed at a relatively low proportional rate ($\varkappa$), equal to the lowest rate on labor income. Labor income is instead taxed according to the personal progressive income tax rates (with rate $t_p \geq \varkappa$).[34]

Given these characteristics, we can consider dual income taxation as an intermediate solution between comprehensive income and consumption-based taxation, as it taxes normal capital income at a lower rate than other sources of income.

Under the Nordic DIT, business activities are taxed differently depending on their organizational form. In fact, this system encourages the transformation of more taxed labor income into less taxed capital income, e.g., through the incorporation of business activities (Sørensen, 1994). Such system may also distort a company's deci-

[32] Denmark was the first country that implemented a DIT system. However, it soon radically changed its system, by repealing crucial features of a pure DIT system (see Sørensen, 1998).

[33] Under the Swedish system the imputation rate is equal to the interest rate on ten-year government bonds plus a premium of 5%. In Finland the imputation rate is set by the government and exceeds risk-free long-term interest rates. In 2005 it was set at 9%. Until 2005, Norway's imputation rate was equal to the five-year government bond plus 4%. In 2006, the Norwegian system was deeply changed, with the introduction of a shareholder tax, whose imputation rate is equal to the risk-free interest rate.

[34] A detailed analysis on Nordic DIT is e.g. provided by Hagen and Sørensen (1998), and Cnossen (2000).

TABLE 6.4. A comparison between different imputation schemes

Tax system	Corporate sector	Non-corporate sector
Nordic DIT (gross method)	$\tau\Pi$	$\varkappa(\rho A - iD) + t_p \cdot [(\Pi + iD) - \rho A]$
Nordic DIT (net method)	$\tau\Pi$	$\varkappa\rho(A - D) + t_p \cdot [\Pi - \rho(A - D)]$
ACE	$\tau(\Pi - rE)$	$\tau(\Pi - rE)$
Italian DIT (1998 regime)	$Max\{\tau(\Pi - \rho\Delta E_{96}) + \varkappa\rho\Delta E_{96}; \tau^{min}\Pi\}$	$t_p(\Pi - \rho\Delta E_{96}) + \varkappa\rho\Delta E_{96}$
Italian DIT (final regime)	$\tau(\Pi - \rho E) + \varkappa\rho E$	$t_p(\Pi - \rho E) + \varkappa\rho E$

Legenda:
$\Pi =$ net profits (after interest),
$A =$ book value of business assets,
$D =$ debt,
$i =$ interest rate on debt,
$E =$ equity,
$\tau =$ corporate income tax rate,
$\varkappa =$ capital income tax rate,
$t_p =$ personal income tax rate,
$r =$ market interest rate,
$\rho =$ imputation rate,
$\Delta E_{96} =$ increase in net worth from 1996 onwards,
$\tau^{min} =$ minimum average tax rate (27%),

sions to go public.[35] To prevent avoiding practices, many different solutions have been adopted by the Nordic countries; none of them, however, was completely satisfactory. In 2006, Norway implemented an interesting tax reform, aimed at replacing the old dual system with a shareholder tax that applies to both unlisted and listed companies. Under this system, dividends and capital gains, exceeding

[35] According to the Nordic DIT philosophy, public companies are usually characterized by a separation between managers and shareholders. In principle, it should be easy to distinguish between capital income (dividends and capital gains paid to shareholders) and labor income (including income earned by managers). Therefore, it there would not be need to apply the DIT to these companies. However, the wide diffusion of stock option plans and other forms of compensation, related to business performances, makes this distinction less easy.

an imputed return, are taxed at the shareholder level.[36] As shown by Sorensen (2005a), this system is attracting as it is neutral with respect to organizational and financial choices. Moreover, it is equivalent to a cash-flow tax and, therefore, is also neutral in terms of investment choices.[37]

In 1991, the IFS Capital Taxes Group (1991) proposed the ACE, in UK corporate taxation. According to this proposal, the corporate tax base should be 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. Moreover, it should ensure a symmetric treatment of profits and losses.

According to the IFS proposal, the opportunity cost of finance should be 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).[38]

The basic idea of the ACE proposal differs substantially from the Nordic DIT. Under the ACE system a company would be entitled to deduct an allowance (ACE) for equity. As shown in table 6.4, this allowance is calculated by applying the market risk-free interest rate on long-term government bonds (r) to the equity invested into the company (E).[39] Under this tax scheme, companies' earnings are split into the following two components:

[36] The part of dividends and capital gains that does not exceed the imputed return is only subject to the 28 percent company taxation. Under the new regime, moreover, partnerships will still be subject to 28% taxation upon all income irrespective of distribution, plus an additional taxation on dividends (at 28%). In order to compensate for the initial 28% tax levied on all profits, only 72% of dividends will be taxable. Moreover, only the distributed profit exceeding the imputed return interest on the capital invested in the partnership will be taxable. As regards self-employed individuals, the new system taxes all business profits exceeding the imputed return as personal income.

[37] For further details see also Sorensen (2005b).

[38] Devereux and Freeman (1991) point out that, in present value terms, Brown's (1948) cash-flow tax and the ACE tax are equivalent. This means that ACE does not distort investment decisions.

[39] E is given by the shareholders' funds in the previous period, *plus* taxable profits (net of the equity allowance), the equity allowance, dividends received, net new equity issues, *less* taxes payable, dividends paid and net acquisitions of shares in other companies.

1. an imputed return on new investments financed with equity capital (called the "ordinary return"), which is calculated by applying a nominal interest rate to equity capital;

2. the residual taxable profits, namely profits less ordinary return.

The ordinary return, approximating the opportunity cost of new equity capital, is exempt at a corporate level. For this reason, the ACE is a consumption-based tax option.

As pointed out by Devereux and Freeman (1991), the ACE system, if accompanied by a personal consumption tax, has interesting neutrality properties.[40] First of all, the cost of capital is unaffected by taxation, and is also neutral with respect to inflation. Moreover, if extended to the non-corporate sector, it is neutral with respect to organizational choice.

Undoubtedly, the Nordic DIT, as well as ACE, were taken into consideration in shaping the Italian DIT, which came into force in 1998 and was suppressed in 2003. The Italian DIT shared with these reform schemes the idea of dividing profits into two components, of which capital income is calculated first. Normal income was calculated by applying a nominal rate of return to a measure of the equity invested into the firm.[41] The division of income was extended to both the corporate and non-corporate sector, as in the ACE proposal; this was a crucial difference with the Nordic DIT. Moreover, like the Nordic DIT, the Italian one taxed normal capital income

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[40] As regards the integration between personal and corporate taxation, Devereux and Freeman (1991, p. 8) argued that the ACE is "intended to operate in a classical relationship with the personal tax system, so that, in administrative terms, it will function with any form of personal taxation ... The ACE therefore works best in combination with a comprehensive income tax, or an expenditure tax, or with no personal taxes on investment income". Under a comprehensive income tax, however, savings would be discouraged, whereas there would be no distortion with different kinds of saving options.

[41] This imputation rate was set annually by the government with reference to the market interest rate on public and private bonds and could be increased up to three percentage points. According to the government, the need for this correction arose mainly because of the imperfect system of loss reporting: if the ordinary return was higher than total profits or if the firm incurred in operating losses, the amount of profits which could benefit from the preferential tax rate could be carried forward for four years. However, neither interest rate adjustment of carried forward losses, nor carryback were allowed for by the tax law.

at a lower rate: as it did not fully exempt normal capital income it differed from the ACE.[42]

For the Italian DIT, two regimes were considered: the one immediately after the 1998 tax reform and the final one. Under the Italian DIT indeed, the favorable tax treatment involved only new subscriptions of capital and retained earnings, rather than the whole equity capital (E). The starting point was 1996, when the reform was originally presented by the government. Thus the DIT benefit was nil at the beginning and increased over time as new subscriptions and retained earnings from 1996 onwards (ΔE_{96}) led to an accumulation of equity capital. In doing so, it ensured a "soft" move towards the final regime, under which all equity capital would have enjoyed DIT benefit. This gradual implementation was necessary to keep a close eye on public accounts, at a time when Italy was trying its best to gain access to the first stage of the European Monetary Union. For this reason, the average tax rate τ^{min} could not be less than 27%.

The government was conscious that DIT would have produced significant benefits only in the medium term; similarly, it was aware that this mechanism would have guaranteed a benefit only to undercapitalized firms, in the event that they rebalanced their debt/equity structure. More so, the rules encouraged new business initiatives, which would fully enjoy DIT relief. In order to enhance DIT relief, a corrective measure, called as Super-DIT, was introduced in the year 2000: the increase in capital invested was multiplied by 1.2 in 2000 and 1.4 in the subsequent fiscal years, thereby boosting the DIT benefit proportionally.

As we pointed out, the Italian DIT tax was repealed in 2003. When the centre-right government came to power in 2001, the attitude towards DIT radically changed. The imputation rate was almost immediately aligned to the rate of legal interest, and thus halved (declining from 6% to 3.5% first and then to 3%). Furthermore, only equity increases until 30 June 2001 were relevant to calculate the incentive. The cut in the imputation rate and the “freezing” of the benefit were a clear signal of the future abandonment of the DIT, which occurred at the end of 2003.

[42] For this reason, Eggert and Genser (2005) have considered the Italian DIT as a withholding tax. For further details see also Keen (2003).

Compared to other alternative tax schemes, the imputation methods have some appealing characteristics.

Firstly, they have already been implemented. In particular, an ACE-type system was applied in Croatia between 1994 and 2001. Apart from the Nordic countries and Italy, dual tax systems have been introduced in other countries, such as Austria, Belgium and Brazil (see Eggert and Genser, 2005, and Klemm, 2006).[43] Contrary to a cash-flow tax, therefore, policy-makers aiming at implementing a dual tax system could rely on previous experience.

Secondly, imputation schemes are closer to existing corporation taxes, as they allow depreciation allowances instead of immediate expensing: this characteristic implies that such devices can be introduced without any radical change in the existing rules for computing the tax base.[44]

Thirdly, transition problems can be managed more easily than under a cash-flow tax. Given that they allow depreciation allowances, they are not expected to cause pro-cyclical effects, like a cash-flow tax does. Moreover, they can be implemented gradually. The method applied in Italy is a useful example of soft transition towards a final dual income tax regime: as time passes, this device is expected to ensure a progressively low taxation of normal income.[45]

These characteristics make imputation systems fairly attractive policy options. For this reason, in the next chapters we will focus on the main implementation issues regarding imputation systems. Firstly, we will deal with the tax base design in an international setting.[46] Secondly, we will aim at finding the neutral imputation

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[43] See also Fehr and Wiegard (2003), who propose the introduction of an ACE-type system in Germany.

[44] It is worth noting that Bond and Devereux (1995) proved that a R-based ACE-type tax is neutral even if fiscal depreciation allowances are arbitrarily chosen.

[45] The Italian experience had another interesting characteristic: i.e., the joint implementation of DIT and IRAP. Under the 1998 Reform, therefore, the government provided for a stick and a carrot, that is, IRAP (which penalized indebted companies) and DIT (which stimulated undercapitalized firms to reduce their leverage towards a "physiological" level). Under the 2004 reform, which abolished DIT, the attitude of tax authorities vis-à-vis highly undercapitalized firms changed. The reform took away the carrot (i.e. the DIT benefit) and introduced a second stick: a thin capitalization rule. For a discussion on the 2004 reform see Panteghini and Venturi (2005).

[46] Of course, the choice between DIT-type and ACE-type taxation depends on whether the policy-maker wants to tax normal capital income (as under a DIT) or to exempt it (as under an ACE-type tax).

rate. Thirdly, we will analyze the treatment of losses. Fourthly, we will show under what conditions a R base is preferable to a S base.

6.3 Appendix

6.3.1 Intertemporal neutrality of cash-flow taxation

To show that cash-flow tax is neutral in terms of investment timing, we can recall the maximization problem (2.53) discussed in chapter 2 (appendix 2.4.4), namely,

$$\max_{\overline{\Pi}} O(\Pi; \overline{\Pi}).$$

Under the cash-flow tax, investment costs are immediately written off. Therefore, the firm's problem can be rewritten as

$$\begin{aligned} \max_{\overline{\Pi}} O(\Pi; \overline{\Pi}) = \max_{\overline{\Pi}} \left\{ (1-\tau) \left(\frac{\Pi}{\overline{\Pi}} \right)^{\beta_1} \left[V(\overline{\Pi}) - I \right] \right\} = \\ = (1-\tau) \cdot \max_{\overline{\Pi}} \left\{ \left(\frac{\Pi}{\overline{\Pi}} \right)^{\beta_1} \left[V(\overline{\Pi}) - I \right] \right\}. \end{aligned} \tag{6.13}$$

Given (6.13) we see that the optimal threshold point $\overline{\Pi}$ does not depend on taxation. This proves that cash-flow taxation does not affect investment timing.

7

Broad or narrow tax bases?

Empirical evidence shows that, since the beginning of 1980s, statutory tax rates have fallen, while tax bases have widened (see e.g., Devereux and Sørensen, 2005). Bond (2000) provided a simple rationale for this *tax-rate-cut-cum-base-broadening* policies, implemented all over the world. He argued that one of the main reasons that can push a country to widen the tax base is that, by doing so, it can attract MNCs. By widening the tax base, countries can collect the same amount of resources with a lower tax rate. Since MNCs often earn monopolistic rents, they can benefit from tax cuts, as their rents are taxed less heavily.

7.1 The standard approach

To clarify Bond's (2000) argument, let us use a simple numerical example. We assume that there are two MNCs: Alpha and Beta. The first produces and sells 100 euros of goods and faces 50 euros of costs. We assume that Alpha does not enjoy rents: this means that 50 Euros is the normal income. On the contrary, Beta's turnover is equal to 200 Euro; since it faces the same costs as Alpha, it earns a rent of 100 Euros.

TABLE 7.1. Tax burdens in Euroland and Bengodi

	Euroland (tax rate of 30%)	Bengodi (tax rate of 15%)
Alpha	15	15
Beta	45	30

The two MNCs can decide whether to invest in Euroland or in Bengodi (see table 7.1). While Euroland taxes income, i.e., the difference between turnover and costs, at a rate of 30%, Bengodi levies a tax on turnover at a rate of 15%. Table 7.1 shows the tax burden of both MNCs in both Euroland and Bengodi. As we can see, it makes no difference where Alpha is located, as in both cases the tax burden is 15 euros. On the contrary, the rent-seeking MNC Beta will prefer to invest in Bengodi as its rents will be taxed at a lower rate.

This argument was used by Bond (2000) to contrast an ACE-type system with a CBIT one. He argued that, in a closed economy, ACE tax is neutral as it reduces the user cost of capital under equity-financing, while leaving the tax treatment of debt unchanged. On the other hand, under CBIT, interest payments are not deductible: in this case, therefore, the user cost of debt-financed capital investment rises. To show this result, it is sufficient to use the standard neoclassical model, already discussed in section 4.1. As shown in chapter 4 (equation (4.1)), the optimal amount of capital without taxation is such that the marginal product of capital equates its marginal cost, namely $\pi = r$. Under an ACE-type tax system, the after-tax marginal product under full debt financing is equal to

$$\pi^N = (1 - \tau_{ACE})(\pi - r),$$

where τ_{ACE} is the relevant tax rate.[1] In this case, capital can be optimally accumulated until $\pi^N = 0$. This means that for the marginal unit of capital we have $\pi = r$. Therefore, we can conclude that ACE ensures neutrality under debt financing.

Under CBIT, the after-tax marginal product is equal to

$$\pi^N = (1 - \tau_{CBIT})\pi - r.$$

[1] Under full debt financing, the ACE has the same effect as a S-H-S tax ensuring full deductibility of interest expenses.

At point $\pi^N = 0$, therefore, the user cost of capital is

$$\pi = \frac{r}{1 - \tau_{CBIT}} > r.$$

So, in a closed economy, ACE's neutrality properties make ACE preferable to CBIT.

In a small open economy, however, the ACE system has a major drawback. To be revenue neutral, it requires a higher statutory rate on rents. Whereas in a closed economy the taxation of economic rents is an efficient way of collecting revenue without affecting business strategies, these effects might be dramatically different in an open economy. Firstly, companies would be stimulated to shift profits towards less taxed jurisdictions. Secondly, in a world where product and capital markets are not perfectly competitive, high statutory and average tax rates may significantly affect both the investment and location decisions of the MNCs. As underlined by theoretical and empirical literature (see e.g. Devereux and Griffith 1998, 1999, 2002, and Desai and Hines, 1999), for highly mobile MNCs, the statutory and effective average tax rates on profits might even be more important for investment and location decisions than the effective marginal tax rate. This may help explaining why CBIT may be preferred to ACE tax; since CBIT is levied on a broader tax base, it requires a lower tax rate to raise a given amount of revenue. Hence, mobile MNCs, who usually earn rents, face a less burdensome tax under such a system.

It is worth noting that CBIT is distortive even under equity financing, as long as there are tax-exempt entities (such as pension funds), which operate in the international capital market. In this case, investors have the opportunity to choose between taxable FDI projects and tax-exempt financial investments, yielding the risk-free interest rate r. The distortive effect is due to the fact that CBIT taxes normal income. To show this distortion, we could recall the neoclassical model. Under a CBIT system, the after-tax marginal product is equal to

$$\pi^N = (1 - \tau_{CBIT})\,\pi.$$

We know that the MNC's opportunity cost is given by the net return ensured by tax-free entities, namely r. Therefore, the optimal investment strategy is to accumulate until the equality $\pi^N = r$ is reached, and the user cost of capital is thus equal to

$$\pi = \frac{r}{1-\tau_{CBIT}} > r.$$

Since the MNC's user cost is higher than r, we can say that CBIT leads to underinvestment.

Under an ACE system, instead, investment neutrality is ensured. In this case, the after-tax marginal product is

$$\pi^N = (1-\tau_{ACE})\,\pi + \tau_{ACE}\rho_{ACE},$$

where ρ_{ACE} is the imputation rate. Again, the optimal investment strategy is to accumulate capital until the equality $\pi^N = r$ holds. If, according to the IFS' proposal, we set $\rho_{ACE} = r$, normal income is exempted, and the user cost is equal to $\pi = r$. Therefore, neutrality holds.

7.2 A real-option perspective

Bond's (2000) reasoning disregards two important features of FDI: their intrinsic risky nature and the ability of MNCs to choose when to invest. As we know, business projects are opportunities rather than obligations. Moreover investment plans must usually have a minimum size in order to be profitable. In other words, installing 50%, 70% or even 99% of a plant or machinery yields no return. For this reason, the standard marginal model does not fit with discrete FDI.[2]

As pointed out in chapter 5, MNCs can usually decide when to invest, thereby enjoying a certain degree of flexibility. Using a real-option approach, we showed (Panteghini, 2004a) that a high-income MNC investing in an ACE system faces a heavier tax burden at each instant. However, the MNC may find it optimal to invest earlier under an ACE system, and thus it enjoys a longer stream of income.

[2] This point was discussed by Devereux and Griffith (1998, 1999). As they pointed out, the standard literature on income taxation focuses on the impact of tax on marginal investment decisions. In this case, the principal impact of tax on investment is through the user cost of capital. In many cases, however, investors face a choice between mutually exclusive projects. A good example of this is the location of FDIs by MNCs. In this case, therefore, the MNC chooses the location which ensures the highest expected average rate of return.

If, therefore, this latter effect is big enough, the MNC will prefer the ACE system even in an open economy.

To prove this we use the continuous-time model applied in the previous chapters. We will focus on the investment strategies of a representative MNC, that can decide when and where to invest. As usual, we assume that risk is fully diversifiable, and that the MNC's income follows a geometric Brownian motion (see equation (2.1)), with zero drift, namely

$$d\Pi = \sigma \Pi dz, \text{ with } \Pi_0 > 0.$$

The MNC starts to earn Π once investment I has been undertaken. With no loss of generality we will assume that I does not depreciate.[3] For simplicity, we will also assume that the MNC is entirely equity financed, and that tax-exempt entities offer a tax-free return equal to r. As we have shown in section 7.1, ACE is expected to be neutral in terms of investment decisions.

Let us next assume that the tax base of system i is given by the MNC's current income, net of the imputation cost $\rho_i I$. This notation allows a comparison between different tax systems. If we set $\rho_{ACE} = r$ and $\rho_{CBIT} = 0$, we obtain an ACE and a CBIT system, respectively. Given the tax rate τ_i, current tax payments are thus equal to

$$T_i(\Pi) = \tau_i (\Pi - \rho_i I), \text{ with } i = ACE, CBIT. \tag{7.1}$$

Using (7.1), we obtain the after-tax income:

$$\Pi_i^T = (1 - \tau_i)\Pi + \rho_i \tau_i I. \tag{7.2}$$

Let us next calculate the MNC's after-tax project value $V_i^T(\Pi)$ under system i. As shown in appendix 7.4.1 we obtain a perpetual rent

$$V_i^T(\Pi) = \frac{(1 - \tau_i)\Pi}{r} + \tau_i \frac{\rho_i}{r} I, \tag{7.3}$$

where $\tau_i \frac{\rho_i}{r} I$ is the present value of the tax benefit due to the deduction of the opportunity cost.

[3] As we showed in Panteghini (2002), the quality of results does not change if we have both a non-zero drift and depreciation.

Let us now calculate the MNC's option to invest. As shown in appendix 7.4.2 the option function is equal to

$$O(\Pi) = A_{i1}\Pi^{\beta_1}, \tag{7.4}$$

where A_{i1} is an unknown parameter to be found.

To find the optimal trigger point Π_i^*, and the value of A_{i1}, we can substitute (7.3) and (7.4) into the VMC and SPC, namely we set:

$$\begin{cases} V(\Pi_i^*) - I = O(\Pi_i^*), \\ \left.\frac{\partial[V(\Pi)-I]}{\partial\Pi}\right|_{\Pi=\Pi_i^*} = \left.\frac{\partial O(\Pi)}{\partial\Pi}\right|_{\Pi=\Pi_i^*}. \end{cases} \tag{7.5}$$

Solving the two-equation system (7.5), we obtain the MNC's after-tax trigger point

$$\Pi_i^* \equiv \frac{1-\frac{\rho_i}{r}\tau_i}{1-\tau_i}\overline{\Pi}, \tag{7.6}$$

where

$$\overline{\Pi} \equiv \frac{\beta_1}{\beta_1 - 1} rI > rI$$

is the laissez-faire trigger point, and

$$A_{i1} = \frac{1}{\beta_1}\frac{1-\tau_i}{r}\Pi_i^{*\beta_1 - 1} > 0.$$

Given (7.6), we can argue that immediate investment is undertaken if $\Pi > \Pi_i^*$. If, instead, $\Pi < \Pi_i^*$, the MNC will wait until Π reaches Π_i^*.

As we know, the option value multiple $\frac{\beta_1}{\beta_1-1} > 1$ accounts for the additional return required to compensate for investment option exercise. According to the static NPV approach, the differential $\left(\frac{\overline{\Pi}}{I} - r\right)$ would be considered a rent. In an endogenous-time setting, instead, $\left(\frac{\overline{\Pi}}{I} - r\right)$ measures the additional income required to cover the option value multiple. Therefore, it cannot be considered as above-normal income. It is worth noting that this result, *per se*, may explain why MNCs' average operating profits may be relatively high: the reason may simply be that higher operating profits are necessary to cover not only the sunk costs faced when MNCs locate FDIs abroad, but also the MNCs' loss in terms of business flexibility. Therefore, the fact that MNCs often face higher operating profits than those earned by domestic firms does not necessarily mean that they earn higher *net* profits.

Notice that, according to the IFS Capital Taxes Group's (1991) proposal, the imputation rate should be equal to the risk-free return. It is thus easy to show the following:

Proposition 14 *Under an ACE tax system (i.e., with* $\rho_{ACE} = r$*), we have*

$$\Pi^*_{ACE} = \overline{\Pi},$$

while under a CBIT (i.e., with $\rho_{CBIT} = 0$*), we obtain*

$$\Pi^*_{CBIT} = \frac{\overline{\Pi}}{1 - \tau_{CBIT}} > \overline{\Pi}. \tag{7.7}$$

According to proposition 14, the tax system is neutral in terms of investment timing. This neutrality result is equivalent to that obtained in the previous section with a standard neoclassical model. As shown by inequality (7.7), CBIT raises the MNC's trigger point, thereby delaying investment timing.

Despite the fact that these results are equivalent to those obtained in a neoclassical model, policy implications will be different whenever we deal with investment timing. On the one hand, we know that the CBIT system is characterized by a broader tax base. Thus, it requires a lower tax rate in order to raise a given amount of revenues. At any instant, therefore, high-income MNCs face a lighter tax burden. On the other hand, proposition 14 shows that:

$$\Pi^*_{ACE} = \overline{\Pi} < \Pi^*_{CBIT}.$$

In other words, companies investing in the ACE country invest earlier than under a CBIT. Therefore they enjoy a *longer* stream of profits. By accounting for these offsetting effects, the MNC's will thus choose the optimal locational strategy.

7.3 The MNC's strategy

In order to study the locational choice of a representative MNC, we must remember that if $\Pi > \Pi^*_i$ the MNC invests immediately; in this case, timing does not matter, and so the MNC's project value is simply $\left[V_i^T(\Pi) - I\right]$. If, instead, $\Pi < \Pi_i^*$, the MNC waits and timing must be accounted for.

Using the results of appendix 2.4.4, we can say that the MNC's value can be written as

$$\max_t \xi\left\{\left[V_i^T(\Pi) - I\right] e^{-rt}\right\}. \tag{7.8}$$

The solution of problem (7.8), defined as t_i^*, is the optimal time of investment. If, therefore, $t \geq t_i^*$ immediate investment is undertaken. If, instead, $t < t_i^*$, the firm will wait until $t = t_i^*$. It is worth noting that t_i^* may differ from the laissez-faire optimal timing. In this case, taxation distorts investment timing.

As pointed out in appendix 2.4.1, a Brownian motion satisfies the Markov property. Namely, the probability of distribution for all future values of Π depends only on its current value. Applying this property and using the trigger point Π_i^*, one can rewrite (7.8) as

$$\max_t \xi\left\{\left[V_i^T(\Pi) - I\right] e^{-rt}\right\} = \xi\left[e^{-rt_i^*}\right] \cdot \left[V_i^T(\Pi_i^*) - I\right]. \tag{7.9}$$

Following Harrison (1985) we can state that

$$\xi\left[e^{-rt_i^*}\right] = \left(\frac{\Pi}{\Pi_i^*}\right)^{\beta_1} \quad \text{for } \Pi < \Pi_i^*,$$

where the term $\left(\frac{\Pi}{\Pi_i^*}\right)^{\beta_1}$ is the present value of 1 Euro contingent on future investment and measures the expected discount factor. We can thus rewrite (7.9) as follows

$$\Gamma_i\left(\Pi, \Pi_i^*\right) = \begin{cases} \left(\frac{\Pi}{\Pi_i^*}\right)^{\beta_1} \cdot \left[\frac{(1-\tau_i)\Pi_i^*}{r} - \left(1 - \frac{\rho_i}{r}\tau_i\right) I\right], & \text{if } \Pi < \Pi_i^*, \\ \left[\frac{(1-\tau_i)\Pi}{r} - \left(1 - \frac{\rho_i}{r}\tau_i\right) I\right], & \text{otherwise.} \end{cases} \tag{7.10}$$

Similarly, we can calculate the MNC's expected tax burden. If $\Pi < \Pi_i^*$, the MNC postpones investment and, therefore, the expected present value of tax payments, defined as $R_i(\Pi)$, depends on both the current level of Π and Π_i^*. If $\Pi > \Pi_i^*$, instead, investment is immediate and only Π matters. As shown in appendix 7.4.3 we obtain

$$R_i(\Pi) = \begin{cases} \tau_i \left(\frac{\Pi}{\Pi_i^*}\right)^{\beta_1} \frac{\Pi_i^* - \rho_i I}{r} & \text{if } \Pi < \Pi_i^*, \\ \tau_i \left(\frac{\Pi - \rho_i I}{r}\right) & \text{otherwise.} \end{cases} \tag{7.11}$$

Functions (7.10) and (7.11) will be used to compare the ACE and the CBIT system.

Let us next analyze the tax preferences of the representative MNC in an open economy. To do so, we assume the existence of two small open countries. The first country applies an ACE system (i.e., $\rho_{ACE} = r$) with the tax rate τ_{ACE}. The second country implements a CBIT system (i.e., $\rho_{CBIT} = 0$) with the tax rate τ_{CBIT}. The representative MNC must decide in which country to invest. Given these assumptions we can prove the following:

Proposition 15 *For any given tax burden, i.e., for*

$$R_{ACE}(\Pi) = R_{CBIT}(\Pi) \ \ \forall \Pi > 0, \tag{7.12}$$

the MNC will prefer the ACE country if $\Pi < \Pi_{CBIT}^*$. *Otherwise, the MNC will be indifferent.*

Proof. See appendix 7.4.4. ∎

Proposition 15 shows that a CBIT is never preferred to an ACE system for any given tax burden. Since the MNC investing in the ACE country starts to earn profits earlier, it enjoys a longer stream of income. Given this result, we can see that the average effective tax rate is lower under the ACE system, i.e., we have

$$\frac{R_{ACE}(\Pi)}{\Gamma_{ACE}\left(\Pi, \Pi_{ACE}^*\right) + R_{ACE}(\Pi)} < \frac{R_{CBIT}(\Pi)}{\Gamma_{CBIT}\left(\Pi, \Pi_{CBIT}^*\right) + R_{CBIT}(\Pi)}.$$

Thus the timing effect makes the ACE regime preferable for $\Pi < \Pi_{CBIT}^*$.

Proposition 15 is a preliminary result but does not respond to the main argument against the ACE system. If, in fact, the governments set tax rates in line with normal returns, the CBIT might be preferred by MNCs earning extra-profits.

In order to put forward a conjecture on the actual tax rates set by the governments, we assume that governments' target is a "normal"

MNC with "normal" returns. To this end we need to specify what normal returns are. Given that for $\Pi < \overline{\Pi}$, no FDI is observed, it seems plausible to assume that the expected income is actually $\overline{\Pi}$.[4] Along this line of reasoning, we thus introduce the following:

Assumption 23 *The CBIT country sets τ_{CBIT}, and, in turn, the ACE country sets τ_{ACE} such that*

$$R_{ACE}\left(\overline{\Pi}\right) = R_{CBIT}\left(\overline{\Pi}\right). \tag{7.13}$$

Assumption 23 defines $\overline{\Pi}$ as normal income and provides a criterion to determine a plausible value of tax rates. According to this assumption, therefore, both countries consider the laissez-faire trigger point $\overline{\Pi}$ as the normal return and set tax rates in order to collect the same tax revenues. Given proposition 15, the "normal" MNC chooses the ACE country and invests immediately. However, the focus of our analysis is not on normal returns but rather on FDI decisions yielding an above-normal profitability. For this reason, we will analyze the investment decisions by MNCs whose current income is high enough, i.e., $\Pi > \Pi^*_{CBIT}$. According to traditional wisdom, these MNCs would choose a CBIT country. As will be shown, the converse may be true when a MNC can time investment. Indeed, we can prove that:

Proposition 16 *Given assumption 23, a high-income MNC, i.e., with $\Pi > \Pi^*_{CBIT}$, will prefer the ACE system if:*

i) *either τ_{CBIT} is low enough and $\Pi \in \left(\Pi^*_{CBIT}, \widehat{\Pi}\right)$, with*

$$\widehat{\Pi} \equiv \frac{\beta_1 \left(1-\tau_{CBIT}\right)^{\beta_1 - 1}}{\beta_1 \left(1-\tau_{CBIT}\right)^{\beta_1 - 1} - 1} rI;$$

ii) *or τ_{CBIT} is high enough.*

Proof. See appendix 7.4.5. ■

Proposition 16 highlights the importance of timing on MNCs' locational choices. In particular, it shows that even if above-normal returns are taxed at a higher rate, the ACE system may be preferred. In line with the traditional results, it is shown that the CBIT

[4] Therefore, the normal MNC's ROA is $\overline{\Pi}/I$.

TABLE 7.2. MNC's returns exceeding the risk-free interest rate (in percentage points)

	$\tau_{CBIT} = 31\%$	$\tau_{CBIT} = 25\%$
τ^*_{ACE}	42.78	37.50
$\frac{\overline{\Pi}}{I} - r$	4.00	4.00
$\frac{\Pi^*_{CBIT}}{I} - r$	7.59	6.67
$\frac{\widehat{\Pi}}{I} - r$	10.52	8.00

system may be preferred if both τ_{CBIT} is low enough and the MNC's income is high enough. In what follows, however, we will show that even if there exists a threshold value $\widehat{\Pi}$ above which the CBIT is preferred (see point i) of proposition 16), this is much higher than usually thought. Let us next run a simulation and compare the results with Fama and French's (1997) estimates of 48 US industries, over the 1963-1994 period. In line with empirical evidence, we also set $r = 0.04$ and $\sigma = 0.20$.[5] Given these parameters, we can show that if $\tau_{CBIT} < 50\%$, then point i) of proposition 16 will be applied.

We analyze two scenarios. In the first one, we set $\tau_{CBIT} = 31\%$, which is the rate suggested in 1992 by the US Treasury Department. In this case, the ACE tax rate ensuring equality (7.13) will then be $\tau^*_{ACE} = 42.78\%$. In the second scenario, we account for some tax competition pressure, registered over the last decade, and set $\tau_{CBIT} = 25\%$. In this case, condition (7.13) is met if the ACE tax rate is $\tau^*_{ACE} = 37.50\%$.

We can now calculate the MNC's returns exceeding the risk-free interest rate. As shown in table 7.2, if the net return is 4% then investment is immediately undertaken under the ACE system. If the CBIT system is considered, the threshold return is higher (6.67%). The last row of table 7.2 finally shows the threshold values below which the ACE country is preferred (according to proposition 16).

Let us then compare these results with Fama and French's estimates. Under a three-factor model, if $\tau_{CBIT} = 31\%$, only real estates among the 48 industries shows a capital cost which is slightly higher than the threshold return $\left(\frac{\widehat{\Pi}}{I} - r\right)$ (i.e., 11.16% versus 10.52%). When we set $\tau_{CBIT} = 25\%$, 12 industries show an average return

[5] These parameter values are in line with the data provided by Jorion and Goetzman (1999), and by Dimson, Marsh and Staunton (2002).

which overcomes $\left(\frac{\widehat{\Pi}}{I}-r\right)$. If, finally, a CAPM is applied, all industries' returns are far below $\left(\frac{\widehat{\Pi}}{I}-r\right)$, irrespective of the value of τ_{CBIT} applied. We can therefore conclude that, in most industries, the ACE system would be preferred.

It is worth noting that the time effect is amplified when the MNC's capital structure is chosen optimally. As we have shown in a recent article (Panteghini, 2007), if full deduction of interest expenses is allowed and firms can optimally choose their capital structure, under a consumption-based system, debt financing induces the firm to invest earlier in order to benefit from interest deductibility. Therefore, an ACE tax is even more attractive whenever debt financing is assumed.

A caveat to these results is however necessary. In this chapter we do not account for tax avoidance. The existence of a significant tax rate differential $(\tau^*_{ACE}-\tau_{CBIT})$ would ensure a tax benefit to the MNCs that could locate FDI in both countries, rather than in one of them. In this case, therefore, MNCs would indeed save taxation by shifting profits from the ACE to the CBIT country. Profit shifting would therefore be an additional benefit for the CBIT country. In order to offset tax avoidance, however, advocates of imputation systems could recommend the introduction of a DIT. By taxing normal income at a lower rate, the DIT would require a lower upper tax rate in order to raise a given amount of revenues. Therefore, by reducing the tax rate differential on above-normal income, the DIT would reduce the MNCs' incentive to shift income towards the CBIT country.

7.4 Appendix

7.4.1 The MNC's present value (7.3)

Let us write the Bellman function of $V_i^T(\Pi)$ as

$$V_i^T(\Pi)=\Pi_i^T dt+e^{-rdt}\xi\left[V_i^T(\Pi+d\Pi)\right]. \tag{7.14}$$

Let us expand the RHS of (7.14), apply Itô's Lemma and simplify so as to obtain

$$rV_i^T(\Pi)=\Pi_i^T+\alpha\Pi V_{i_\Pi}^T+\frac{\sigma^2}{2}\Pi^2 V_{i_{\Pi\Pi}}^T, \tag{7.15}$$

where $V^T_{i_\Pi} \equiv \frac{\partial V^T_i(\Pi)}{\partial \Pi}$, and $V^T_{i_{\Pi\Pi}} \equiv \frac{\partial^2 V^T_i(\Pi)}{\partial \Pi^2}$. The general solution of (7.15) is

$$V^T_i(\Pi) = G + H_0\Pi + \sum_{j=1}^{2} H_j \Pi^{\beta_j}, \tag{7.16}$$

with $i = ACE, CBIT$. Following the well-known procedure of chapter 2 we substitute (7.16) into (7.15), thus obtaining

$$r(G + H_0\Pi + \sum_{j=1}^{2} H_j\Pi^{\beta_j}) = \Pi^T_i + \alpha\Pi \left(H_0 + \sum_{j=1}^{2} \beta_j H_j \Pi^{\beta_j - 1} \right) +$$

$$+\frac{\sigma^2}{2}\Pi^2 \left[\sum_{j=1}^{2} \beta_j \left(\beta_j - 1\right) H_j \Pi^{\beta_j - 2} \right],$$

where $G = \tau_i \frac{\rho_i}{r} I$, $H_0 = \frac{1-\tau_i}{r}$, $\beta_1 = \frac{1}{2} - \frac{\alpha}{\sigma^2} + \sqrt{\left(\frac{\alpha}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2r}{\sigma^2}} > 1$, and $\beta_2 = \frac{1}{2} - \frac{\alpha}{\sigma^2} - \sqrt{\left(\frac{\alpha}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2r}{\sigma^2}} < 0$.[6]

Let us next calculate H_j for $j = 1, 2$. As regards H_2, we know that $\Pi = 0$ is an absorbing barrier and that the condition $V^T_i(0) = 0$ holds. This implies that $H_2 = 0$. Moreover, in the absence of financial bubbles we have $H_1 = 0$. Applying these boundary conditions to (7.16) we thus obtain (7.3).

7.4.2 The MNC's option value (7.4)

Let us write the Bellman function of $O^T_i(\Pi)$, i.e.,

$$O^T_i(\Pi) = e^{-rdt}\xi \left[O^T_i(\Pi + d\Pi) \right]. \tag{7.17}$$

Expanding the RHS of (7.17), applying Itô's Lemma, and simplifying gives the following general closed-form solution

$$O^T_i(\Pi) = \sum_{j=1}^{2} A_{ij}\Pi^{\beta_j}, \text{ with } i = ACE, CBIT. \tag{7.18}$$

As shown in appendix 2.4.2, we have $A_{i2} = 0$. Therefore, (7.18) reduces to (7.4).

[6] β_1 and β_2 are the same roots obtained in appendix 2.4.2.

7.4.3 *The calculation of (7.11)*

The present value of tax payments is equal to

$$R_i = \xi \left\{ e^{-rt_i^*} \left[\int_{t_i^*}^{\infty} T_i(s) e^{-rs} ds \right] \right\}. \tag{7.19}$$

Easy calculations show that if $\Pi > \Pi_i^*$, the present value of tax payments is simply

$$R_i = \tau_i \left(\frac{\Pi - \rho_i I}{r} \right). \tag{7.20}$$

If, otherwise, $\Pi < \Pi_i^*$, the MNC's optimal strategy is to wait. As we have seen, we can rewrite (7.19) as

$$\xi \left\{ e^{-rt_i^*} \left[\int_{t_i^*}^{\infty} T_i(s) e^{-rs} ds \right] \right\} = \left(\frac{\Pi}{\Pi_i^*} \right)^{\beta_1} \tau_i \left(\frac{\Pi_i^* - \rho_i I}{r} \right). \tag{7.21}$$

Using (7.20) and (7.21) we thus obtain (7.11).

7.4.4 *Proof of proposition 15*

Given inequality $\Pi^*_{ACE} = \overline{\Pi} < \Pi^*_{CBIT}$, we have three cases:

1. $\Pi < \Pi^*_{ACE} < \Pi^*_{CBIT}$;
2. $\Pi^*_{ACE} < \Pi < \Pi^*_{CBIT}$;
3. $\Pi^*_{ACE} < \Pi^*_{CBIT} < \Pi$.

We will analyze these cases under condition (7.12).

Case 1: $\Pi < \Pi^*_{ACE} < \Pi^*_{CBIT}$

If $\Pi < \Pi^*_{ACE}$, under both regimes the MNC will postpone investment. In this case, ACE is preferred to CBIT if the ACE before-tax NPV is greater than the CBIT one. Given (7.10), (7.11) and (7.12), the ACE system is preferable if

$$\left(\frac{\Pi}{\Pi^*_{ACE}} \right)^{\beta_1} \left(\frac{\Pi^*_{ACE}}{r} - I \right) > \left(\frac{\Pi}{\Pi^*_{CBIT}} \right)^{\beta_1} \left(\frac{\Pi^*_{CBIT}}{r} - I \right). \tag{7.22}$$

Inequality (7.22) can be rewritten as

$$g(\tau_{CBIT};\beta_1) \equiv (1-\tau_{CBIT})^{-(\beta_1-1)}\left[\frac{1}{\tau_{CBIT}(\beta_1-1)+1}\right] > 1.$$

Notice that $g(0;\beta_1)=1$ and that $\frac{\partial g(\tau_{CBIT};\beta_1)}{\partial \tau_{CBIT}} > 0$. This is sufficient to prove that $g(\tau_{CBIT};\beta_1) > 1$ for any $\tau_{CBIT} > 0$. Accordingly, (7.22) always holds for any $\tau_{CBIT} > 0$.

Case 2: $\Pi^*_{ACE} < \Pi < \Pi^*_{CBIT}$

If $\Pi^*_{ACE} < \Pi < \Pi^*_{CBIT}$, investment is immediately undertaken in the ACE country, while it is postponed in the CBIT one. Given (7.12), the ACE country is preferred to the CBIT one if

$$\left(\frac{\Pi}{r}-I\right) > \left(\frac{\Pi}{\Pi^*_{CBIT}}\right)^{\beta_1}\left(\frac{\Pi^*_{CBIT}}{r}-I\right). \tag{7.23}$$

Inequality (7.23) can be rewritten as $f(\Pi) > f(\Pi^*_{CBIT})$, where $f(\Pi) \equiv (\Pi - rI)\,\Pi^{-\beta_1}$ and $f(\Pi^*_{CBIT}) \equiv (\Pi^*_{CBIT}-rI)\,\Pi^{*-\beta_1}_{CBIT}$. We can show that

$$\frac{\partial f(\Pi)}{\partial \Pi} = \frac{(\beta_1-1)\left(\overline{\Pi}-\Pi\right)}{\Pi^{\beta_1+1}}.$$

Since $\Pi \in (\Pi^*_{ACE}, \Pi^*_{CBIT})$, we also have $\frac{\partial f(\Pi)}{\partial \Pi} < 0$. This is sufficient to state that inequality $f(\Pi) > f(\Pi^*_{CBIT})$ holds for any $\Pi \in (\Pi^*_{ACE}, \Pi^*_{CBIT})$. Hence, (7.23) always holds.

Case 3: $\Pi^*_{ACE} < \Pi^*_{CBIT} < \Pi$

If, finally, $\Pi > \Pi^*_{CBIT}$, the MNC will immediately invest irrespective of the tax system. Given condition (7.12), the before-tax present value will be $\left(\frac{\Pi}{r}-I\right)$, under both systems. This leads to indifference. Proposition 15 is thus proven.■

7.4.5 Proof of proposition 16

According to assumption 23, the ACE country sets τ_{ACE} so as to obtain (7.13). Substituting (7.11) into (7.13) gives

$$\tau_{ACE}\left(\frac{\Pi^*_{ACE}}{r}-I\right) = \left(\frac{\Pi^*_{ACE}}{\Pi^*_{CBIT}}\right)^{\beta_1}\tau_{CBIT}\left(\frac{\Pi^*_{CBIT}}{r}\right). \tag{7.24}$$

Using (7.6), equation (7.24) reduces to

$$\tau_{ACE} = \beta_1 \tau_{CBIT} \left(1 - \tau_{CBIT}\right)^{\beta_1 - 1}. \tag{7.25}$$

Given (7.25), we can therefore show that

$$\tau_{ACE} > \tau_{CBIT} \text{ if } \beta_1 \left(1 - \tau_{CBIT}\right)^{\beta_1 - 1} > 1,$$

and vice versa.

Let us next focus on the high-income MNC (with $\Pi > \Pi^*_{CBIT}$). Define $NB(\Pi)$ as the net benefit arising from investing in the ACE country. $NB(\Pi)$ is given by the difference between the after-tax NPV under the ACE regime and that obtained under the CBIT one. Notice that, given inequality $\Pi > \Pi^*_{CBIT}$, the MNC will immediately invest irrespective of the tax system. Thus, $NB(\Pi)$ will be

$$NB(\Pi) = \frac{(1-\tau_{ACE})(\Pi - rI) - [(1-\tau_{CBIT})\Pi - rI]}{r}, \text{ for } \Pi > \Pi^*_{CBIT}. \tag{7.26}$$

If $\tau_{ACE} > \tau_{CBIT}$, i.e.,

$$\beta_1 \left(1 - \tau_{CBIT}\right)^{\beta_1 - 1} > 1,$$

the level of current income is crucial for the MNC's preferences. Substituting (7.25) into (7.26) gives

$$NB(\Pi) = \frac{\tau_{CBIT} \left[\beta_1 \left(1 - \tau_{CBIT}\right)^{\beta_1 - 1} - 1\right]}{r} \left(\widehat{\Pi} - \Pi\right),$$

with

$$\widehat{\Pi} \equiv \frac{\beta_1 \left(1 - \tau_{CBIT}\right)^{\beta_1 - 1}}{\beta_1 \left(1 - \tau_{CBIT}\right)^{\beta_1 - 1} - 1} rI > \Pi^*_{CBIT}.$$

This means that $NB(\Pi)$ is positive if $\Pi < \widehat{\Pi}$. Point i) is thus proven. Let us next turn to point ii). If $\tau_{ACE} < \tau_{CBIT}$, i.e.,

$$\beta_1 \left(1 - \tau_{CBIT}\right)^{\beta_1 - 1} < 1$$

we can show that

$$NB(\Pi) = \frac{(\tau_{CBIT} - \tau_{ACE})\Pi + \tau_{ACE} rI}{r} > 0, \quad \forall \Pi > 0.$$

This completes the proof of proposition 16.■

8

Risk-adjusted or risk-free imputation rate?

One of the most controversial aspects of imputation systems is the choice of the imputation rate. This is an important topic not only on theoretical grounds but also on tax policy grounds.

Theoretically, Boadway and Bruce (1984, p. 232) proposed "a simple and general result on the design of a neutral and inflation-proof business tax". According to their proposal, 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 they argued, however, each firm may have a firm-specific value of the imputation rate, which must reflect the investment-specific risk, 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 tax credit and liabilities are sure to be redeemed and that the tax rate is known and constant. He also proved that neutrality could be achieved by simply setting the deductible imputation rate equal to the risk-free nominal interest rate. "Since government bonds provide an (almost) certain nominal return", Fane argued that "it is not difficult to estimate the risk-free interest rate" (p. 99), and the tax design turns out to be much less informationally demanding. More recently, Bond and Devereux (1995) proved that an ACE-type system is neutral even when income, capital and default risk are assumed. They also proved that the imputation rate ensuring neutrality is equal to the nominal default-free interest rate.

On policy grounds, we know that many European countries have adopted imputation systems. However, the implementation of these systems mirrors the controversial results of the theoretical literature. While some countries have applied a risk-adjusted imputation rate,[1] others have preferred to set a risk-free imputation rate.[2]

It is worth noting that, so far, only a few articles have analyzed imputation systems under interest rate uncertainty. To deal with this topic we apply a discrete-time model, based on Panteghini (2001b).

8.1 The model

In line with chapter 1, we assume that a representative firm must decide when to undertake I. We assume that, at the end of each period, the firm will receive a constant cash flow. For simplicity, we omit default risk and assume that the firm's lifetime is infinite.

The short-term interest rate is a binomial 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. With no loss of generality, uncertainty vanishes at time 1 and the interest rate will remain constant forever.[3]

Let us finally assume the following inequalities:

$$\frac{r_2}{1+r_2}I > \Pi > \frac{r_1}{1+r_1}I,$$

which mean that if the ex-post rate of return of the entrepreneurial investment is less than the rate of return of a short-term bond, the

[1] As pointed out in chapter 6, Sweden sets an imputation rate that is equal to the interest rate on ten-year government bonds plus a risk premium of 5%. In Finland the imputation rate is set by the government and exceeds risk-free long-term interest rates. Croatia's Interest Adjusted Income Tax (IAIT) was equal to the growth rate of manufacturing prices plus 300 basis points. Italy's presumptive rate was proportional to the market interest rate on public and private bonds plus up to 300 basis points.

[2] In line with Fane (1987) and Bond and Devereux (1995), Norway's imputation rate is equal to the risk-free interest rate. Two other interesting examples are Denmark and Norway's petroleum tax reforms, discussed by Lund (2002a). These proposals were close to Garnaut and Clunies Ross' (1975) Resource Rent Tax (RRT), according to which only profits exceeding a given threshold are taxed. Both Denmark and Norway's commission proposed an imputation rate close to the risk-free interest rate.

[3] According to the model discussed in chapter 1, the first period lasts until time 1 and the second period lasts from time 1 to infinity.

financial investment is preferred to the entrepreneurial one and vice versa. This implies that an increase (decrease) in the short-term interest rate will be bad (good) news for the firm.

If the firm cannot postpone investment, it invests if the expected NPV at time 0 is positive, i.e.,

$$NPV_0 = \left[\sum_{t=1}^{\infty} \frac{q}{(1+r_1)^{t-1}} + \sum_{t=1}^{\infty} \frac{1-q}{(1+r_2)^{t-1}} \right] \frac{\Pi}{1+r} - I > 0. \quad (8.1)$$

Re-elaborating (8.1) we obtain

$$NPV_0 = \frac{\Pi}{r_c} - I, \quad (8.2)$$

where

$$r_c \equiv (1+r) \left[\sum_{t=1}^{\infty} \frac{q}{(1+r_1)^{t-1}} + \sum_{t=1}^{\infty} \frac{1-q}{(1+r_2)^{t-1}} \right]^{-1} = \\ = (1+r) \left[q \frac{1+r_1}{r_1} + (1-q) \frac{1+r_2}{r_2} \right]^{-1}$$

is the current consol rate of a long-term bond.[4] As can be seen, r_c is equal to 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 given by the probabilities of the events, q and $(1-q)$, respectively.[5]

As we know, if the present discounted value of future cash flow is greater than the investment cost, then the firm invests. The investment rule is therefore equal to (1.2), i.e., $\max\{NPV_0, 0\}$.

It is worth noting that Fane (1987) and Bond and Devereux (1995) apply a standard NPV rule to check whether neutrality holds. As we know, however, this rule is correct only if either the investment is reversible or it is irreversible, but the firm cannot delay it.

If the firm can delay the investment choice until time 1, we know that the positive value of NPV_0 is no longer a sufficient condition for investing at time 0. To decide when to invest (i.e., when to exercise

[4] If capital markets are perfect, the value of this consol bond today, namely $1/r_c$, is equal to its discounted expected value one period from today plus one coupon payment.

[5] For further details on state-contingent prices see e.g. Backus, Foresi and Telmer (2001).

the option), the firm must compare NPV_0 with its expected NPV at time 1, namely

$$NPV_1 = \frac{q}{1+r}\left[\sum_{t=1}^{\infty}\frac{\Pi}{(1+r_1)^{t-1}} - I\right] = \frac{q}{1+r}\left(\frac{\Pi}{r_1} - I\right). \quad (8.3)$$

As we know, NPV_1 does not account for 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. Equating (8.2) to (8.3) we obtain the trigger value of the short-term interest rate:

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

If, therefore, the current interest rate r is less than the trigger value r^*, then immediate investment is undertaken and vice versa. Given Bernanke's (1983) BNP, r^* depends only on unfavorable events (i.e., on the probability and the seriousness of bad news).[6]

For a better understanding of the firm's behavior, we can rewrite the firm's decision rule by using equations (8.2) and (8.3). We thus obtain:

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

where

$$r_m = \frac{r+(1-q)}{r_2+(1-q)}r_2 \quad (8.4)$$

is the adjusted interest rate, which accounts for the option to delay. As usual, the firm's decision rule is based on the comparison between the present discounted value of future cash flow and the investment cost. When the representative firm owns an option to wait, however, its discount rate is different: easy calculation shows that $r_m > r_c$. The interest rate differential $(r_m - r_c)$ measures the option to delay.

As shown by Berk (1999), r_m has an economic meaning. To show this, let us rewrite (8.4) as

$$\frac{1}{r_m} = \frac{1}{1+r}\left[q\frac{1+r_m}{r_m} + (1-q)\frac{1+r_2}{r_2}\right]. \quad (8.5)$$

[6] This trigger point is the same as that obtained by Ingersoll and Ross (1992) in a continuous-time setting.

The meaning of equation (8.5) is simple. The LHS is the current price of the long-term consol bond issued for financing the firm's investment. 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 no longer $\frac{1+r_1}{r1}$ but rather $\frac{1+r_m}{r_m}$, with

$$\frac{1+r_1}{r_1} > \frac{1+r_m}{r_m}.$$

To understand this different evaluation of good news, let us focus on the behavior 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, the firm might, in principle, finance its immediate investment by issuing a bond, which incorporates a prepayment option. The prepayment option allows borrowers to pay a fee in order to reimburse a loan earlier, and thus reduce the interest rate in charge. As shown in figure 8.1, if the interest rate decreases to r_1, the firm can exercise the prepayment (put) option thereby reimbursing the loan. Then, it issues a new bond at the current rate r_1. Therefore, if capital markets are perfect, 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 neutralized.

Note that setting 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. As we know, the Modigliani-Miller theorem tells us that, if capital markets are perfect, equity-financing is equivalent to debt-financing, namely an equity-debt swap does not alter the value of the firm.[7]

Finally, it is worth noting that neither r_c nor r_m are calculated by the firm. If capital markets are perfect, both of them are given by the market 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", that 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

[7] As shown in chapter 4, this equivalence holds on condition that default causes no sunk cost, that is $\upsilon = 0$.

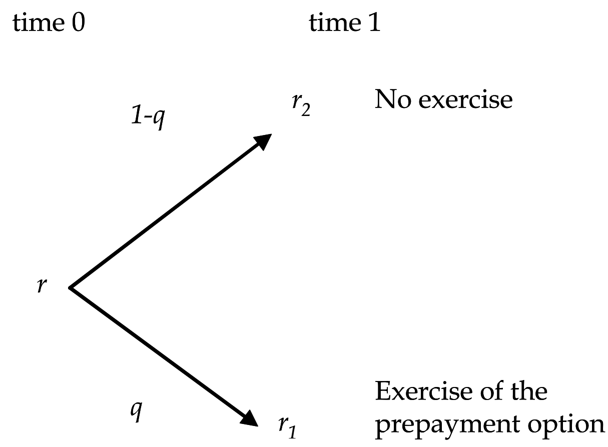

FIGURE 8.1. The exercise of the prepayment option

option) on the same bond. As argued by Berk (1999) such mortgage obligations exist and are listed in the US markets: they are 30-year bonds, guaranteed by the US government. Given their high rating, prices do not account for default risk.

8.2 Neutrality properties

Let us next introduce a dual tax system, where current earnings 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 calculate the ordinary return we define the imputed rate of return as ρ. Let $\varkappa$ and τ be the tax rate on the ordinary return and that on the residual profits (with $\varkappa < \tau$), respectively. Taxes are paid at the end of each period. For simplicity we assume that the project is fully equity-financed. Moreover, let us introduce the following:

Assumption 24 *The firm's discount rate is r.*

According to assumption 24, the opportunity cost of the representative firm is tax exempt. Tax exemption may be due to the fact that either no withholding tax is levied on interest income or the firm can exploit tax-exempt vehicles (e.g., pension funds) to avoid the withholding tax.[8]

If the firm cannot postpone investment (namely, it can invest either at time 0 or never), the NPV of the expected tax burden is equal to

$$T_0 = \left[\sum_{t=1}^{\infty} \frac{q}{(1+r_1)^{t-1}} + \sum_{t=1}^{\infty} \frac{1-q}{(1+r_2)^{t-1}} \right] \frac{\varkappa \rho I + \tau(\Pi - \rho I)}{1+r} = \\ = \frac{\varkappa \rho I + \tau(\Pi - \rho I)}{r_c}. \tag{8.6}$$

Using equations (8.2) and (8.6), we obtain the after-tax NPV of the project

$$NPV_0 - T_0 = (1-\tau)\left(\frac{\Pi}{r_c} - I\right) + \left[(\tau - \varkappa)\frac{\rho}{r_c} - \tau\right] I. \tag{8.7}$$

Clearly, if $\varkappa = 0$, we turn to an ACE-type scheme, i.e.,

$$NPV_0 - T_0 = (1-\tau)\left(\frac{\Pi}{r_c} - I\right) + \tau\left(\frac{\rho}{r_c} - 1\right) I.$$

Let us next focus on the neutrality properties of the imputation scheme. As we know, the firm's decision depends on the sign of the after-tax NPV of its project at time 0. Namely, if $(NPV_0 - T_0)$ is positive, investing is profitable. Following Brown (1948), we can say that a tax system is neutral if the after-tax NPV is $(1-\tau)$ times the before-tax NPV, i.e., condition (1.11) holds. In order to obtain neutrality, therefore, the second term in the RHS of (8.7) must be nil. It is easy to show that if we set

$$\rho_c^* = \frac{\tau}{\tau - \varkappa} r_c,$$

equation (8.7) reduces to

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

[8] For further details on this point, see Lund (2002a), who deals with the crucial choice on whether to apply an after-tax or a before-tax imputation rate. Using an after-tax imputation rate is optimal whenever the firm cannot avoid a withholding tax levied on interest income (i.e., on its opportunity cost) and vice versa. For a discussion of tax effects on the cost of capital see also Lund (2002b).

Therefore, we can see that when 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. This result is similar to that obtained by Fane (1987), who argued that the benchmark interest rate must be the nominal interest rate on government bonds since "tax credits are equivalent to 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 is an application of the Modigliani-Miller theorem.

Notice that the differential $(\rho_c^* - r_c)$ is independent of any stochastic factor, and hence cannot be interpreted as a risk premium. Rather, it is due to the existence of the minimum withholding tax $\varkappa$. This can be seen by switching to an ACE system: in this case, we have $\varkappa = 0$, and the imputation rate ρ_c^* is equal to the consol rate of interest r_c.

Let us now turn to the now-or-later case. In order to find the neutral imputation rate, we must calculate the expected present value of tax payments when the firm invests at time 1, i.e.,

$$T_1 = \frac{q}{1+r}\left[\sum_{t=1}^{\infty} \frac{\varkappa \rho I + \tau \left(\Pi - \rho I\right)}{\left(1+r_1\right)^t}\right]. \tag{8.8}$$

To check whether neutrality holds, we must account for the firm's option to wait. This modified condition arises from the comparison between the immediate undertaking of investment and its postponement. As shown in chapter 1, this implies that if we have

$$\left(NPV_0 - T_0\right) - \left(NPV_1 - T_1\right) = (1-\tau)\left(NPV_0 - NPV_1\right), \tag{8.9}$$

then the trigger value r^* is unaffected by taxation. According to condition (8.9), 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, this tax rate increase 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 nil.

Substituting equations (8.3), (8.7), and (8.8), into condition (8.9), we thus obtain

$$(NPV_0 - T_0) - (NPV_1 - T_1) =$$

$$= \tfrac{r+(1-q)}{1+r} \left\{ (1-\tau)\tfrac{\Pi}{r_m} - \left[1 - (\tau - \varkappa)\tfrac{\rho}{r_m} \right] I \right\}.$$

We can show that when the firm has an option to delay, the imputed return ensuring neutrality changes. If, in fact, we set the imputation rate equal to ρ_c^*, a distortion arises. Since $r_c < r_m$, we have the following inequality

$$(NPV_0 - T_0) - (NPV_1 - T_1) =$$

$$= \tfrac{r+(1-q)}{1+r} \left[(1-\tau)\tfrac{\Pi}{r_m} - \left(1 - \tfrac{r_c}{r_m}\tau \right) I \right] <$$

$$< (1-\tau)(NPV_0 - NPV_1).$$

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. Hence, the firm underinvests. In order to eliminate real distortions, we must set

$$\rho_m^* = \frac{\tau}{\tau - \varkappa} r_m.$$

In this case, we obtain (8.9). The reasoning behind 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. Again, the neutrality result is an application of the Modigliani-Miller theorem, which 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 break down the imputation rate as follows:

$$\rho_m^* = r_c + \frac{\varkappa}{\tau - \varkappa} r_c + \frac{\tau}{\tau - \varkappa}(r_m - r_c). \tag{8.10}$$

The first term of (8.10) is the interest rate on default-free long-term bonds, namely the imputation rate recommended by the IFS for ACE taxation. The term $\frac{\varkappa}{\tau-\varkappa} r_c$ is closely related to assumption 24, and represents the compensation for the dual treatment of the firm's earnings. Such compensation is necessary whenever the opportunity cost of the business activity is tax exempt, as we have assumed. When the firm is endowed with an option to wait, moreover, the term $\frac{\tau}{\tau-\varkappa}(r_m - r_c)$ must be added. As can be seen, this term is positively related to the risk premium $(r_m - r_c)$, and is negatively affected by the tax rate differential $(\tau - \varkappa)$.[9]

Note that ρ_m^* is the neutral imputation rate at time 0. Although the same neutrality rule holds at any time $t > 0$, the result is trivial when uncertainty vanishes. In this case, 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 finds it optimal to wait until uncertainty is resolved (namely at time 1), the neutral imputation rate is proportional to the current rate. Since investment is undertaken at time 1 (only if the interest rate drops to r_1), the neutral imputation rate is

$$\rho_1^* = \frac{\tau}{\tau - \varkappa} r_1.$$

It is worth noting that these results do not depend on the binomial stochastic process assumed. In Panteghini (2001b), we showed that results hold even when the interest rate follows a generic stochastic process and uncertainty does not vanish after one period. Accordingly, the neutral imputation rate must be proportional to the mortgage rate in order to take into account the firm's option to wait.

To conclude, we can say that the choice of the neutral imputation rate depends crucially on the nature of the firm's investment. If, indeed, investment is reversible, in line with Fane (1987), the neutral rate 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 owns an option to wait or not.

[9] Again, setting $\varkappa = 0$ one obtains the neutral ACE imputation rate. As can be seen, this rate is higher than that recommended by Bond and Devereux (1995), since they do not account for the risk premium due to irreversibility.

9

Full loss offset or no-loss offset?

Most of the existing neutrality results are based on two well-known conditions, namely that:

1. the treatment of profits and losses is symmetric;
2. the statutory tax rate is known and constant.

It is worth noting that both conditions are difficult to implement. In principle, the symmetry condition 1 entails the payment of a subsidy to loss-making firms. However, such a device would have at least two undesirable effects. First of all, loss-making firms might be inefficient ones; therefore, subsidies would finance inefficient business activities. Moreover, the existence of these subsidies would certainly encourage fraudulent losses. To offset these effects, the government has two alternatives. Firstly, it might allow the carrying forward of tax credits with interest at the risk-free rate: in doing so, the present value of tax credits would be preserved. Investors would be allowed to use these grossed-up credits whenever they earn sufficiently high profits.[1] As pointed out by Ball and Bowers (1983), however, future positive revenues might not be sufficient to use all the tax credit. In

[1] For a discussion of these tax devices see e.g. Bond and Devereux (1995), and Zee (2006).

this case, therefore, full symmetry could be ensured only by an *ad hoc* rebate. In other words, a subsidy would still be necessary.[2]

The second alternative device could be the trading of tax credits among taxpayers. In other words, profit-making firms could buy tax credits from loss-making firms. Using one of these mechanisms would at least partially remove tax asymmetries. However, the incentive to claim fraudulent losses would still exist. For this reason, the governments are reluctant to ensure full loss-offset.[3]

Condition 2 is also far from being realistic. Since the pioneering article of Lucas (1976), it became clear that a shock generated by a stochastic process has different effects from a change in the process itself. As argued by Dotsey (1990), when predicting the reaction of economic agents to tax rate changes, an economist should carefully consider agents' forecasting problems. Indeed, as pointed out by Sandmo (1979, p. 176), "academic discussions of tax reform in a world of unchanging tax rates is something of a contradiction in terms".

As pointed out in chapter 5, under policy uncertainty distortions are likely to cause a time inconsistency. Indeed, firms which have paid an 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 and 1978, and Mintz, 1995), unless a government precommits itself.

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[2] It is worth stressing what Auerbach (1986, p. 206) said in discussing the use of carryforward or carrybackward mechanisms. He pointed out that: "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". Therefore, this devices may be distortive. On this point see also Majd and Myers (1985), who noticed that for small projects, the firm's tax position may be exogenous, whereas large projects may affect the overall status of the firm. Thus, interactions between the firm's tax status and its size might be distortive.

[3] In discussing the Bond and Devereux (1995) proposal to introduce a fully symmetric tax scheme, 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 anecdotal evidence that both governments and companies commonly place considerably more value on cash flow than is measured by conventional NPV arithmetic" (pp. 308-309).

9.1 The role of tax loss offsets

To analyze the effects of tax loss offsets, we apply the discrete-time model of chapter 1. Therefore, we assume that risk is fully diversifiable and that the risk-free interest rate r is fixed. At time 0, 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 $(1-d)\Pi_0$ forever. Given inequalities (1.4), the upward (downward) jump is good (bad) news.

In order to study the effects of tax refunding, we focus on two alternative imputation systems. The first system is similar to that proposed by Garnaut and Clunies Ross (1975).[4] Namely, the tax base is given by the firm's income, net of an imputed income that is equal to the product between the rate ρ and the investment cost. This system is symmetric and, hence, when the firm's return is less than the imputation rate, the government fully subsidizes firms in a bad state.

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.

9.1.1 The symmetric scheme

Let us begin with the symmetric design. Define τ_t as the tax rate at time t. Furthermore, we can 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 expected value of tax revenues is equal to

$$\begin{aligned} T_0^R &= \tau_0 \left(\Pi_0 - \rho I \right) + \\ &+ \sum_{t=1}^{\infty} \frac{\tau_t}{(1+r)^t} \left\{ \left[q(1+u) + (1-q)(1-d) \right] \Pi_0 - \rho I \right\}. \end{aligned} \tag{9.1}$$

[4] Garnaut and Clunies Ross' (1975) proposal, called the Resource Rent Tax (RRT), was aimed to tax natural resource projects. According to this proposal, no deduction of interest payments were allowed, while investment costs were immediately written off. Once real cash flows had been calculated, the RRT was then levied on the portion of real cash flow that exceeded a pre-determined threshold rate of return, denoted by $x\%$. Such an imputation rate should have been in line with "international long-term lending rate". As pointed out by Lund (2002a), a RRT-type system was introduced in the Faroe Islands.

Setting $\tau_t = \tau_0$ for $t > 0$,[5] and using (9.1) we can write the expected after-tax NPV at time 0:

$$NPV_0 - T_0^R = (1-\tau_0)\left[1 + \tfrac{q(1+u)+(1-q)(1-d)}{r}\right]\Pi_0 - \\ - \left(1 - \tau_0 \tfrac{1+r}{r}\rho\right) I, \tag{9.2}$$

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 behavior, namely if the after-tax trigger point is equal to the laissez-faire one, Π_0^*. We can show that neutrality holds on condition that the imputation rate is equal to

$$\rho = \frac{r}{1+r}.$$

In this case, equation (9.2) reduces to

$$NPV_0 - T_0^R = (1-\tau_0) NPV_0,$$

with

$$NPV_0 \equiv \left\{\left[1 + \frac{q(1+u)+(1-q)(1-d)}{r}\right]\Pi_0 - I\right\}.$$

Let us now introduce the option to delay. To calculate the value of ρ ensuring neutrality we must also measure the firm's expected tax burden if investment is undertaken at time 1. Since the postponed investment is undertaken only if profits rise, the tax revenues' present discounted value is

$$T_1^R = \sum_{t=1}^{\infty} \frac{q\tau_0}{(1+r)^t}\left[(1+u)\Pi_0 - \rho I\right]. \tag{9.3}$$

Using (9.3), we can next calculate the expected after-tax NPV when the firm invests at time 1, i.e.,

$$NPV_1 - T_1^R = q\left[-\tfrac{I}{1+r} + \sum_{t=1}^{\infty} \tfrac{(1+u)\Pi_0}{(1+r)^t}\right] - \\ - \sum_{t=1}^{\infty} \tfrac{q\tau_0}{(1+r)^t}\left[(1+u)\Pi_0 - \rho I\right]. \tag{9.4}$$

[5] In the next section we will let τ_t differ from τ_0.

Again, if we set $\rho = \frac{r}{1+r}$, equation (9.4) reduces to

$$NPV_1 - T_1^R = q\,(1-\tau_0)\left[\frac{(1+u)\Pi_0}{r} - \frac{I}{1+r}\right],$$

and, therefore, neutrality holds. It is worth noting that this neutrality result holds if *all* future tax rates are both known and constant. In this case, given $\rho = \frac{r}{1+r}$, the present discounted value of all future tax deductions is

$$\tau_0 \sum_{t=0}^{\infty} \frac{\rho I}{(1+r)^t} = \tau_0 I,$$

and, therefore, the Garnaut-Clunies Ross tax design is equivalent to a cash-flow tax.[6]

9.1.2 The asymmetric scheme

Under tax asymmetry, if the firm invests at time 0, the present discounted value of all future tax payments is

$$\begin{aligned} T_0^{NR} &= \tau_0 \cdot \max\left[0, \Pi_0 - \rho I\right] + \\ &+ q \cdot \max\left\{0, \sum_{t=1}^{\infty} \tfrac{\tau_t}{(1+r)^t} \cdot \left[(1+u)\cdot \Pi_0 - \rho I\right]\right\} + \\ &+ (1-q) \cdot \max\left\{0, \sum_{t=1}^{\infty} \tfrac{\tau_t}{(1+r)^t} \cdot \left[(1-d)\Pi_0 - \rho I\right]\right\}. \end{aligned} \tag{9.5}$$

Using (9.5), one obtains the expected after-tax value of the project at time 0, namely,

$$\begin{aligned} NPV_0 - T_0^{NR} &= \\ &= \Pi_0 + \sum_{t=1}^{\infty} \tfrac{[q(1+u)+(1-q)(1-d)]\cdot \Pi_0}{(1+r)^t} - I - \\ &- \tau_0 \cdot \max\left[0, \Pi_0 - \rho I\right] - q \cdot \max\left\{0, \sum_{t=1}^{\infty} \tfrac{\tau_t[(1+u)\cdot \Pi_0 - \rho I]}{(1+r)^t}\right\} + \\ &- (1-q) \cdot \max\left\{0, \sum_{t=1}^{\infty} \tfrac{\tau_t}{(1+r)^t} \cdot \left\{(1-d)\cdot \Pi_0 - \rho I\right\}\right\}. \end{aligned} \tag{9.6}$$

[6] As pointed out by Bond and Devereux (1995), condition $\tau_t = \tau_0$ for $t > 0$ must hold even if the tax base coincides with the economic rent earned in each period.

In order for investment neutrality to hold, ρ must be higher than $\frac{r}{1+r}$. When the asymmetric device is introduced, indeed, 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.[7]

We can show that the calculation of the neutral imputation rate is easy when the firm is endowed with an option to delay. To do so, we first need to calculate the expected tax burden obtained when the firm invests at time 1:

$$T_1^{NR} = q \cdot \max\left\{0, \sum_{t=1}^{\infty} \frac{\tau_t}{(1+r)^t} \cdot \{(1+u) \cdot \Pi_0 - \rho I\}\right\}. \tag{9.7}$$

Using (9.6) and (9.7) we have

$$\begin{aligned} &(NPV_0 - NPV_1) - \left(T_0^{NR} - T_1^{NR}\right) = \\ &= \left[\tfrac{r+(1-q)(1-d)}{r}\Pi_0 - \tfrac{r+(1-q)}{1+r}I\right] - \tau_0 \cdot \max\left[0, \Pi_0 - \rho I\right] - \\ &-(1-q) \cdot \max\left\{0, \textstyle\sum_{t=1}^{\infty} \tfrac{\tau_t[(1-d)\Pi_0 - \rho I]}{(1+r)^t}\right\}. \end{aligned} \tag{9.8}$$

As can be seen in (9.8), the difference

$$\left[(NPV_0 - NPV_1) - \left(T_0^{NR} - T_1^{NR}\right)\right]$$

is unaffected by good news. Thus, the tax burden which can potentially distort the firm's decisions is equal to the current tax liability plus the present discounted value of future taxes paid in the bad state. But if we set $\rho \geq \Pi_0/I$, this tax liability is nil, and equation (9.8) reduces to

$$(NPV_0 - NPV_1) - \left(T_0^{NR} - T_1^{NR}\right) = (NPV_0 - NPV_1). \tag{9.9}$$

On the RHS of equation (9.9), the tax rate vanishes.[8] This means that, since the trigger point is equal to the laissez-faire one Π_0^*, the asymmetric tax design is neutral.

[7] This point was discussed by, among others, Ball and Bowers (1983) and Auerbach (1986).

[8] Condition (9.9) is equivalent to the sufficient neutrality condition discussed by Johansson (1969) on p. 105.

Given these results we can now calculate the minimum imputation rate ensuring neutrality. To do so we substitute Π_0^* into inequality $\rho \geq \Pi_0/I$, and thus we have

$$\rho \geq \rho^* \equiv \frac{r + (1-q)}{r + (1-q)(1-d)} \cdot \frac{r}{1+r}.$$

As can be seen, the parameter ρ^* is always higher than the ex-ante interest rate $r/(1+r)$ since the difference $[\rho^* - r/(1+r)]$ represents the minimum compensation for the lack of the tax refunds arrangement.[9] Moreover, we can see that ρ^* does not depend on current and future tax rates. Given these results we can say that:

Proposition 17 *If the imputation rate is high enough, i.e., $\rho \geq \rho^*$, the asymmetric tax scheme is neutral.*

Proposition 17 shows that tax asymmetries do not necessarily distort investment decisions. 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 new in this case, however, is the identification of an entire set of imputation rates, rather than a single value, guaranteeing neutrality.[10]

The reasoning behind proposition 17 is as follows: if the firm invests at time 0, it enjoys a tax holiday (see Garnaut and Clunies Ross, 1975); if it waits, instead, no taxes are paid. Thus, equality

$$T_0^{NR} = T_1^{NR}$$

holds irrespective of the firm's investment strategy. This leads to the neutrality result.

To understand proposition 17 better, we can also use the interesting interpretation of tax asymmetries proposed by van Wijnbergen

[9] It is worth noting that the rate ρ^* depends on the size of the downward move and its probability, but is independent of the upward move's parameter. Differentiating ρ^* with respect to d and q one obtains $\frac{\partial \rho^*}{\partial d} > 0$ and $\frac{\partial \rho^*}{\partial q} < 0$, namely the worse the news, the higher the minimum rate ensuring neutrality. The rationale for this result is due to the well-known BNP.

[10] Note that inequality $\rho < (1+u)\Pi_0/I$ must also hold in order for the government to collect positive taxes. If, in fact, the rate ρ 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 (2001c), however, this upper limit disappears when uncertainty is modelled as a geometric Brownian motion, and the project's lifetime is infinite.

and Estache (1999).[11] Following Domar and Musgrave (1944), they argue that the corporate tax is equivalent to equity participation. When losses are non-refundable, therefore, the government is also endowed with a *put option with strike price zero* written on the firm's profits. This means that when a 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 re-bought (at price zero) when the firm faces a positive result. The van Wijnbergen-Estache interpretation is useful to explain why we obtain a set of neutral imputation rates instead of a single value. In the $[\rho^*, \infty)$ region, 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 ability to avoid losses increases (namely, the tax asymmetry arrangement is more valuable). According to proposition 17, therefore, if the imputation rate is high enough, these two effects neutralize each other.

9.2 Policy uncertainty

Future tax rates are neither known nor constant. Moreover, a full-refundability tax scheme turns to be distortive even if a *credible* tax rate change is previously announced (see e.g., Auerbach, 1989, and Panteghini, 1995).[12] As shown by Alvarez, Kanniainen, and Södersten (1998), timing uncertainty may deeply affect a representative firm's reversible investment decision.[13] Under the realistic assump-

[11] This interpretation is in line with Green and Talmor (1985), who argued that loss-carry devices are a tax claim for the government. In other words, the government owns a portfolio of call options on the firm's earnings with a variable exercise price. On this point see also Majd and Myers (1985, 1987).

[12] On the effects of tax reform announcements see also Auerbach and Hines (1988).

[13] In particular, Alvarez, Kanniainen, and Södersten (1998) show that increased timing uncertainty may accelerate or decelerate investment as an optimal response to an expected tax cut. Moreover, they find that, under reasonable assumptions, a rate-cut cum base-broadening tax reform of the type implemented in several OECD countries in the 1980s and 1990s cannot be revenue neutral. See also Nickell (1977, 1978) and Bizer and Judd (1989). The former showed that uncertain tax rates tend to discourage investment. The latter found that uncertainty on future investment tax credits causes a welfare loss.

tion that future tax rates are neither known nor constant, the well-known Boadway-Bruce neutrality result may fail to hold.

So far there has been little work on the relationship between irreversible investment and tax policy uncertainty. Moreover, most of this work concentrates on the effects of uncertain investment tax credits, while disregarding the corporation tax.[14] As shown by Hassett and Metcalf (1994, 1999), if investment tax credits follow a Brownian motion the firm's trigger point is increased, and irreversible investment is postponed.[15] If, on the other hand, 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.[16] Although it is not clear whether policy uncertainty stimulates or discourages investment, we can say that policy uncertainty represents a potential source of distortion on investment choices.

In this section we study the effects of policy uncertainty on irreversible investment. As we know, under irreversibility, policy uncertainty may arise from a time inconsistency. As already pointed out in chapter 5, the government may announce a tax rate change which is not implemented subsequently (i.e., the tax rate is unknown but remains constant). Alternatively, an unexpected tax change may take place (i.e., the tax rate is unknown and variable). Firms are usually 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, we assume that τ_0 is known. However, at any instant $t > 0$, the tax rate is uncertain.

[14] A notable exception is Niemann (2004), who has analyzed the effects of tax rate uncertainty under both comprehensive income and consumption-based taxation. In a more recent article (Niemann, 2006), he has also shown that when tax payments follow a geometric Brownian motion, policy uncertainty has an ambiguous effect on investment timing.

[15] This result is a direct implication of Pindyck's (1988) findings. See also Aizenman (1998), who uses a general equilibrium model with uncertain jumps in the corporate income tax rate. He shows that this kind of policy uncertainty discourages investment.

[16] On empirical grounds, Cummins, Hassett and Hubbard (1994, 1995, 1996) found evidence of statistically significant investment responses to tax changes in 12 of the 14 countries under study.

9.2.1 The symmetric scheme

Under tax symmetry we can rewrite the expected present value of tax payments at time 0 and 1 as

$$\xi\left(T_0^R\right) = \tau_0\left(\Pi_0 - \rho I\right) + \\ +\xi\left\langle \sum_{t=1}^{\infty} \frac{\tau_t}{(1+r)^t} \cdot \left\{\left[q(1+u) + (1-q)(1-d)\right] \cdot \Pi_0 - \rho I\right\}\right\rangle, \tag{9.10}$$

and

$$\xi\left(T_1^R\right) = \xi\left\langle \sum_{t=1}^{\infty} \frac{\tau_t}{(1+r)^t} \cdot q\left\{(1+u) \cdot \Pi_0 - \rho I\right\}\right\rangle, \tag{9.11}$$

respectively.

Using (9.10) and (9.11), we can see that the imputation rate $\rho = \frac{r}{1+r}$ is no longer neutral, unless the future uncertain tax changes neutralize each other so as to make the expected present value of the tax burden equal to that raised with the initial rate τ_0. As we know, under neutrality, the following equality should hold:

$$\left[NPV_0 - \xi(T_0^R)\right] - \left[NPV_1 - \xi(T_1^R)\right] = (1-\tau_0) \cdot (NPV_0 - NPV_1). \tag{9.12}$$

Substituting (9.10) and (9.11) into (9.12) we can show that neutrality is ensured if

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

If we have

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

the firm underinvests and vice versa.

9.2.2 The asymmetric scheme

We will next show that the asymmetric system has the same effect as a pre-commitment for the government and guarantees neutrality even under policy uncertainty. To do so, let us calculate the expected present discounted value of all future tax payments, i.e.,

$$\xi\left(T_0^{NR}\right) = \tau_0 \cdot \max\left[0, \Pi_0 - \rho I\right] +$$

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

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

and

$$\xi\left(T_1^{NR}\right) = \xi\left\langle q \cdot \max\left\{0, \sum_{t=1}^{\infty} \frac{\tau_t}{(1+r)^t} \cdot \left[(1+u)\cdot \Pi_0 - \rho I\right]\right\}\right\rangle,$$

at time 0 and 1, respectively. If we set $\rho \geq \rho^*$, it is straightforward to see that

$$\xi(T_0^{NR}) = \xi(T_1^{NR}).$$

This means that condition (9.9) holds. Therefore, we can write the following:

Proposition 18 *If the imputation rate is $\rho \geq \rho^*$, the asymmetric tax scheme is neutral even though future tax rates are uncertain.*

According to proposition 18, if the imputation rate is high enough, the firm investing immediately will pay no taxes (because of the tax holiday); nor will it benefit from any tax refund (because of the elimination of tax refundability). Like the firm postponing investment, it will take into account only future taxes. Irrespective of whether the firm invests immediately or waits, therefore, it will face the same expected tax burden. This implies that uncertain taxation does not affect investment timing.

Moreover, we can see that policy uncertainty does not affect the imputation rate. This implies that the amount of information required to calculate the neutral imputation rate does not change. As policy uncertainty affects neither the trigger point nor the minimum imputation rate, the asymmetric design is equivalent to precommitment by the government.

It is worth noting that, as shown by Panteghini (2001c), proposition 18 is true 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. Therefore, the above result holds even if, using a Knightian definition, future tax rates are *uncertain.*[17]

9.3 Some extensions

In two subsequent articles (Panteghini 2001c and 2005) we extended the above neutrality result. Using a continuous-time model we showed that the asymmetric tax design is neutral even if we introduce capital risk and also assume that the representative firm can make incremental (and sequential) investment choices.[18]

9.3.1 Capital risk

Bulow and Summers (1984) argue that capital risk is the most important source of risk involved in holding an asset. For this reason, in Panteghini (2001c) we introduced capital risk by assuming that the lifetime of investment follows a Poisson process.[19] Moreover, we assumed that when the project expires, the firm gets the original opportunity to re-invest whenever it is profitable. These assumptions make analysis more realistic, since depreciation allows us to weaken the irreversibility assumption. In other words, investment is partially reversible because of technical obsolescence. When the investment project expires, indeed, the firm gets an option to restart. As immediate restarting may not be profitable, the firm may find it profitable to wait until Π rises. With such an option, therefore, the firm regains a limited degree of reversibility.

[17] In many cases it is more realistic to consider policy as *uncertain* rather than *risky*.
[18] Formal proofs are shown in the original articles.
[19] Of course, the quality of results would not change under deterministic depreciation.

Given these assumptions we proved that the asymmetric scheme is neutral in terms of investment timing. In other words we showed that neutrality derives from the following conditions:

$$V^T(\Pi) - I - C^T(\Pi) = [V(\Pi) - I - C(\Pi)] = 0, \tag{9.13}$$

and

$$\frac{\partial \left[V^T(\Pi) - I - C^T(\Pi)\right]}{\partial \Pi} = \frac{\partial \left[V(\Pi) - I - C(\Pi)\right]}{\partial \Pi} = 0, \tag{9.14}$$

where $V(\Pi)$ and $V^T(\Pi)$ are the before- and after-tax present discounted value, respectively. Similarly, $C(\Pi)$ and $C^T(\Pi)$ are the before- and after-tax value of the firm's compound option, namely the joint option incorporating both the option to delay investment and the option to re-start the business. Conditions (9.13) and (9.14) are equivalent to condition (9.9) and thus ensure a sufficient neutrality condition that accounts for the firm's ability to modify strategies by exercising options. In particular, equation (9.13) arises from the VMC, which requires the equality between the before- and after-tax NPV of the project, net of the compound option. Equation (9.14) is derived from the SPC, and requires the equality between the slopes of NPVs.

It is worth noting that an increase in the tax rate reduces not only the present value $V^T(\Pi)$, but also the option value $C^T(\Pi)$. In Panteghini (2001c), we proved that these effects neutralize each other. As equalities (9.13) and (9.14) hold irrespective of the tax rate applied, investment neutrality holds.

9.3.2 Incremental investment

In Panteghini (2005), we focused on incremental investment. We assumed a two-step investment strategy where the firm decides whether and when to invest first I_1, and then I_2. After investing I_1 the firm's payoff is Π. When the firm expands its production by investing I_2, its payoff raises to $\Psi\Pi$, with $\Psi > 1$. Therefore, when the firm invests I_1, its ROA is $\frac{\Pi}{I_1}$ and, in the latter case, it is equal to $\frac{\Psi\Pi}{I_1+I_2}$.

Given these assumptions, we applied Dixit (1995), according to which under decreasing returns to scale, a two-stage incremental strategy is optimal. Otherwise, the firm's optimal strategy is one-off.

As we have pointed out in section 9.1, corporate taxation is equivalent to equity participation (see Domar and Musgrave, 1944). Under asymmetric taxation, the government's tax claim is equivalent to a portfolio of European call options, one on each year's cash flow (see Majd and Myers, 1987), and ρK is the exercise price, where K is the amount of capital so far accumulated (i.e., $K = I_1, I_1 + I_2$). If, therefore, the firm's payoff reaches ρK, the government exercises the call option and shares profits.

Again, an entire region of neutral imputation rates can be derived. Thus, it is sufficient to find the minimum imputation rate ρ^*. If, therefore, $\rho \in [\rho^*, \infty)$, the tax system is neutral. To explain this result, let us assume an increase in ρ. The effects of this increase are twofold. On the one hand, the increase in ρ raises the government's exercise price ρK, thereby increasing the after-tax value of the project. On the other hand, the increase in ρ raises both the option to wait (related to investment I_1) and the option to expand (related to investment I_2). If therefore the imputation rate is high enough, conditions (9.13) and (9.14) are met, and neutrality is ensured.

9.3.3 Sequential investment

In Panteghini (2005), we also dealt with sequential investment. Sequential investment is a special but important case, where firms earn no revenues until more than one or, even, all the investment stages have been undertaken. Oil production is a good example of sequential investment. In the first stage, exploration takes place. When oil has been found, a pipeline can be built and, subsequently, oil can be sold. Other interesting examples are exploitation of natural resources and R&D, as well as sequential investment undertaken by pharmaceutical and aircraft companies.

Dixit and Pindyck (1994) argue that the study of sequential strategies case is important for at least two reasons. Firstly, undertaking investment takes time. Thus, firms often complete the early stages and then wait before undertaking the following stages. Secondly, as pointed out in chapter 1, different investment stages may require different skills or they may be located in different places. In all these cases, therefore, a firm might find it optimal to sell a partially completed project.

Applying the same reasoning as that used for incremental strategies, we proved that conditions (9.13) and (9.14) hold if the imputation rate is high enough. Therefore, we can conclude that if the imputation rate is high enough, the asymmetric tax system ensures neutrality irrespective of whether investment arises from an one-off, an incremental or a sequential decision.

10

R-based or S-based taxation?

Under an imputation system, the cost of debt can be treated in two alternative ways: it may be deductible either at the risk-free rate or at the interest rate actually paid. The former is equivalent to a R-based cash-flow system, while the latter refers to a S-based one. For this reason, we will define these imputation systems as R-based and S-based, respectively.

The S-based system is supported by Keen and King (2002), who maintain that the calculation of the tax base is easy as it is based on book values. Moreover, they argue that the deduction of actual interest expenses does not distort a firm's choices as long as debt is competitively supplied. The reason is simple: in a perfectly competitive capital market, all rents accrue to shareholders, and taxation is neutral.[1] This result was proven by Bond and Devereux (2003), who showed that a S-based system is neutral under default risk even if the firm's tax rate differs from the lender's one.

Bond and Devereux (2003) pointed out that their result holds on condition that capital markets are perfectly efficient and informa-

[1] A similar point is discussed in Zee (2006). In his article, however, he assumes the absence of default risk. Given this assumption, he concludes that a S-based system is preferable to a R-based one, since the former does not affect the implied rate of return, while the latter is distortive.

tion is symmetric. If, instead, capital markets are imperfect and in particular information is asymmetric, they argue that borrowers and lenders might collude against the government in order to avoid taxation. In this case, the government would require a greater amount of information to fight tax avoidance.

In this chapter we will show that the neutrality properties of the S-based system are less general than thought, and that distortions may arise even under perfect credit market efficiency and symmetric information. In particular, we will see that investment neutrality holds when debt is protected. When, instead, debt is unprotected, results are different. In this case, real neutrality is ensured only under uniform taxation. Moreover, financial neutrality never holds, as the S-based system causes a delay in default timing.

In section 10.3 we will also show that a R-based system, allowing for deduction of debt at the risk-free rate, ensures both real and financial neutrality irrespective of whether debt is protected or unprotected. This allows us to conclude that, in terms of neutrality, a R-based system is preferable to a S-based one even in perfectly efficient capital markets.

10.1 The model

The model applied is that described in chapter 4. Namely, we assume that the firm's EBIT follows a geometric Brownian motion with zero drift, i.e., $d\Pi = \sigma \Pi dz$ where $\Pi_0 > 0$ is the initial value. Moreover, we assume that:

1. the risk-free interest rate r is fixed;
2. credit markets are perfectly competitive;
3. information is symmetric;
4. at time 0, the firm borrows some resources and pays a constant coupon $C \leq \Pi_0$, which cannot be renegotiated.[2]

[2] Assumption 4. means that debt maturity is in line with the investment lifetime. This assumption is realistic: as shown for instance by Graham and Harvey (2001), more than 63% of the US firms surveyed state that debt maturity is aimed at matching with assets' lifetime.

Unlike chapter 4, for simplicity we assume that there are no default costs. This implies that C cannot be the result of an optimal choice based on the trade-off between the costs and the tax benefits of debt financing, but rather it is given exogenously.

10.2 The S-based system

As we know, a S-based system allows the deduction of both effective interest payments and the opportunity cost of equity finance. Assuming full loss-offset, therefore, the tax base will be

$$\left\{\Pi - C - r\left[I - D^i\left(\widetilde{\Pi}^i; \Pi_0, C\right)\right]\right\} \text{ for } i = p, u,$$

where $\widetilde{\Pi}^i$, for $i = p, u$, denotes the default trigger point under either protected (p) or unprotected debt financing (u).[3]

As can be seen, the opportunity cost of equity finance is equal to the default-free interest rate times the book value of equity,[4] i.e.,

$$\left[I - D^i\left(\widetilde{\Pi}^i; \Pi_0, C\right)\right],$$

that is equal to the difference between the historical cost of the investment project and the initial value of debt.[5]

Contrary to cash-flow systems, tax benefits are distributed along the investment's lifetime. Therefore, in the event of default, shareholders would fail to obtain a full tax benefit unless an *ad hoc* full loss offset were granted. Along this line of reasoning, Bond and Devereux (2003) propose a rebate equal to

$$R^i\left(\widetilde{\Pi}^i\right) = \tau\left(I - \frac{\widetilde{\Pi}^i}{r}\right) \text{ for } i = p, u, \tag{10.1}$$

which is paid when default takes place. As shown in (10.1), the rebate is equal to the tax rate τ multiplied by the difference between the

[3] This section is based on Panteghini (2006b).

[4] This rule, which only requires the knowledge of book values, is in line with the ACE tax proposal. See e.g. Devereux and Freeman (1991).

[5] It is worth noting that $D^i\left(\widetilde{\Pi}^i; \Pi_0, C\right)$ measures both the market and book value of debt at time 0.

book value of the asset, i.e., I, and the NPV of the subsequent before-tax cash flow in the event of default, i.e., $\frac{\widetilde{\Pi}^i}{r}$. If, therefore, information is symmetric, the government observes $\widetilde{\Pi}^i$ and then pays $R^i\left(\widetilde{\Pi}^i\right)$.

10.2.1 The value of debt

We assume that, like the firm, the lender is subject to S-based tax. Before default, therefore, the lender' base is given by the difference between the interest payment (i.e., the coupon) and the opportunity cost of debt, i.e., $rD^i\left(\widetilde{\Pi}^i;\Pi_0,C\right)$.

In line with Bond and Devereux (2003), we also assume that when default occurs, the tax relief is proportional to the NPV of the subsequent before-tax cash flow of the project. In this case, the opportunity cost of debt will be r times the market value of debt when $\Pi=\widetilde{\Pi}^i$, i.e., $D^i\left(\widetilde{\Pi}^i;\widetilde{\Pi}^i,C\right)$.

Finally, we assume that the lender's tax rate may differ from that of the firm. Given the tax rate h, therefore, the lender's after-tax cash flow will be equal to

$$\begin{cases} C-h\left[C-rD^i\left(\widetilde{\Pi}^i;\Pi_0,C\right)\right] & \text{before default,}\\ \Pi_t-h\left[\Pi_t-rD^i\left(\widetilde{\Pi}^i;\widetilde{\Pi}^i,C\right)\right] & \text{after default.}\end{cases}$$

Under perfect market efficiency, the value of debt at time 0 is such that the following non-arbitrage condition (see appendix 10.4.1)

$$rD^i\left(\widetilde{\Pi}^i;\Pi_0,C\right)=C+\frac{\frac{\sigma^2}{2}\Pi^2D^i_{\Pi\Pi}\left(\widetilde{\Pi}^i;\Pi_0,C\right)}{1-h} \tag{10.2}$$

holds. Equation (10.2) entails the equality between a risk-free asset whose return is r and a risky asset (the lender's credit) whose return is the effective interest rate, net of the default risk premium. As can be seen, taxation may be distortive since any change in the rate h must be offset by a change in the value of debt in order for condition (10.2) to hold.[6] Solving (10.2) we can write the value of debt at time 0 (see appendix 10.4.1) as a weighted average between the cash flow

[6] The second term of the RHS of (10.2) is due to Jensen's inequality. Namely, for any Π, a change in volatility affects the expected value of debt.

received before default and that received after, i.e.,

$$D^i\left(\widetilde{\Pi}^i;\Pi_0,C\right)=\left[1-c\left(\widetilde{\Pi}^i;\Pi_0\right)\right]\frac{C}{r}+c\left(\widetilde{\Pi}^i;\Pi_0\right)\frac{\widetilde{\Pi}^i}{r}. \qquad (10.3)$$

The weight is

$$c\left(\widetilde{\Pi}^i;\Pi_0\right)\equiv\frac{b\left(\widetilde{\Pi}^i;\Pi_0\right)}{1-h+hb\left(\widetilde{\Pi}^i;\Pi_0\right)},$$

where $b\left(\widetilde{\Pi}^i;\Pi_0\right)\equiv\left(\frac{\Pi_0}{\widetilde{\Pi}^i}\right)^{\beta_2}$, and $\beta_2<0$.

The term $c\left(\widetilde{\Pi}^i;\Pi_0\right)$ measures the present value of 1 Euro contingent on the event default. As can be seen, it differs from the discount factor $b\left(\widetilde{\Pi}^i;\Pi_0\right)$. We can show that an increase in the rate h raises the after-tax risk premium and, consequently, $c\left(\widetilde{\Pi}^i;\Pi_0\right)$. Therefore, inequality

$$b\left(\widetilde{\Pi}^i;\Pi_0\right)<c\left(\widetilde{\Pi}^i;\Pi_0\right)$$

holds, and hence we can say that S-based taxation affects the contingent claim evaluation.

Let us next analyze the impact of the default conditions on the value of debt. By definition, full protection implies that the value of debt is equal to that of a default risk-free asset.[7] Using (10.3) we can thus obtain

$$\frac{C}{D^p\left(\widetilde{\Pi}^p;\Pi_0,C\right)}=r. \qquad (10.4)$$

Equality (10.4) implies that full protection holds if $\widetilde{\Pi}^p=C$. It is thus clear that taxation does not affect the value of debt. As we will see, full protection is the implicit assumption adopted by Bond and Devereux (2003).

When debt is unprotected, the trigger point $\widetilde{\Pi}^u$ is not necessarily equal to C. In this case, default entails that the lender's expected cash flow changes from C to $\widetilde{\Pi}^u$. Using (10.3) we obtain the effective

[7] Setting $\sigma=0$ into eq. (10.2) and re-elaborating gives the value of the risk-free asset $D^p\left(\widetilde{\Pi}^p;\Pi_0,C\right)=\frac{C}{r}$.

interest rate as the sum of the risk-free interest rate and the default risk premium:

$$\frac{C}{D^u\left(\widetilde{\Pi}^u;\Pi_0,C\right)}=r+\underbrace{c\left(\widetilde{\Pi}^u;\Pi_0\right)\frac{C-\widetilde{\Pi}^u}{r}}_{\text{default risk premium}}. \tag{10.5}$$

In this case, the tax-distorted discount factor $c\left(\widetilde{\Pi}^u;\Pi_0\right)$ is crucial to calculate the effective interest rate paid to the lender, i.e., $C/D^u\left(\widetilde{\Pi}^u;\Pi_0,C\right)$.

10.2.2 The value of equity

To calculate the value of equity, we must introduce a default boundary condition. We know that, at point $\Pi=\widetilde{\Pi}^i$, shareholders are expropriated and, therefore, their claim is simply equal to the tax rebate. Defining $E^i\left(\widetilde{\Pi}^i;\Pi,C\right)$ as the value of equity, we can write the following VMC:

$$E^i\left(\widetilde{\Pi}^i;\widetilde{\Pi}^i,C\right)=R^i\left(\widetilde{\Pi}^i\right)\ \text{for}\ i=p,u. \tag{10.6}$$

According to (10.6), therefore, in the event of default, the shareholders' claim is simply equal to the tax rebate. Applying condition (10.6) (see appendix 10.4.2) we can calculate the value of equity at time $t\geq 0$:

$$\begin{aligned}E^i\left(\widetilde{\Pi}^i;\Pi,C\right)&=\frac{\Pi^N\left(\widetilde{\Pi}^i;\Pi,C\right)}{r}+\\&+b\left(\widetilde{\Pi}^i;\Pi\right)\left[R^i\left(\widetilde{\Pi}^i\right)-\frac{\Pi^N\left(\widetilde{\Pi}^i;\widetilde{\Pi}^i,C\right)}{r}\right],\end{aligned} \tag{10.7}$$

where

$$\Pi^N\left(\widetilde{\Pi}^i;\Pi,C\right)\equiv(1-\tau)(\Pi-C)+\tau r\left[I-D^i\left(\widetilde{\Pi}^i;\Pi_0,C\right)\right]$$

is the after-tax cash flow. As shown in (10.7), the value of equity consists of two terms. The first term, $\frac{\Pi^N\left(\widetilde{\Pi}^i;\Pi,C\right)}{r}$, is a perpetual rent proportional to after-tax cash flow. The second term measures the overall effect of default. This component is equal to the product between the discount factor $b\left(\widetilde{\Pi}^i;\Pi\right)$ and the shareholders' net tax rebate $\left[R^i\left(\widetilde{\Pi}^i\right)-\frac{\Pi^N\left(\widetilde{\Pi}^i;\widetilde{\Pi}^i,C\right)}{r}\right]$, i.e., the tax rebate received in the event of default minus future cash flow lost by expropriation.

As can be seen in (10.7), the shareholders' discount factor is equal to $b\left(\widetilde{\Pi}^i;\Pi\right)$, whereas the lender's one is $c\left(\widetilde{\Pi}^i;\Pi\right)$. This means that the contingent evaluation made by shareholders differs from that of the lender.

10.2.3 Neutrality results

Let us next analyze the neutrality properties of the S-based system. Here, we deal with both real and financial neutrality, when the firm's decisions are made at time $t=0$.[8] Let us first write the firm's NPV, i.e.,

$$NPV^i\left(\widetilde{\Pi}^i;\Pi_0,C\right)=E^i\left(\widetilde{\Pi}^i;\Pi_0,C\right)+D^i\left(\widetilde{\Pi}^i;\Pi_0,C\right)-I. \quad (10.8)$$

Applying (1.11), we know that investment neutrality holds if

$$NPV^i\left(\widetilde{\Pi}^i;\Pi_0,C\right)=(1-\tau)\,NPV_0, \quad (10.9)$$

where $NPV_0\equiv\frac{\Pi_0}{r}-I$ is the NPV in the absence of taxation. Substituting (10.3) and (10.7) into (10.8) gives

$$NPV^i\left(\widetilde{\Pi}^i;\Pi_0,C\right)=(1-\tau)\,NPV_0+X\left(\widetilde{\Pi}^i;\Pi_0,C\right) \quad (10.10)$$

where

$$X\left(\widetilde{\Pi}^i;\Pi_0,C\right)\equiv$$

$$\equiv(1-\tau)\left[1-b\left(\widetilde{\Pi}^i;\Pi_0,C\right)\right]\left[D^i\left(\widetilde{\Pi}^i;\Pi_0,C\right)-\frac{C}{r}\right]+$$

$$+b\left(\widetilde{\Pi}^i;\Pi_0,C\right)\left[D^i\left(\widetilde{\Pi}^i;\Pi_0,C\right)-D^i\left(\widetilde{\Pi}^i;\widetilde{\Pi}^i,C\right)\right]$$

---

[8] For simplicity we assume that the firm cannot delay the investment decision.

is the overall tax distortion. This distortion consists of two terms. The first one measures the present value of the after-tax risk premium before default. The second term is given by the expected devaluation of debt conditional on the event of default. We can thus write the following:

Condition 1 *If* $X\left(\widetilde{\Pi}^i;\Pi_0,C\right)=0$, *real neutrality is achieved.*

The second neutrality condition regards only unprotected debt. As we know, shareholders can decide when to default. Defining $\widetilde{\Pi}^u_{LF}$ as the default trigger point in the absence of taxation, we can thus state that:

Condition 2 *Financial neutrality holds if default timing is not affected by taxation, i.e.,* $\widetilde{\Pi}^u=\widetilde{\Pi}^u_{LF}$.

Let us next analyze the neutrality properties of the S-based tax. Under protected debt financing we can prove the following:

Proposition 19 *If debt is fully protected, under a S-based system, condition 1 holds.*

Proof. See appendix 10.4.3. ■

As we pointed out, full protection is ensured if $\widetilde{\Pi}^p=C$. This implies that $D^p\left(\widetilde{\Pi}^p;\Pi_0,C\right)=D^p\left(C;\Pi_0,C\right)$. Moreover, appendix 10.4.3 shows that the lender's post-default claim is equal to

$$D^i\left(\widetilde{\Pi}^i;\widetilde{\Pi}^i,C\right)=\frac{\widetilde{\Pi}^i}{r},$$

for $i=p,u$.[9] Therefore, the shareholders' rebate is equal to

$$R^p\left(C\right)=\tau\left(I-\frac{C}{r}\right),$$

and the real distortion $X\left(\widetilde{\Pi}^p;\Pi_0,C\right)$ goes to zero. The reasoning behind this result is simple: the cash-flow tax and, equivalently, any imputation system can be thought of as ensuring a relief for both the risk-free rate and the risk premium (see Devereux, 2003). As shown

[9] Remember that the default trigger point $\widetilde{\Pi}^u$ is set at time 0 and is known by the lender.

in (10.4), however, the default risk premium falls to zero and any distortive effect of h on the value of debt vanishes. Proposition 19 is thus in line with Bond and Devereux (2003).

When debt is unprotected, results are quite different. In this case, the default trigger point $\widetilde{\Pi}^u$ is optimally chosen by maximizing the value of equity, i.e.,

$$\max_{\widetilde{\Pi}^u} E^u\left(\widetilde{\Pi}^u; \Pi_0, C\right). \tag{10.11}$$

Solving (10.11) we obtain:

Proposition 20 *Under unprotected debt financing, the inequalities* $\widetilde{\Pi}^u < \widetilde{\Pi}^u_{LF} < C$ *hold* $\forall\tau$.

Proof. See appendix 10.4.4. ■

Proposition 20 shows that shareholders postpone their default decision. To understand this result it is worth noting that $\widetilde{\Pi}^u_{LF} < C$. Hence, without taxation, the default option is exercised when the net cash flow is negative. This is due to the fact that default is an irreversible choice: shareholders know that the exercise of the put option entails the *irreversible* loss of any opportunity to exploit future profit recoveries. Under the S-based system, the lower the point $\widetilde{\Pi}^u$ is, the greater is the value of the rebate received by shareholders. Not surprisingly therefore we have $\widetilde{\Pi}^u < \widetilde{\Pi}^u_{LF}$, i.e., default timing is delayed.[10] Thus, condition 2 fails to hold.

Let us next focus on real effects. We can prove the following:

Proposition 21 *Under unprotected debt financing a real distortion arises if* $h \neq \tau$*, i.e.*

$$NPV^u\left(\widetilde{\Pi}^u; \Pi_0, C\right) - (1-\tau)\, NPV_0 \propto (\tau - h)\,. \tag{10.12}$$

Proof. See appendix 10.4.5. ■

The reasoning behind proposition 21 is as follows. Let us assume that initially the equality $\tau = h$ holds. Then suppose that h is reduced. This tax rate cut has a twofold effect. On the one hand, it reduces the value of debt $D^u\left(\widetilde{\Pi}^u; \Pi_0, C\right)$; on the other hand,

[10] Notice that the delay of default is stimulated by full loss-offset provisions. In this case, loss-making firms enjoy a tax benefit and may be induced to further postpone default.

it raises shareholders' tax benefit $\tau r \left[I - D^u \left(\widetilde{\Pi}^u ; \Pi_0, C \right) \right]$, thereby increasing the value of equity. Proposition 21 thus shows that the decrease in $D^u \left(\widetilde{\Pi}^u ; \Pi_0, C \right)$ is over-compensated by the increase in $E^u \left(\widetilde{\Pi}^u ; \Pi_0, C \right)$. Since inequality

$$NPV^u \left(\widetilde{\Pi}^u ; \Pi_0, C \right) > (1 - \tau) \, NPV_0$$

holds, condition 1 fails to hold and the firm overinvests.[11] The converse is true if h is raised.

Proposition 21 is not surprising if we disregard the firm's ownership and, rather, focus on the project value. We can indeed say that inequality $\tau > h$ is equivalent to an expected tax rate cut occurring whenever Π falls to $\widetilde{\Pi}^u$. This expected tax cut thus stimulates investment. The converse is true if $\tau < h$. A similar point was made by Bond and Devereux (1995), who showed that any expected future tax rate change is distortive.

It is worth noting that the tax rebate can be designed in different ways. To have a clearer picture of the effects of the rebate, we can introduce an alternative definition of R_0^u, which ensures real neutrality for any τ and h. This implies that R_0^u must be set before the firm's decisions. In this case, the firm's problem is

$$\begin{array}{c} \max_{\widetilde{\Pi}^u} \left[E^u \left(\widetilde{\Pi}^u ; \Pi_0, C \right) \right] \\ \text{with } R_0^u \text{ such that (10.9) holds.} \end{array} \tag{10.13}$$

We can thus prove the following:

Proposition 22 *If we set*

$$\widehat{R_0^u} \left(\widetilde{\Pi}^u ; \Pi_0, C \right) = \frac{\Pi^N \left(\widetilde{\Pi}^u ; \widetilde{\Pi}^u, C \right)}{r} - \frac{(1 - \tau) \left[D^u \left(\widetilde{\Pi}^u ; \Pi_0, C \right) - \frac{C}{r} \right]}{b \left(\widetilde{\Pi}^u ; \Pi_0 \right)}, \tag{10.14}$$

real neutrality is ensured for any $h \lesseqgtr \tau$. However, the inequality $\widetilde{\Pi}^u < \widetilde{\Pi}^u_{LF} < C$ still holds.

Proof. See appendix 10.4.6. ∎

[11] Notice that, under full debt protection, the default premium is nil and, hence, this distortive effect disappears.

As can be seen in (10.14), $\widehat{R_0^u}\left(\widetilde{\Pi}^u;\Pi_0,C\right)$ is risk-specific, as it depends on the term $b\left(\widetilde{\Pi}^u;\Pi_0\right)$, and hence on volatility (σ). This means that the system is informationally very demanding.

Moreover, the ex-ante determination of the rebate cannot eliminate the financial distortion. Inequality $\widetilde{\Pi}^u < \widetilde{\Pi}^u_{LF}$ means that shareholders are still encouraged to delay default in order to raise a greater rebate. We can thus state that real neutrality holds on the unrealistic condition that the government has full information and is thus able to assign firm-specific rebates. Even in this case, however, default timing is distorted, i.e., condition 2 fails to hold.

10.3 The R-based tax system

Let us next analyze the R-based system.[12] In this case, the base is given by the difference between Π and a tax allowance, equal to the risk-free interest rate r times the book value of the asset I. Therefore, tax payments are equal to $T = \tau(\Pi - rI)$ and the firm's after-tax cash flow is

$$\Pi^N\left(\widehat{\Pi}^i;\Pi,C\right) = \Pi - C - \tau(\Pi - rI), \qquad (10.15)$$

where $\widehat{\Pi}^i$ is the default trigger point under either protected (p) or unprotected (u) debt financing.

Following Bond and Devereux (2003), tax charges are assumed to be independent of ownership of the firm. This means that, after expropriation, the lender is subject to the same tax treatment as shareholders.

Let us next find the default trigger points. When debt is protected, the default threshold $\widehat{\Pi}^p$ is such that, at point $\Pi = \widehat{\Pi}^p$, the after-tax cash $\Pi^N\left(\widehat{\Pi}^p;\widehat{\Pi}^p,C\right)$ is zero, i.e.,

$$(1-\tau)\,\widehat{\Pi}^p - C + \tau r I = 0.$$

This means that when $\Pi = \widehat{\Pi}^p$, the value of equity falls to zero, and we have:

$$E\left(\widehat{\Pi}^p;\widehat{\Pi}^p,C\right) = 0. \qquad (10.16)$$

[12] This section is based on Panteghini (2004b).

When debt is unprotected the optimal default threshold, $\widehat{\Pi}^u$, is calculated by solving (10.11). To do so we apply the VMC and SPC, i.e.,

$$E\left(\widehat{\Pi}^u;\Pi,C\right)\Big|_{\Pi=\widehat{\Pi}^u}=0, \tag{10.17}$$

and

$$\left.\frac{\partial E\left(\widehat{\Pi}^u;\Pi,C\right)}{\partial \Pi}\right|_{\Pi=\widehat{\Pi}^u}=0. \tag{10.18}$$

Using (10.17) and (10.18) we obtain the following:

Proposition 23 *Given the tax rate τ, the R-based tax is neutral, i.e.,*

$$NPV^i\left(\widehat{\Pi}^i;\Pi,C\right)=(1-\tau)\cdot NPV_0,\ \textit{for } i=p,u, \tag{10.19}$$

irrespective of the characteristics of debt.

Proof. See appendix 10.4.7. ■

The intuition behind proposition 23 is as follows. In appendix 10.4.7 we show that $\widehat{\Pi}^p > \widehat{\Pi}^u$: this means that, under unprotected debt financing, default does not take place when the net cash flow is nil: when Π lies between $\widehat{\Pi}^u$ and $\widehat{\Pi}^p$, shareholders face a negative cash flow. However, they prefer to inject equity capital in order to exploit future recoveries in the firm's profitability. The existence of such a put option means that, *coeteris paribus*, the value of equity is greater under unprotected debt financing. On the other hand, for any C, the value of unprotected debt is less than that of protected debt. This is due to the fact that the shareholders' ability to delay default reduces the value of the firm in the event of default. We can thus say that any switch from protected to unprotected debt financing causes both an increase in the value of equity and a decrease in the value of debt. As proven in proposition 23, however, these two effects neutralise each other. This implies that the after-tax NPV is always $(1-\tau)$ times NPV_0, irrespective of the characteristics of debt.

To sum up, we have seen that the neutrality properties of a S-based system depend on the default condition assumed. In particular, investment neutrality holds when debt is protected. When debt is unprotected, results are different: investment neutrality is ensured only under uniform taxation, while financial neutrality never holds, as the default timing is postponed. Under a R-based system, instead, both investment and financial neutrality hold irrespective of whether debt is protected or unprotected. This allows us to conclude that, in terms of neutrality, a R-based system is preferable to a S-based one even in perfectly efficient capital markets.

10.4 Appendix

10.4.1 The calculation of (10.2) and (10.3)

Using dynamic programming, the value of debt can be written as follows

$$D^i\left(\widetilde{\Pi}^i;\Pi,C\right)=\begin{cases}\begin{array}{l}(1-h)\,Cdt+\\ +hrD^i\left(\widetilde{\Pi}^i;\Pi_0,C\right)dt+\\ +e^{-rdt}\xi\left[D^i\left(\widetilde{\Pi}^i;\Pi+d\Pi,C\right)\right]\end{array} & \text{before default}\\ \\ \begin{array}{l}(1-h)\,\Pi+\\ +hrD^i\left(\widetilde{\Pi}^i;\Pi_0,C\right)dt+\\ +e^{-rdt}\xi\left[D^i(\widetilde{\Pi}^i;\Pi+d\Pi,C)\right]\end{array} & \text{otherwise.}\end{cases} \tag{10.20}$$

Let us now calculate the value of debt before default. Expanding the RHS of (10.20) and applying Itô's Lemma, one obtains

$$\begin{aligned}D^i\left(\widetilde{\Pi}^i;\Pi,C\right)&=\left[(1-h)\,C+hrD^i\left(\widetilde{\Pi}^i;\Pi_0,C\right)\right]dt+\\ &+(1-rdt)\left[D^i\left(\widetilde{\Pi}^i;\Pi,C\right)+\tfrac{\sigma^2}{2}D^i_{\Pi\Pi}\left(\widetilde{\Pi}^i;\Pi,C\right)\right].\end{aligned} \tag{10.21}$$

Since $(dt)^2\to 0$, we obtain the following non-arbitrage condition:

$$\begin{aligned}rD^i\left(\widetilde{\Pi}^i;\Pi,C\right)&=\left[(1-h)\,C+hrD^i\left(\widetilde{\Pi}^i;\Pi_0,C\right)\right]+\\ &+\tfrac{\sigma^2}{2}\Pi^2D^i_{\Pi\Pi}\left(\widetilde{\Pi}^i;\Pi,C\right).\end{aligned} \tag{10.22}$$

Re-arranging we thus have (10.2). Let us next solve (10.22). Before default we obtain

$$D^i\left(\widetilde{\Pi}^i;\Pi,C\right)=\frac{(1-h)\,C+hrD^i\left(\widetilde{\Pi}^i;\Pi_0,C\right)}{r}+\sum_{j=1}^{2}G_j^i\Pi^{\beta_j},\tag{10.23}$$

where

$$\beta_1=\frac{1}{2}+\sqrt{\left(\frac{1}{2}\right)^2+\frac{2r}{\sigma^2}}>1$$

and

$$\beta_2=\frac{1}{2}-\sqrt{\left(\frac{1}{2}\right)^2+\frac{2r}{\sigma^2}}<0$$

are the roots of the characteristic equation

$$\Psi(\beta)=\frac{1}{2}\sigma^2\beta(\beta-1)-r=0.$$

After default, the value of debt is

$$D^i\left(\widetilde{\Pi}^i;\Pi,C\right)=\frac{(1-h)\,\Pi+hrD^i\left(\widetilde{\Pi}^i;\widetilde{\Pi}^i,C\right)}{r}+\sum_{j=1}^{2}L_j^i\Pi^{\beta_j}.\tag{10.24}$$

To calculate the values of G_j^i and L_j^i, for $j=1,2$, we introduce two well-known boundary conditions, which are in line with the assumption of perfectly efficient capital markets. In the absence of financial bubbles, we have $G_1^i=L_1^i=0$. Moreover, we assume that, when $\Pi=0$, the lender's claim is worth the tax benefit, namely,

$$D^i\left(\widetilde{\Pi}^i;0,C\right)=hD^i\left(\widetilde{\Pi}^i;\widetilde{\Pi}^i,C\right).$$

This implies that $L_2^i=0$. Given (10.24) we thus have

$$D^i\left(\widetilde{\Pi}^i;\widetilde{\Pi}^i,C\right)=\frac{\widetilde{\Pi}^i}{r}.\tag{10.25}$$

To calculate G_2^i, let the two branches (10.23) and (10.24) meet at point $\Pi=\widetilde{\Pi}^i$. Using (10.25), we thus have

$$D^i\left(\widetilde{\Pi}^i;\widetilde{\Pi}^i,C\right)=\frac{(1-h)\,C+hrD^i\left(\widetilde{\Pi}^i;\Pi_0,C\right)}{r}+G_2^i\widetilde{\Pi}^{i^{\beta_2}}=\frac{\widetilde{\Pi}^i}{r}.\tag{10.26}$$

Using (10.23) and setting $\Pi = \Pi_0$ gives the value of debt at time 0, i.e.,

$$D^i\left(\widetilde{\Pi}^i;\Pi_0,C\right) = \frac{C}{r} + \frac{G_2^i \Pi_0^{\beta_2}}{1-h}. \tag{10.27}$$

Substituting (10.27) into (10.26), and solving for G_2^i we have

$$G_2^i = \frac{\widetilde{\Pi}^i - C}{r}\left[\frac{h}{1-h}\Pi_0^{\beta_2} + \widetilde{\Pi}^{i\beta_2}\right]^{-1}. \tag{10.28}$$

Finally, re-arranging gives (10.3).

10.4.2 The calculation of (10.7)

The firm's value of equity can be written as

$$E^i\left(\widetilde{\Pi}^i;\Pi,C\right) = \begin{cases} \Pi^N\left(\widetilde{\Pi}^i;\Pi,C\right)dt + \\ +e^{-rdt}\xi\left[E(\widetilde{\Pi}^i;\Pi+d\Pi,C)\right] & \text{before default,} \\ \\ R^i\left(\widetilde{\Pi}^i\right) & \text{otherwise.} \end{cases} \tag{10.29}$$

As shown in (10.29), in the event of default, shareholders are expropriated and the value of their claim is simply equal to $R^i\left(\widetilde{\Pi}^i\right)$.

Let us next focus on the pre-default case. Expanding the RHS of (10.29), one obtains the following Bellman equation

$$rE^i\left(\widetilde{\Pi}^i;\Pi,C\right) = \Pi^N\left(\widetilde{\Pi}^i;\Pi,C\right) + \frac{\sigma^2}{2}\Pi^2 E^i_{\Pi\Pi}\left(\widetilde{\Pi}^i;\Pi,C\right). \tag{10.30}$$

Solving (10.30) gives

$$E^i\left(\widetilde{\Pi}^i;\Pi,C\right) = \frac{\Pi^N\left(\widetilde{\Pi}^i;\Pi,C\right)}{r} + \sum_{j=1}^{2} F_j^i \Pi_t^{\beta_2}. \tag{10.31}$$

Let us next calculate F_j^i for $j = 1, 2$. As usual, the absence of bubbles entails that $F_1^i = 0$. To calculate F_2^i we use (10.31) and apply the VMC (10.6). We thus obtain

$$\frac{\Pi^N\left(\widetilde{\Pi}^i;\widetilde{\Pi}^i,C\right)}{r} + F_2^i\widetilde{\Pi}^{i\beta_2} = R^i\left(\widetilde{\Pi}^i\right) = \tau\left(I - \frac{\widetilde{\Pi}^i}{r}\right),$$

which gives

$$F_2^i = \left[R^i \left(\widetilde{\Pi}^i \right) - \frac{\Pi^N \left(\widetilde{\Pi}^i ; \widetilde{\Pi}^i , C \right)}{r} \right] \left(\widetilde{\Pi}^i \right)^{-\beta_2} . \tag{10.32}$$

Substituting (10.32) into (10.31), at point Π_0 gives (10.7).

10.4.3 Proof of proposition 19

Substituting (10.4) into (10.3), gives the equality $\widetilde{\Pi}^p = C$. This means that

$$D^p \left(\widetilde{\Pi}^p ; \Pi_0, C \right) = D^p \left(C ; \Pi_0, C \right) = \frac{C}{r}. \tag{10.33}$$

Moreover using (10.25) we have

$$D^p \left(\widetilde{\Pi}^p ; \widetilde{\Pi}^p , C \right) = D^p \left(C ; C, C \right) = \frac{C}{r}. \tag{10.34}$$

Substituting (10.33) and (10.34) into (10.8) and re-arranging gives (10.9). This proves proposition 19.■

10.4.4 Proof of proposition 20

Using (10.7) and (10.32), we can write the value of equity as

$$E^u \left(\widetilde{\Pi}^u ; \Pi_0, C \right) = \left[\frac{(1-\tau)\,\Pi_0 - C}{r} + \tau I \right] + H \left(\widetilde{\Pi}^u ; \Pi_0, C \right) \tag{10.35}$$

with

$$H \left(\widetilde{\Pi}^u ; \Pi_0, C \right) \equiv -\tau \frac{G_2^u \Pi_0^{\beta_2}}{1-h} \left[1 - \left(\frac{\Pi_0}{\widetilde{\Pi}^u} \right)^{\beta_2} \right] - \frac{\left(\widetilde{\Pi}^u - C \right)}{r} \left(\frac{\Pi_0}{\widetilde{\Pi}^u} \right)^{\beta_2},$$

and

$$\frac{G_2^u \Pi_0^{\beta_2}}{1-h} = \frac{\widetilde{\Pi}^u - C}{r} \frac{\left(\frac{\Pi_0}{\widetilde{\Pi}^u} \right)^{\beta_2}}{\left[(1-h) + h \left(\frac{\Pi_0}{\widetilde{\Pi}^u} \right)^{\beta_2} \right]}.$$

Using (10.35) we can solve problem (10.11), and obtain the following f.o.c.

$$\frac{\partial E^u \left(\widetilde{\Pi}^u ; \Pi_0, C \right)}{\partial \widetilde{\Pi}^u} = \frac{\partial H \left(\widetilde{\Pi}^u ; \Pi_0, C \right)}{\partial \widetilde{\Pi}^u} = 0, \tag{10.36}$$

where

$$\frac{\partial H\left(\widetilde{\Pi}^u;\Pi_0,C\right)}{\partial\widetilde{\Pi}^u} = \frac{\partial\left[-\frac{\left(\widetilde{\Pi}^u-C\right)}{r}\left(\frac{\Pi}{\widetilde{\Pi}^u}\right)^{\beta_2}\right]}{\partial\widetilde{\Pi}^u}\cdot\frac{1+(\tau-h)\left[1-\left(\frac{\Pi_0}{\widetilde{\Pi}^u}\right)^{\beta_2}\right]}{\left[(1-h)+h\left(\frac{\Pi_0}{\widetilde{\Pi}^u}\right)^{\beta_2}\right]}- \\ -\left[\frac{\left(\widetilde{\Pi}^u-C\right)}{r}\left(\frac{\Pi_0}{\widetilde{\Pi}^u}\right)^{\beta_2}\right]\cdot\frac{\partial}{\partial\widetilde{\Pi}^u}\left\{\frac{1+(\tau-h)\left[1-\left(\frac{\Pi_0}{\widetilde{\Pi}^u}\right)^{\beta_2}\right]}{\left[(1-h)+h\left(\frac{\Pi_0}{\widetilde{\Pi}^u}\right)^{\beta_2}\right]}\right\},$$

$$\frac{\partial\left[-\frac{\left(\widetilde{\Pi}^u-C\right)}{r}\left(\frac{\Pi_0}{\widetilde{\Pi}^u}\right)^{\beta_2}\right]}{\partial\widetilde{\Pi}^u} = -\frac{(1-\beta_2)\left(\frac{\Pi_0}{\widetilde{\Pi}^u}\right)^{\beta_2}\left(\widetilde{\Pi}^u\right)^{-1}\left(\widetilde{\Pi}^u-\frac{\beta_2}{\beta_2-1}C\right)}{r},$$

and

$$\frac{\partial\left\{1+\tau\frac{\left[1-\left(\frac{\Pi_0}{\widetilde{\Pi}^u}\right)^{\beta_2}\right]}{\left[(1-h)+h\left(\frac{\Pi_0}{\widetilde{\Pi}^u}\right)^{\beta_2}\right]}\right\}}{\partial\widetilde{\Pi}^u} = \left(\frac{\tau}{h}\right)\frac{\beta_2\left(\frac{\Pi_0}{\widetilde{\Pi}^u}\right)^{\beta_2}\left(\widetilde{\Pi}^u\right)^{-1}}{\left\{1-h\left[1-\left(\frac{\Pi_0}{\widetilde{\Pi}^u}\right)^{\beta_2}\right]\right\}^2}<0.$$

Using (10.36), we obtain

$$\frac{\partial H\left(\widetilde{\Pi}^u;\Pi_0,C\right)}{\partial\widetilde{\Pi}^u} = -\frac{(1-\beta_2)\left(\frac{\Pi_0}{\widetilde{\Pi}^u}\right)^{\beta_2}\cdot\frac{\widetilde{\Pi}^u-\frac{\beta_2}{\beta_2-1}C}{\widetilde{\Pi}^u}}{r}\left[1+\tau\frac{1-\left(\frac{\Pi_0}{\widetilde{\Pi}^u}\right)^{\beta_2}}{(1-h)+h\left(\frac{\Pi_0}{\widetilde{\Pi}^u}\right)^{\beta_2}}\right]- \\ -\left[\frac{\left(\widetilde{\Pi}^u-C\right)}{r}\left(\frac{\Pi_0}{\widetilde{\Pi}^u}\right)^{\beta_2}\right]\frac{\frac{\tau}{h}\beta_2\left(\frac{\Pi_0}{\widetilde{\Pi}^u}\right)^{\beta_2}\left(\widetilde{\Pi}^u\right)^{-1}}{\left\{1-h\left[1-\left(\frac{\Pi_0}{\widetilde{\Pi}^u}\right)^{\beta_2}\right]\right\}^2}=0 \tag{10.37}$$

and, re-arranging (10.37), we have

$$\widetilde{\Pi}^u = \frac{\beta_2}{\beta_2-1}C+ \\ +\frac{\frac{\tau}{h}\frac{\beta_2}{\beta_2-1}\left(\widetilde{\Pi}^u-C\right)\left(\frac{\Pi_0}{\widetilde{\Pi}^u}\right)^{\beta_2}}{\left\{1-h\left[1-\left(\frac{\Pi_0}{\widetilde{\Pi}^u}\right)^{\beta_2}\right]\right\}\left\{1+(\tau-h)\left[1-\left(\frac{\Pi_0}{\widetilde{\Pi}^u}\right)^{\beta_2}\right]\right\}}. \tag{10.38}$$

Notice that (10.38) is not a closed-form solution. However, it allows us to analyze the distortive effect of taxation. To do so, we need to recall (10.37), and set $\tau = h = 0$. We thus obtain the *laissez-faire* threshold point:

$$\widetilde{\Pi}^u_{LF} = \frac{\beta_2}{\beta_2 - 1} C. \qquad (10.39)$$

By contradiction we can now prove that $\widetilde{\Pi}^u < \widetilde{\Pi}^u_{LF}$. Assume *ab absurdo* that $\widetilde{\Pi}^u > C$. In this case equation (10.38) holds, but it is straightforward to see that $H\left(\widetilde{\Pi}^u; \Pi_0, C\right) < 0$. This means that no solution with $\widetilde{\Pi}^u > C$ ensures a maximum. Moreover, assume *ab absurdo* that $\frac{\beta_2}{\beta_2-1} C < \widetilde{\Pi}^u < C$. In this case, (10.38) does not hold; thus no solution can be found. Therefore, the solution must be such that inequality $\widetilde{\Pi}^u < \frac{\beta_2}{\beta_2-1} C$ holds. In this case, equation (10.38) holds, and $H\left(\widetilde{\Pi}^u; \Pi_0, C\right) > 0$. This proves proposition 20.■

10.4.5 Proof of proposition 21

Using (10.3) we can rewrite (10.10) as

$$NPV^u\left(\widetilde{\Pi}^u; \Pi_0, C\right) = (1-\tau) NPV_0 + X\left(\widetilde{\Pi}^u; \Pi_0, C\right), \qquad (10.40)$$

where

$$\begin{aligned} X\left(\widetilde{\Pi}^u; \Pi_0, C\right) \equiv \; & (1-\tau)\left[1 - b\left(\widetilde{\Pi}^u; \Pi_0\right)\right] \cdot \\ & \cdot \left[D^u\left(\widetilde{\Pi}^u; \Pi_0, C\right) - \tfrac{C}{r}\right] + \\ & + b\left(\widetilde{\Pi}^u; \Pi_0\right)\left[D^u\left(\widetilde{\Pi}^u; \Pi_0, C\right) - \tfrac{\widetilde{\Pi}^u}{r}\right]. \end{aligned}$$

Let us substitute (10.3) into (10.40) and re-arrange, so as to obtain

$$\begin{aligned} NPV^u\left(\widetilde{\Pi}^u; \Pi_0, C\right) = \; & (1-\tau) NPV_0 - \\ & - \frac{\left(\widetilde{\Pi}^u - C\right)}{r} b\left(\widetilde{\Pi}^u; \Pi_0\right) \cdot \frac{(\tau - h)\left[1 - b\left(\widetilde{\Pi}^u; \Pi_0\right)\right]}{1 - h\left[1 - b\left(\widetilde{\Pi}^u; \Pi_0\right)\right]}. \end{aligned}$$

Since $\widetilde{\Pi}^u < C$, we can write (10.12), thereby proving proposition 21.■

10.4.6 Proof of proposition 22

Substituting (10.3) and (10.7) into (10.8) one obtains

$$NPV^u\left(\widetilde{\Pi}^u; \Pi_0, C\right) = (1-\tau) NPV_0 + Z\left(\widetilde{\Pi}^u; \Pi_0, C\right),$$

where

$$Z\left(\widetilde{\Pi}^u;\Pi_0,C\right) \equiv (1-\tau)\left[D^u\left(\widetilde{\Pi}^u;\Pi_0,C\right)-\tfrac{C}{r}\right]+ \\ +b\left(\widetilde{\Pi}^u;\Pi_0\right)\left[R_0^u-\tfrac{\Pi^N\left(\widetilde{\Pi}^u;\widetilde{\Pi}^u,C\right)}{r}\right]$$

is the overall distortion. Setting

$$Z\left(\widetilde{\Pi}^u;\Pi_0,C\right)=0,$$

and solving for R_0^u one thus obtains (10.14). Substituting (10.14) into (10.7) gives the value of equity at time 0, i.e.,

$$E^u\left(\widetilde{\Pi}^u;\Pi_0,C\right)=\left[\frac{(1-\tau)\,\Pi_0}{r}+\tau I\right]-D^u\left(\widetilde{\Pi}^u;\Pi_0,C\right). \quad (10.41)$$

Using (10.3) and (10.41), and solving (10.13) gives the following f.o.c.

$$\frac{\partial E^u\left(\widetilde{\Pi}^u;\Pi_0,C\right)}{\partial\widetilde{\Pi}^u}=\frac{\partial c\left(\widetilde{\Pi}^u;\Pi_0\right)}{\partial\widetilde{\Pi}^u}\cdot\frac{C-\widetilde{\Pi}^u}{r}-\frac{c\left(\widetilde{\Pi}^u;\Pi_0\right)}{r}=0, \quad (10.42)$$

with

$$\frac{\partial c\left(\widetilde{\Pi}^u;\Pi_0\right)}{\partial\widetilde{\Pi}^u}=\frac{1-h}{\left[1-h+hb\left(\widetilde{\Pi}^u;\Pi_0\right)\right]^2}\frac{\partial b\left(\widetilde{\Pi}^u;\Pi_0\right)}{\partial\widetilde{\Pi}^u},$$

and

$$\frac{\partial b\left(\widetilde{\Pi}^u;\Pi_0\right)}{\partial\widetilde{\Pi}^u}=-\beta_2\left(\widetilde{\Pi}^u\right)^{-1}b\left(\widetilde{\Pi}^u;\Pi_0\right).$$

Re-arranging (10.42) we obtain

$$\widetilde{\Pi}^u=\frac{\beta_2}{\beta_2-1}C+\underbrace{\frac{1}{\beta_2-1}\left[\frac{hb\left(\widetilde{\Pi}^u;\Pi_0\right)}{1-h}\right]\widetilde{\Pi}^u}_{<0}. \quad (10.43)$$

Let us finally compare (10.43) with (10.39). We can see that $\widetilde{\Pi}^u<\widetilde{\Pi}^u_{LF}<C$. Proposition 22 is thus proven.■

10.4.7 Proof of proposition 23

Let us calculate the value of debt. Before default, the lender receives C. After default, the lender becomes shareholder and the value of debt turns to be equity. Using dynamic programming one can write debt as

$$D^i\left(\widehat{\Pi}^i;\Pi,C\right)=\begin{cases}\Pi^N\left(\widehat{\Pi}^i;\Pi,C\right)dt+e^{-rdt}\cdot \\ \cdot\xi\left[D^i\left(\widehat{\Pi}^i;\Pi+d\Pi,C\right)\right] & \text{after default,}\\ \\ Cdt+e^{-rdt}\cdot \\ \cdot\xi\left[D^i\left(\widehat{\Pi}^i;\Pi+d\Pi,C\right)\right] & \text{before default,}\end{cases} \tag{10.44}$$

with $i=p,u$. Expanding (10.44) and using Itô's Lemma, one obtains

$$D^i\left(\widehat{\Pi}^i;\Pi,C\right)=\begin{cases}\frac{(1-\tau)\Pi}{r}+\tau I+ \\ +\sum_{j=1}^2 B_j^i\Pi^{\beta_j} & \text{after default,}\\ \\ \frac{C}{r}+ \\ +\sum_{j=1}^2 D_j^i\Pi^{\beta_j} & \text{before default.}\end{cases} \tag{10.45}$$

In the absence of any financial bubbles, we have $B_1^i=D_1^i=0$. Moreover, we know that the lender's claim is nil when $\Pi=0$: thus the boundary condition $D^i\left(\widehat{\Pi}^i;0,C\right)=0$ holds. This implies that $B_2^i=0$, irrespective of the quality of debt. To calculate D_2^i, we let the two branches of function (10.45) meet at point $\Pi=\widehat{\Pi}^i$. Using (10.45) and solving for D_2^i one easily obtains

$$D_2^i=\left[\frac{(1-\tau)\widehat{\Pi}^i-C}{r}+\tau I\right]\widehat{\Pi}^{i^{-\beta_2}},$$

which gives

$$D^i\left(\widehat{\Pi}^i;\Pi,C\right)=\begin{cases}\frac{(1-\tau)\Pi}{r}+\tau I & \text{after default,}\\ \\ \frac{C}{r}+\left[\frac{(1-\tau)\widehat{\Pi}^i-C}{r}+\tau I\right]\left(\frac{\Pi}{\widehat{\Pi}^i}\right)^{\beta_2} & \text{before default.}\end{cases} \tag{10.46}$$

As can be seen, the value of D_2^i depends on the default condition applied (namely, on the relevant trigger point).

Let us next calculate the value of equity. We can write

$$E^i\left(\widehat{\Pi}^i;\Pi,C\right)=\begin{cases}0 & \text{after default,}\\ \Pi^N dt+e^{-rdt}\cdot \\ \cdot\xi\left[E^i\left(\widehat{\Pi}^i;\Pi+d\Pi,C\right)\right] & \text{before default.}\end{cases} \tag{10.47}$$

Substituting (10.15) into (10.47), expanding and using Itô's Lemma gives

$$rE^i\left(\widehat{\Pi}^i;\Pi,C\right)=\left[(1-\tau)\,\Pi-C+\tau rI\right]+\frac{\sigma^2}{2}\Pi^2E^i_{\Pi\Pi}\left(\widehat{\Pi}^i;\Pi,C\right). \tag{10.48}$$

Solving (10.48) one can rewrite (10.47) as

$$E^i\left(\widehat{\Pi}^i;\Pi,C\right)=\begin{cases}0 & \text{after default,}\\ \frac{(1-\tau)\Pi-C+\tau rI}{r}+\sum_{j=1}^{2}A^i_j\Pi^{\beta_i} & \text{before default.}\end{cases} \tag{10.49}$$

Again, without financial bubbles we have $A^i_1=0$. Moreover, to calculate A^i_2 we substitute (10.49) into (10.16). Under protected debt financing we can show that $A^p_2=0$ and, therefore, we have:

$$E^p\left(\widehat{\Pi}^p;\Pi,C\right)=\begin{cases}0 & \text{after default,}\\ \frac{(1-\tau)\Pi-C+\tau rI}{r} & \text{before default.}\end{cases} \tag{10.50}$$

Let us next turn to the unprotected-debt case. Substituting (10.49) into (10.17) and (10.18), one obtains a two-equation system where $\widehat{\Pi}^u$ and A^u_2 are the unknowns. Re-arranging gives

$$\widehat{\Pi}^u=\frac{\beta_2}{\beta_2-1}\frac{C-\tau rI}{1-\tau}<\widehat{\Pi}^p,$$

and

$$A^u_2=-\frac{(1-\tau)}{r}\frac{1}{\beta_2}\widehat{\Pi}^{u^{1-\beta_2}}>0.$$

The value of equity is thus equal to

$$E^u\left(\widehat{\Pi}^u;\Pi,C\right)=\begin{cases}0 & \text{after default,}\\ \frac{(1-\tau)\Pi-C+\tau rI}{r}- \\ -\frac{(1-\tau)}{r}\frac{1}{\beta_2}\widehat{\Pi}^u\left(\frac{\Pi}{\widehat{\Pi}^u}\right)^{\beta_2} & \text{before default.}\end{cases} \tag{10.51}$$

Therefore, comparing (10.50) with (10.51) one can see that the value of equity is higher under unprotected debt financing. Using (10.46), (10.50), and (10.51), one finally shows that condition (10.9) holds under both protected and unprotected debt financing. This concludes the proof of proposition 23.■

11

Conclusions and topics for future research

11.1 Review of main results

In the first part of this book we have addressed basic tax issues by means of option pricing techniques. In particular, in chapter 1 we have introduced a discrete-time model, and shown how sufficient neutrality conditions must be modified in order to account for managerial flexibility.

In chapter 2 we have analyzed the effects of taxation on start-up decisions. As we have shown, entrepreneurial choices depend not only on labor market characteristics (such as the unemployment rate as a proxy for search costs) but also on industry-specific risk. However, so far empirical analysis has not yet dealt with this risk. Therefore, we believe that there is room for future empirical research in this field.

In chapter 3, we have studied organizational choices. Option pricing is helpful studying the relationship between a firm's tax status and its non-tax characteristics (such as limited liability): both determinants may affect organizational choices and, for this reason, deserve a joint analysis. We have thus focused on a common case, where firms start non-corporate and then can decide whether and when to incorporate.

In chapter 4 we have analyzed financial choices. In particular we have studied the effects of taxation on a domestic firm's financial choices and, then, focused on a MNC's financial strategy. It is well known that financial strategies help MNCs to alter transfer prices and thus shift income from high- to low-tax jurisdictions. Therefore, in chapter 4 we have established a theoretical framework that is in line with empirical evidence and, at the same time, allows us to study the interactions between MNCs' income shifting activities and financial strategies.

FDI is at least partially sunk. Moreover, imperfect information concerning market conditions, national rules and regulations means that there is uncertainty related to the true cost of FDI and its payoff. Finally, managers are aware that FDI presents opportunities and is not an obligation. The fact that FDI is often characterized by irreversibility, uncertainty, and the ability to choose its optimal timing makes the real-option approach suitable for its analysis. In chapter 5 we have thus studied the interactions between transfer pricing activities and investment timing. Moreover, we have dealt with the so-called "capital levy problem", arising when capital is sunk and unexpected tax changes may take place. It is well known that firms are usually aware that a government can undertake actions different from those initially planned and try to anticipate tax rate changes. As we have shown, the MNC's ability to delay investment exacerbates the capital levy problem.

The second part of this book has focused on tax design problems. Chapter 6 has provided a review of the main corporate tax options, which are based on two well-known schemes, namely, comprehensive income and consumption-based tax. In the nineties, various kinds of imputation tax systems were proposed and/or introduced. According to these mechanisms, corporate income is split into two components: normal income and above-normal income. Imputation systems seem to be promising tax options for both advocates of comprehensive income and consumption-based taxation. For this reason, the remaining chapters of the book have focused on the main characteristics of these systems.

Chapter 7 deals with tax-rate-cut-cum-base-broadening policies, implemented throughout the world over the last three decades. As pointed out in the existing literature, one of the main objectives that can push a country to widen the tax base is that, by doing so, it can attract MNCs. By widening the tax base, countries can collect the same amount of resources with a lower tax rate. Since MNCs often earn monopolistic rents, they can benefit from tax cuts, as their rents are taxed less heavily. In chapter 7, we have compared two alternative systems: an imputation consumption-based system, and a comprehensive income tax system. Since the former is characterized by a narrower tax base and a higher tax rate, according to standard literature, a high-income MNC investing in an imputation consumption-based system would face a heavier tax burden. For this reason, the MNC would prefer a comprehensive income tax regime. As we have shown, however, results may change if a MNC can time its FDI decision. Under a consumption-based system, the MNC would find it optimal to invest earlier and thus enjoy a longer stream of income. If this effect were big enough, therefore, the MNC would prefer the consumption-based system.

In chapter 8 we have dealt with one of the most controversial aspects of imputation systems, i.e., the choice of the imputation rate. We have shown that, under interest rate uncertainty, the imputation rate ensuring investment neutrality depends crucially on the nature of the firm's investment. If investment is reversible, the neutral rate 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. Moreover, if the firm can delay investment, the imputation rate must be proportional to a mortgage rate.

Chapter 9 has analyzed the tax treatment of losses. In order to study the effects of tax refunding, we have focused on two alternative systems, under which the tax base is given by the firm's income, net of an imputed income. The first system is symmetric and hence entails that when the firm's return is less than the imputation rate, the firm is subsidized by the government. The second system, instead, is asymmetric, as it allows no tax refunds in a negative tax state. As we have shown, when a firm can delay investment, the asymmetric system is neutral if the imputation rate is high enough. In other words, irrespective of whether a firm invests immediately or waits, it will face the same expected tax burden. This implies that taxation does not affect investment timing. Moreover, we have shown that policy uncertainty does not affect the neutral imputation rate. Therefore, the asymmetric tax scheme is equivalent to pre-commitment by the government.

Finally, chapter 10 has analyzed the treatment of the cost of debt under imputation systems. As we know, there are two alternative ways to treat debt: its cost may be deductible either at the risk-free rate or at the interest rate actually paid. The former is equivalent to a R-based cash-flow system, while the latter refers to a S-based one. As we have shown, the neutrality properties of a S-based system depend on the default condition assumed. In particular, investment neutrality holds when debt is protected. When debt is unprotected, instead, investment neutrality is ensured only under uniform taxation. Moreover shareholders postpone their default decision and, therefore, financial neutrality never holds. Under a R-based system, both investment and financial neutrality hold irrespective of whether debt is protected or unprotected. This has led to the conclusion that, in terms of neutrality, a R-based system is preferable to a S-based system.

11.2 Future research directions

The option pricing approach is a promising tool to extend our results in many new directions. For instance, the tax treatment of venture capital (VC) activities could be addressed by means of option pricing techniques. Indeed, the existing tax literature usually disregards investment staging, which is an important aspect of VCs' strategies. As we know, venture capitalists usually time investment stages depending on the state of nature. Therefore, a real-option model would enable us to investigate the effects of taxation on sequential investment strategies and, therefore, find the optimal tax treatment of VC backed entrepreneurship.

Moreover, it would be interesting to analyze the effects of taxation on both entrepreneurial and organizational choices (studied in chapters 2 and 3, respectively). These decisions could be jointly analyzed as a two-stage process. In this case, the economic agent would behave as if he owned a compound option: in other words, in the first stage the individual would exercise the start-up option and, at the same time, would acquire an option to change organizational form.

Another important topic looks at the widespread diffusion of financial engineering as a powerful tool to avoid taxation. Both derivatives and other financial instruments (such as cash pooling devices within MNCs) allow managers to mis-report tax profits, thereby guaranteeing tax savings. Of course, option pricing would enable us to measure tax savings arising from financial engineering.

A related topic looks at the tax treatment of debt financing. In this book, we have focused on protected and unprotected debt financing. However, there are other default conditions that should be investigated. For instance, after default, the firm might be reorganized: in this case the existing shareholders might continue to hold some equity and the creditors would receive new equity. Moreover, convertible debt, as well as other financial arrangements, should be accounted for. All these financial contracts would have an impact on the firm's leverage and, therefore, their study would be useful to evaluate the firm's tax burden more carefully. This would be certainly an improvement in the measurement of effective taxation and in the understanding of its effects on investment decisions.

Last but not least, policy issues would be addressed more carefully by means of option pricing. In this book we have mainly focused on imputation systems. However, the techniques applied here could also enable us to investigate the effects of other corporation tax devices, as well as the interactions between personal and corporate taxation.

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