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Tax Neutrality: Illusion or Reality? The Case of Entrepreneurship

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The Case of Entrepreneurship*

Abstract

The theoretical work on capital income taxation has focused on conditions under which a tax system preserves investment neutrality. The trouble with such a neutrality view is that it is focused on one margin among others. The economics of start-up firms is, however, fundamentally different from the economics of established corporations. In particular, the opportunity cost of an entrepreneur should be stated in terms of foregone earnings in the labor market, adjusted for the option value to abandoning the firm throughout the life time. Moreover, the future exit option interferes with the early start-up decision when a nascent entrepreneur is forward-looking. The paper shows that the requirement of start-up neutrality is not satisfied by any of the well-known investment neutral tax systems including comprehensive income tax, the dividend tax, the Johansson-Samuelson tax, the cash flow tax and the ACE tax.

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1   Introduction

For quite some time, the theoretical work on capital income taxation focused on conditions under which a tax system preserves investment neutrality. Neutral tax systems are desirable for efficiency reasons. An understanding was built that there are alternative ways of making the return on marginal investment tax-free. The idea of taxing *corporate cash flow* suggested by Brown (1948) and Smith (1963) was the early one and was developed into a practical tax reform proposal by the Meade Committee (1978). The notion of investment neutrality of the dividend tax was subsequently introduced in the spirit of the so-called *new view of equity finance* and developed by various authors (Auerbach (1979), Bergström and Södersten (1977), Bradford (1981) and King (1977)). As in the case of the cash flow tax, it was shown that the dividend tax falls on the company value, not on the marginal investment returns. It turned out that such investment neutrality can be cast in a general condition, known as the *Johansson-Samuelson Theorem* (see Sinn (1987)). It states that if all capital income is subject to a uniform marginal tax rate and if the tax depreciation coincides with true economic depreciation, the present value of the marginal cash flow is left unchanged.

Echoing the ingenious tax theorem of Boadway and Bruce (1984), the IFS Capital Taxes Group proposed the Allowance for Corporate Equity (hereafter ACE) in 1991 for the UK corporate system. 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). Under the ACE system the ordinary return, approximating the opportunity cost of new equity capital at the margin, is exempt at the corporate level resulting in tax neutrality.

The trouble with such a neutrality view is that it is focused on one margin among several. The economic dynamics are derived not only from the expansion of existing firms; new start-up firms represent another key engine. The economics of start-up firms is, however, fundamentally different from the

economics of established corporations.[1] The opportunity cost of investment and the opportunity cost of the discrete choice of establishing a start-up firm are based on different mechanisms and subject of different taxation. While the market rate of interest dictates the former the wage income in the labor market determines the latter. Consequently, taxes which are understood to be neutral in terms of the marginal investment decisions may be distortionary in terms of entry decisions. Investment neutrality and start-up neutrality are analogous issues but they require separate analyses.

The effects that tax policies can have on entrepreneurship have been subject of a number of studies, both theoretical and empirical. For exhaustive surveys, we refer to Schuetze and Bruce (2004) and Gurley-Calvez and Bruce (2008). The theoretical literature has considered the effects of business risk, risk preferences and loss offsets (starting with Cullen and Gordon 2002), and the opportunities for tax evasion (starting with Watson 1985). For the purposes of our paper, it is of importance to notice that the theory suggests a number of mechanisms through which taxation tends to interact with entrepreneurship. As those effects have, however, been found to be at least partially offsetting each other, empirical studies have tried to solve the ambiguities. A number of the early time series studies (cf. Schuetze and Bruce (2004)) concluded that higher tax rates tend to lead to a higher rate of self-employment. However, subsequently, even those findings have been challenged. On the theoretical frontier, the "now or never" investment decision was replaced by a more careful analysis as to when the expansion investment is valuable enough to be activated. The emerging literature with taxes in the real option framework included Alvarez and Kanniainen (1997), Niemann (1999) and Sureth (2002). Tax neutrality of the cash flow tax and the Johansson-Samuelson tax was derived under risk neutrality and extended to the case of risk aversion by Niemann and Sureth (2004). Pennings (2000) showed that in such a framework, a subsidy to investment in combination with taxation of future profits decreases the trigger value of investment.

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[1] The start-up firms are subject of a much greater risk of failure, their ability to share their risk with markets is more limited and consequently, their access to debt is therefore more restricted to point out some key differences. The econometric evidence on the high failure risk of start-up enterprises is convincing. This evidence includes Bruderl et.al (1992) on German data, Cressy (1996) on the UK, and Mata and Portugal (1994) on the Portuguese data. Moreover, Geroski (1995) provides an extensive survey of the stylized facts on entry emphasizing that while entry is common, entry rates are far higher than market penetration rates.

Though the neutrality properties of cash flow tax, ACE and comprehensive income tax are well-known in the real option framework, these results have been derived in terms of the investment programs of existing firms. Typically, the opportunity cost of a start-up entrepreneur in terms of lost wage earnings from an alternative career has not been incorporated.[2] What our paper does is to focus on the tax effects on such a career choice. While the earlier papers have studied the effects of particular taxes, our paper's focus on those taxes on capital income which have been found to be neutral in regard to the capacity investments of corporations. We ask whether those "neutral" taxes are neutral also in another margin i.e. at the start-up stage. We show that they mostly fail.[3]

The idea of tax neutrality is first stated in a simplified "micky mouse" model of occupational choice. Is is used if only to make the point that for the tax neutrality the taxation of labor income is relevant in the early stage of the entrepreneur's life cycle. Needless to mention, the tax rate on labor income is missing from the whole theoretical literature on neutrality of taxing capital income. Subsequently, the issue is thoroughly examined in this paper in an extended model where entry is viewed as a real option of a nascent entrepreneur with potential of re-entering into the labor market.[4] It is then shown that the taxation of labor income is relevant not only at the early stage but also in later stages of the incumbent entrepreneur if and when he has an option to re-enter the labor market.[5]

To sum up, our results suggest that *any* of the above discussed tax formats - though neutral around the steady state of a mature company - are

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[2] It was analyzed empirically by Gurley-Calvez and Bruce (2008).

[3] There is a further margin which is relevant. Niemann (2008) raised the question of another dimension of effects of (differential) taxation, the effort choice and risk-taking examining how differential taxation adds to the tax effects of symmetric taxation.

[4] Thus, our paper is also related to those with partial flexibility.

[5] The empirical paper by Gurley-Calvez and Bruce (2008) is the first one to examine the effects of tax rates on exit decisions using duration analysis techniques. The authors found that cutting marginal tax rates faced by wage and salary workers can reduce the duration of entrepreneurial activities, while cutting marginal tax rates faced by entrepreneurs can lengthen entrepreneurial spells. Their results thus support the view that tax policies are not neutral when entrepreneurship is concerned. Moreover, Agliardi and Agliardi (2008) introduced the real option model to study the tax effects on the closure, the exit policy of a firm. Their main conclusion is that only the adoption of a progressive tax schedule can slow down or speed up a closure policy of a firm while any flat plan does not interfere with liquidation. Our paper differs from this conclusion as we show how the exit policy is affected by a flat tax rate on entrepreneurial and labor income.

distortionary in an early margin in the life-cycle of a firm, i.e., at the stage of a start-up firm.[6] The major result of this paper thus is a negative one: the well-known neutral systems of taxing income from existing corporations typically distort the economic decisions both at the start-up and at the liquidation stage. We show that neither of those celebrated tax systems can possibly satisfy the requirement of start-up neutrality unless the expected overall tax burden on entrepreneurial lifetime income is equal to the expected overall tax burden on labor income. This is a special case that is unlikely to hold in any real tax system. Though this view can easily be justified, we think that it needs to be taken up to be delivered into the literature. We prove that, under a comprehensive income tax, the entrepreneurial choice is delayed unless the double taxation of capital income is eliminated and a proper depreciation allowance is ensured. Indeed, business taxes tend to raise the trigger value of entry. We also demonstrate that uniform taxation is necessary even under the cash-flow and the ACE taxation for neutrality to hold. However, we will also show that these tax conditions are hard or even impossible to implement because of informational problems. When the entrepreneur has an option to quit his business activity and re-enter the labor market, the tax system faces a new challenge in that it must cope with the interaction among multiple options. Our contribution is thus to consider these two neutrality requirement simultaneously within the same framework and show that they may be incompatible. From this perspective, we point out that even the Mirrlees Review overlooks this problem as it does not consider the tax effects in the pre-entry stage – though it considers small firms in the post entry stage. We thus extend the earlier real option analyses with no occupational choice into a model with an occupational choice.[7]

The structure of this paper is as follows. Section 2 provides an insight into our argument using a simple model with no uncertainty. Section 3 introduces an intertemporal model which describes the effects of taxation on the entrepreneurial choice by a representative agent when uncertainty shapes the value of the entrepreneurial career. Section 4 extends the model by assuming that the representative entrepreneur has an option to quit the

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[6]The burden of dividend tax on initial equity injection and the growth path of a firm was examined by Sinn (1991). He did not, however, address the occupational choice issue.

[7]Niemann and Sureth (2009) examined the capital gains tax in the real option model showing that it tends to be harmful for immediate investments. Moreover, Schneider and Sureth (2010) found that the option to abandon an investment project can have paradoxical tax effects.

business sector and re-enter the labor market. Section 5 warns against simple policy implications from models of mature firms.

2   The basic intuition

The prevailing view of entrepreneurship builds on the occupational choice of heterogenous individuals, indexed below by i. People are considered taking rational economic decisions on their career choices. There are a number of differences characterizing these careers. Whatever these differences are, we denote the pre-tax value of the entrepreneurial career by V (with potential options to optimize entry and exit) and the pre-tax life-time income of a worker by O.[8]

If only to illustrate, consider first the simple case where individuals make career choices at the start of their life-cycle and in the absence of risks. Then, the option to delay has no value and the career choice is a permanent once-for-all decision. We assume that people are homogenous as workers but differ in terms of their entrepreneurial abilities, say $a^i \epsilon [\underline{a}, \overline{a}]$. Then, by definition $\partial V(a^i)/\partial a^i > 0$. High-ability entrepreneurs generate more profits. Denote the total life-time tax liabilities from operating a firm as an entrepreneur, or alternatively, being a worker are by T and T_w. Those tax liabilities crucially depend on the real options of the individuals as we will see in the next sections. The career choice of the marginal individual with ability a^m can be characterized by a simple indifference condition

$$V(a^m) - T = O - T_w. \tag{1}$$

The marginal entrepreneur is thus identified through equation (1), $a^m = a^m(T, T_w)$. Individuals with $a^i \geq a^m$ choose entrepreneurship, individuals with $a^i < a^m$ become workers. Given (1), the enterprise formation depends on *total tax liabilities*, rather than on *marginal tax rates* at various income levels. In particular, given the life-time tax liability of a worker, T_w, an increase in the tax liability on the entrepreneurial career reduces the equilibrium start-up entrepreneurship in the economy, while an increase in the tax liability of workers has the opposite effect,

$$\partial a^m/\partial T > 0, \quad \partial a^m/\partial T_w < 0. \tag{2}$$

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[8]We interpret the value of the entrepreneurial career as including any business options arising during the career.

Intuitively, a higher tax burden on the entrepreneurial career calls for greater entrepreneurial quality at the margin. The non-neutrality result shown in (2) holds for any tax on an entrepreneurial income, regardless of the potential neutrality in regard to the marginal capital on the growth path or around the steady state. Tax start-up neutrality holds only if the tax rates satisfy a particularly harsh requirement in terms of tax liabilities, $T = T_w$. Therefore, even a comprehensive income tax is distortionary if the double taxation of capital income makes the total tax rate exceed the tax on wage income.[9]

In the absence of any start-up sunk cost, the above analysis can be easily extended to the case of uncertainty of the entrepreneurial income. With risk neutrality, the marginal entrepreneur is determined by his expected income relative to the wage income; with risk aversion a risk premium is introduced. When sunk costs are involved, the career choice becomes more involved and will be analyzed in the subsequent sections. Here we hasten, however, to point out that under a comprehensive income tax without double taxation at a personal level, tax neutrality is carried over to the case of occupational choice only on condition that the option values of the entrepreneur have been properly considered. As we will show, they must also include the option to quit the business activity.

Many entrepreneurial choices are dichotomous. In line with Devereux and Griffith (1999), therefore, whenever an agent faces a discrete choice between two or more mutually exclusive projects, it is the average rather than marginal effective tax rate which matters. Therefore, when the proponents of the "new view" of the dividend tax, the cash flow tax, the Johansson-Samuelson tax, or the ACE-tax claim to the neutrality of these taxes, they have in mind a different margin. They refer to a situation where an established firm with some pre-invested capital is undertaking a marginal investment. Even the Johansson-Samuelson tax discriminates against the enterprise formation if the overall effective tax rate (arising typically in the case of double taxation) exceeds the total tax rate on labor income. We have been unable to locate this view in the literature.[10] This apparently innocuous result has crucial

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[9]We notice that in a more complicated model it is not necessarily the case that an increase in the tax on entrepreneurship leads to fewer entrepreneurs. For example, it is well-known that entrepreneurs can manipulate their income more easily than workers. With a higher tax rate, the entrepreneurs' incentive might increase, thereby resulting in increased market entry.

[10]Neither did the Meade Committee (1978) discuss this case. The idea of neutrality of

policy implications, in that it implies that many celebrated tax systems fail to be start-up neutral in terms of entrepreneurship, unless harsher conditions are met.

3   Worker's option

In this section, we introduce a partial equilibrium model to study the effects of taxation on an individual's career choice. We consider an agent who first enters the labor market earning the market wage w per unit of time. However, he has a business idea that develops according to a stochastic process (to be introduced below). Once he is sufficiently convinced that the value of his business idea exceeds some threshold level, he quits the labor market and establishes a start-up firm. We first consider the case where the commitment to an entrepreneurial career is irreversible and thus permanent. In order to deal with these characteristics, we therefore introduce a continuous-time real option model.[11] In the next section, we will analyze the case where the individual subsequently has an option to quit entrepreneurship and re-enter the labor market.

Let us first abstract from taxes and introduce the following:

Assumption 1 *at time $t = 0$ the individual is an infinitely-lived worker, earning an exogenous wage w, and is endowed with an option to start an entrepreneurial activity;*[12]

Assumption 2 *to undertake a risky activity, the individual pays a sunk start-up cost I;*

dividend tax has been challenged recently by Henreksson and Sanandaji (2004) and its non-neutrality has been stated by Kanniainen, Kari and Ylä-Liedenpohja (2005, 2007), but otherwise it has been overlooked.

[11]In the next section, we extend the model to copy with both the entry decision and the exit decision from the business sector. In principle, we could use a discrete time model with three periods, i.e., 0, 1, 2, to deal with both entry and exit. However, in this case, the agent would be obliged to make decisions at discrete times 0, 1 or 2. Since we want the agent to be free make choices at any instant, we prefer to use a continuous time model.

[12]As shown by Panteghini (2007a), assuming an infinitely-lived business project does not affect the quality of results.

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

$$\frac{d\Pi_t}{\Pi_t} = \alpha dt + \sigma dz_t \ \ with \ \Pi_0 > 0, \tag{3}$$

where α is the growth rate, σ is the instantaneous standard deviation of $\frac{d\Pi_t}{\Pi_t}$ and dz_t is an increment to a Wiener process.

Assumption 4 *the agent is risk-neutral.*[13]

For simplicity, assumption 1 states that the pre-tax wage rate is exogenously given. As 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.[14] When the individual decides to become an entrepreneur, thus exercising the option, he loses his wage and, according to assumption 2, must pay I,[15] which accounts for consultancy and administrative costs representing the strike price of the individual's option. It is worth noting that, whereas entry fees are observable,[16] a relevant part of entry costs may be unobservable. As pointed out by Djankov et al. (2002), bureaucracy delays may be dramatic and therefore their cost may be high.[17] Moreover, they may greatly vary from one individual to another, thereby causing heterogeneity.

According to assumption 3, the firm's payoff follows a stochastic process, described in (3) by a geometric Brownian motion. The drift parameter α mea-

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[13]The risk-neutrality assumption does not affect the quality of our results. Indeed, an optimal timing problem under risk aversion is equivalent to a risk-neutrality one, if we apply a risk-adjusted drift (accounting for a risk premium). In other words, the stochastic process (3) can be substituted with an equivalent risk-neutral one, equal to $\frac{d\Pi_t}{\Pi_t} = \widehat{\alpha}dt + \sigma dz_t$, where $\widehat{\alpha} = \alpha - \lambda\sigma$, with λ representing the market price of risk (see e.g. Dixit and Pindyck (1994), McDonald and Siegel (1985, 1986) and Trigeorgis (1996, Ch.3)). Since we deal with a partial-equilibrium setting, λ is given. As pointed out by Niemann and Sureth (2004, 2005), an agent's risk premium may be affected by taxation. If we accounted for this tax effect, we would further complicate the conditions for tax neutrality to hold.

[14]Since this option can be exercised at any future instant, it is an American call option. For further details, see McDonald and Siegel (1985, 1986).

[15]For simplicity, we have assumed that the sunk cost I is self-financed. The results do not change qualitatively under debt-finance on condition that the risk of default is nil (see Panteghini (2006, 2007a)).

[16]For a cross-country comparison of entry fees and procedures see World Bank's (2011) *Doing Business 2012*.

[17]Djankov et al. (2002) also show that bureaucracy delays vary among countries.

sures a worker's entrepreneurial ability:[18] namely, the higher the parameter α, the higher is the probability that our agent undertakes an entrepreneurial career successfully.

Using these assumptions, we can calculate the pre-entry value function of the worker, defined as $O(\Pi_t)$, and the (post-entry) firm value, denoted by $V(\Pi_t)$. In particular, the pre-entry value function is equal to the current wage (namely, the wage received in the short interval dt) plus the remaining value, that is the value function after the instant dt has passed. Defining r as the relevant risk-free interest rate, and applying dynamic programming (see Panteghini (2007a)) we obtain:

$$O(\Pi_t) = wdt + e^{-rdt}\xi\left[O(\Pi_t + d\Pi_t)\right] \tag{4}$$

where $\xi[.]$ is the expectation operator. Following the same procedure we can write the entrepreneurial post-entry gross value function as

$$V(\Pi_t) = \Pi_t dt + e^{-rdt}\xi\left[V(\Pi_t + d\Pi_t)\right].^{19} \tag{5}$$

Using (4) and (5) we can rewrite the worker's value function as follows (see Appendix A):

$$O(\Pi_t; \Pi^*) = \frac{w}{r} + \max_{\Pi^*}\left[\left(\frac{\Pi}{\Pi^*}\right)^{\beta_1}\left[V(\Pi^*) - I - \frac{w}{r}\right]\right], \tag{6}$$

where $\beta_1 > 1$ is the positive root of the quadratic equation, see Appendix A.

As can be seen, the worker's value function consists of two terms: the first one is the present value of a perpetual rent yielding w. This term measures the worker's value function when he works forever (and cannot enter the business sector). The second term measures the worker's start-up option value at the optimal trigger point Π^*. Therefore, by solving the problem $\max_{\Pi^*}\left[\left(\frac{\Pi}{\Pi^*}\right)^{\beta_1}\left[V(\Pi^*) - I - \frac{w}{r}\right]\right]$, a worker can calculate the value of his start-up option and find when it is optimal to become an entrepreneur.

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[18] In line with Section 2, we could generalize our analysis by considering a set of potential entrepreneurs, each with his own α, i.e., determined by his own entrepreneurial skill. However, the quality of results would not change.

3.1 Comprehensive income taxation and the Johansson-Samuelson Theorem

According to the well-known Schanz-Haig-Simons (hereafter SHS) definition of income, the tax base must be comprehensive. In other words, it must include all income from production factors, such as labor, capital and non-reproducible factors (e.g., land, raw materials), net of expenses incurred in earning the income. The idea underlying the SHS scheme is that the income tax base must be as close as possible to the true net income. This means that any change in the firm's net worth must be taken into account, *even in the value of the worker's option!* Advocates of this tax argue not only that such a tax is desirable in terms of fairness, but also that it is neutral in terms of marginal investment decisions. Indeed, according to the well-known Johansson-Samuelson Theorem (JST),[20] if all kinds of capital are subject to the same marginal tax rate and fiscal depreciation allowances coincide with economic depreciation, the investment strategies are unaffected by taxation.

To analyze the effects of a SHS comprehensive income tax on entrepreneurship, let us denote by $O^{JS}(\Pi)$ and $V^{JS}(\Pi)$ the before- and after-entry value functions, respectively. Moreover, in the spirit of Samuelson (1964) and the JST, the pre-entry and post-entry depreciation allowance should reflect the change in the option value:

$$\delta_O dt = -\xi \left[dO^{JS}(\Pi) \right], \tag{7}$$

and

$$\delta_V dt = -\xi \left[dV^{JS}(\Pi) \right], \tag{8}$$

respectively. We note that even with no physical depreciation, an individual's value function can change over time because of the stochastic development of the value of the business idea (3). In particular, the value of a worker's option to enter the business sector appreciates if the cash flow increases and depreciates if it decreases. Finally, remember that under a comprehensive income tax, all kinds of capital income (including the interest income) must be subject to taxation. Therefore, the relevant discount rate is $(1-\tau)r$. Defining τ_w and τ as the wage and business tax rates, respectively, we prove:

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[20]The JST is the joint result of Johansson's (1961, 1969) and Samuelson's (1964) findings. For a discussion of the JST see e.g. Sinn (1987, Ch. 5). For an analysis in a stochastic context, see also Menoncin and Panteghini (2012). Earlier, Niemann and Sureth (2004) deduced neutral depreciations in the Samuelson spirit in a real option model.

Proposition 1 *Two conditions are needed for the entrepreneurial choice to be unaffected by taxation, first $\tau_w = \tau$, and second, a depreciation allowance has to coincide with the economic depreciation of the worker's option to become an entrepreneur.*

Proof. See Appendix B. ∎

According to Proposition 1, uniform taxation is not sufficient to ensure entrepreneurial neutrality. In line with Niemann (1999), we have shown that neutrality holds in a real-option setting only if all sources of income, including changes in a taxpayer's portfolio of real options, are subject to taxation. This implies that a neutral income tax system also requires the deduction of economic depreciation related to the worker's entrepreneurial option. Otherwise, a distortion arises (see Alvarez and Kanniainen (1997)).

Proposition 1 has two important implications. First, it states that a uniform tax is necessary (but not sufficient) to ensure neutrality at the entry stage. This means that no double tax can be levied; otherwise, taxation discourages entrepreneurship. This result contradicts the new view of equity finance according to which the dividend tax is neutral. The intuition behind our result is here: many well-known tax proposals (e.g., based on the new view) hold only for mature firms. We think, however, that most firms do not operate in steady state but rather on their expansion or contraction paths, not to mention firms which are not yet created. For start-ups and future firms, the neutrality of the dividend tax breaks down for the reasons discussed in the context of the comprehensive income tax and the JST.

A second implication regards information requirements. According to Proposition 1, a comprehensive income tax is neutral if a depreciation, i.e., $\delta_O dt = -\xi \left[dO^{JS}(\Pi) \right]$, is allowed under labor taxation! However, the entrepreneurial ability, and thus the option value varies from one worker to another. This means that, due to the heterogeneity of workers, a serious informational problem arises. In the absence of market prices, it is hard (even impossible) to evaluate a worker's option,[21] and therefore, to measure his depreciation allowance. The problem arises from the existence of information

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[21]Notice that these options are non-tradable. The absence of trading has already been dealt with by Hall and Murphy (2000, 2002) in a different context. By focusing on stock option plans, they showed that a company's cost of granting employee stock options differs from the value of the same stock options to employees, under a certainty-equivalence approach. Differently from the stock-option-plan topic, where two agents (the employee and the employer) are involved, here we focus on a self-employed agent. Therefore, in our model, there is no wedge in the evaluation of options, and above all, the start-up option

asymmetry where workers are the agents and the government is the principal. In such a context, an individual would be clearly induced to overstate the value of his entry option in order to reduce his before-entry tax burden.[22]

3.2   Cash-flow and ACE taxation

Let us next study two alternative consumption-based tax systems: a standard cash-flow tax and an ACE-type one. In both cases, interest income (i.e., ordinary capital income) is tax exempt, and therefore, the relevant discount rate is r.

Cash-flow tax   Under the cash-flow tax, the difference between receipts and outlays is taxed at the tax rate τ at any instant t. In this case, the after-tax cash flow will be equal to:

$$\Pi^{CF} = (1 - \tau) \Pi. \tag{9}$$

Note that under the cash-flow tax, the investment cost I must be fully deducted when it is undertaken. The after-tax cost is therefore equal to $(1 - \tau) I$.

ACE tax   Under the ACE tax, the entrepreneur's payoff, Π, is taxed at the rate τ, and, at any time period, a portion ρ of the investment cost I is deductible from the current tax base where ρ measures the cost of financing.[23] Thus, the tax payment is equal to $T(\Pi) = \tau (\Pi - \rho I)$ and a firm's after-tax cash flow will be:

$$\Pi^{ACE} = \Pi^{CF} + \tau \rho I. \tag{10}$$

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cannot be reckoned in any balance sheet. This leads to another relevant informational problem.

[22] Notice that workers might also own options which are never exercised. Even on an ex-post basis, therefore, it would be impossible to evaluate them. Of course, this leaves the authorities with a hard task.

[23] Boadway and Bruce (1984) assume that a representative firm is financed with both debt and equity. According to their tax system, the firm can deduct the total cost of capital, i.e., the market rate of interest, r, times the firm's capital, K, so that it can deduct rK from the tax base. Here, we have assumed for simplicity that the firm is fully self-financed. Thus, ρ should be interpreted as the opportunity cost of equity. However, the quality of results would not change if we assumed an optimally-debt financed firm (see Panteghini, 2007b).

Using dynamic programming, we can write an agent's before-entry value function as:

$$O^j(\Pi) = (1 - \tau_w)\, w dt + e^{-rdt}\xi\left[O^j(\Pi + d\Pi)\right] \text{ with } j = CF, ACE. \quad (11)$$

Solving (11) we obtain (see Appendix C):

$$O^j(\Pi) = \frac{(1 - \tau_w)\, w}{r} + A_1^j \Pi^{\beta_1}, \text{ with } j = CF, ACE. \quad (12)$$

As shown in (12), the worker's value function consists of two terms: the present value of after-tax wages, $\frac{(1-\tau_w)w}{r}$, and $A_1^j \Pi^{\beta_1}$, which measures the value of his (call) option of entering the business sector. In particular, A_1^j is an unknown parameter to be determined and $\beta_1 > 1$.[24]

Following the same procedure, we can write the after-entry value function as:

$$V^j(\Pi) = \Pi^j dt + e^{-rdt}\xi\left[V^j(\Pi + d\Pi)\right] \text{ with } j = CF, ACE. \quad (13)$$

As shown in Appendix D, (13) can be solved as

$$V^j(\Pi) = \begin{cases} \frac{(1-\tau)\Pi}{r-\alpha} & \text{under } CF, \\ \frac{(1-\tau)\Pi}{r-\alpha} + \frac{\rho}{r}\tau I & \text{under } ACE. \end{cases} \quad (14)$$

Note 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 (14), the individual's value function is a perpetual rent. This is due to the fact that, after entering the business sector, the individual is assumed not to make any further decisions.

Functions (12) and (14) allow us to deal with an individual's intertemporal decision. The individual's problem is one of choosing the optimal entrepreneurial timing, which can be associated with a trigger point $\Pi^{*,j}$. This means that, whenever the current income reaches $\Pi^{*,j}$, the individual starts his business activity. As shown in Appendix E, we can solve for the trigger points under the cash-flow and the ACE taxes as

$$\Pi^{*,CF} = \frac{\beta_1}{\beta_1 - 1}\,(r - \alpha)\left(\frac{1 - \tau_w}{1 - \tau}\frac{w}{r} + I\right), \quad (15)$$

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[24]Notice that, under taxation, β_1 differs from that in the previous section. For simplicity, however, we use the same notation.

$$\Pi^{*,ACE} = \frac{\beta_1}{\beta_1 - 1}(r - \alpha)\left(\frac{1 - \tau_w}{1 - \tau}\frac{w}{r} + \frac{1 - \frac{\rho}{r}\tau}{1 - \tau}I\right), \tag{16}$$

respectively. Using (12) and (14) we also find

$$A_1^j = \frac{1}{\beta_1}\frac{(1 - \tau)}{r - \alpha}\left(\Pi^{*,j}\right)^{1-\beta_1} > 0, \ \text{with} \ j = CF, ACE. \tag{17}$$

As can be seen in (15) and (16), the entrepreneur's trigger points $\Pi^{*,j}$ are in general affected by the tax rates τ_w and τ. However, we find:

Proposition 2 *The timing decision of the entrepreneurial career is unaffected by taxation if:*

1. *under cash-flow taxation, $\tau_w = \tau$;*

2. *under ACE-type taxation, $\rho = r$, and $\tau_w = \tau$.*

As shown by Proposition 2, uniform taxation is a necessary and sufficient neutrality condition under the cash-flow taxation. Even in this case, a firm's income cannot be *taxed twice* (i.e., both at the corporate level and at the personal level); otherwise, neutrality fails to hold. This result has an interesting policy implication: i.e., given uniform taxation, neutrality is ensured by a Hall-Rabushka flat tax (Hall and Rabushka (1995)) that entails the taxation of the cash flow only at the firm level. On the contrary, a distortion arises under the US Panel's GIT proposal since this tax design entails a double taxation of capital income.[25]

Let us focus on the ACE proposal. In line with Devereux and Freeman (1991) and Bond and Devereux (1995), Proposition 2 states that neutrality can be achieved if $\rho = r$, i.e., if the tax treatment of the sunk cost I is equivalent to that ensured by the cash-flow tax.[26] However, Proposition 2 also requires that condition $\tau_w = \tau$ is met. This means that an ACE-type

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[25]Similarly, a distortion would also arise under Bradford's (1986) X tax. Under the Bradford proposal, indeed, labor income would be subject to a graduated-rate tax, and therefore, tax rates might differ from one taxpayer to another. This would violate the uniform-tax-rate condition.

[26]Brown (1948, p. 537) argues 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". See Niemann (1999) and Panteghini (2001a, 2001b) for details on investment neutrality in a real-option framework.

tax is distortive in terms of start-up decisions if business income is subject to double taxation. In particular, the lower the tax rate τ_w and/or the higher the tax rate τ, the greater the trigger point $\Pi^{*,ACE}$ is. It is worth noting that double taxation was not excluded by the IFS Capital Taxes Group (1991). On this point, e.g., Devereux and Freeman (1991, p. 8) argued that the ACE can "operate in a classical relation with the personal tax system, so that, in administrative terms, it will function with any form of personal taxation". We now see that, however, entrepreneurship is discouraged if $\tau_w < \tau$.

Let us finally say that, under both systems, an implementation issue may arise because entry costs are partially unobservable. Like comprehensive income taxation, information asymmetry may arise, and therefore, cause a distortion in entry decisions.

4 Entry and the option to quit

We next analyze the impact of taxation on entrepreneurship when individuals can decide not only whether and when to enter the business sector but also whether and when to quit their entrepreneurial activities and re-enter the labor market.[27] This means that an entrepreneur owns an (American) real put option, that enables him to quit the business activity whenever he likes. We therefore analyze a model with multiple options of the worker. It is expected that the depreciation allowance required for tax neutrality becomes even more complicated than analyzed above.

Since quitting a business activity is not a free lunch, we introduce the following:

Assumption 5 *If the individual re-enters the labor market, he faces an exit cost equal to E.*

Given assumption 5, we can say that E is the before-tax strike price of the option to quit. When the value of the underlying asset (the firm value)

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[27]Since the individual faced a sunk cost when he entered the business sector, this implies that the entrepreneurial choice is only partially reversible, cf. also Sureth (2002). For an early analysis of exit decision, see Dixit and Pindyck, Ch 7. The tax effects on exit have earlier been analyzed by Panteghini (2006), Agliardi and Agliardi (2009), Niemann and Sureth (2009) and Schneider and Sureth (2010). At exit, there might be a positive book value of the firm relative to the cost of investment and room for capital gains taxation. We abstract from this rather complicated problem.

is low enough, the entrepreneur finds it optimal to exercise such an option by paying the strike price. In doing so, he re-enters the labor market. For simplicity, we assume that re-entering the labor market is an irreversible choice.[28]

Exit costs are at least partially unobservable. Indeed, the parameter E may account for on-the-job-search costs under unemployment.[29] It is realistic to think that the higher the unemployment rate is the greater also the parameter E is, and therefore the more costly it is to re-enter the labor market.[30] Hence, assumption 5 allows us to deal with labor market flexibility, in that the greater the cost E, the less flexible the labor market is. As we will see, the effects of taxation may crucially depend on the characteristics of the labor market.

Exit costs also account for the liquidation procedures which are time-consuming, costly, and may vary from one case to another.[31] Moreover, we must consider that our entrepreneur had already abandoned the labor market to undertake his business venture. Therefore, he may have lost employment protection as well as job benefits. In particular, the health benefits financed by the employer are lost when the worker leaves. The loss of the benefits results in an exit cost which works against entrepreneurship. There may be other exit costs like the need to move to another location, the loss of co-workers as friends etc. As will be shown however, the option to quit increases enterprise formation in the first place.

Given assumption 4, we first calculate the worker's post-exit value function as a perpetual rent, related to the wage rate w net of exit cost E, i.e.,[32]

$$W = \frac{w}{r} - E. \tag{18}$$

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[28] Of course, the model could be extended by assuming that an ex-entrepreneur could re-start a business activity and so on. This assumption would not alter the quality of our results.

[29] These costs may dramatically differ from an individual to another (see Card et al. (2007)).

[30] This is in line with Bruce (2002) who found that unemployment discourages the exit decision.

[31] For a cross-country analysis of exit costs see World Bank's (2011) *Doing Business 2012*.

[32] Since, by assumption, re-entering the labor market is an irreversible choice, the worker no longer has options, and therefore, W is measured by a perpetual rent.

4.1 Comprehensive income taxation

Let us define ϕ as the percentage of deductible exit costs. This means that the after-tax strike price is $(1 - \phi\tau_w)E$.[33] Given this assumption, the worker's post-exit value function under income taxation is

$$W = \frac{(1 - \tau_w)\,w}{(1 - \tau)\,r} - (1 - \phi\tau_w)\,E. \tag{19}$$

As can be seen, (19) is given by a perpetual rent because, after re-entering the labor sector, an individual owns no option to change his status.

Given (19) we prove the following:

Proposition 3 *Three conditions are required for the entrepreneurial choices to be unaffected by income taxation: i) $\tau_w = \tau$, ii) $\phi = 0$, and iii) the fiscal depreciation allowance coincides with economic depreciation.*

Proof. See Appendix F. ∎

Proposition 3 represents a generalization of Proposition 1. As can be seen, no deduction is needed for the exit costs. It is sufficient to set $\tau_w = \tau$ for the exit decision being unaffected by taxation. Given Propositions 1 and 3 we can say that implementation problems regarding income taxation are completely due to the impossibility of appropriately measuring the value of a worker's entry option. On the other hand, the tax treatment of the exit choice does not cause any implementation problem *per se*.

4.2 Cash-flow and ACE taxation

Under cash-flow and ACE taxation, a worker's value function takes the following form:

$$O^j(\Pi) = \frac{(1 - \tau_w)\,w}{r} + B_1^j\Pi^{\beta_1} \text{ with } j = CF, ACE. \tag{20}$$

Notice that the value of the call option to start, $B_1^j\Pi^{\beta_1}$, differs from the term $A_1^j\Pi^{\beta_1}$ of function (12), in that the former accounts for the higher degree of flexibility, due to the ownership of a (put) option to quit.[34]

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[33]Notice that we are focusing on an ex entrepreneur who has re-entered the labor market. The relevant tax rate is therefore τ_w.

[34]In other words, when an entrepreneur can quit his business activity, the exercise of the start-up option allows him to acquire an option to quit.

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

$$V^j(\Pi) = \begin{cases} \frac{(1-\tau)\Pi}{r-\alpha} + H_2^{CF}\Pi^{\beta_2} & \text{under} \quad CF, \\ \frac{(1-\tau)\Pi}{r-\alpha} + \frac{\rho}{r}\tau I + H_2^{ACE}\Pi^{\beta_2} & \text{under} \quad ACE. \end{cases} \tag{21}$$

If we compare (21) with (14), we have now the additional term $H_2^j\Pi^{\beta_2}$. It measures the value of the individual' (put) option to quit and to re-enter the labor market. In Section 3 we applied the boundary condition $V^j(0) = 0$ (that implied $H_2^j = 0$), i.e., we assumed that the entrepreneur owned no (put) option to quit. Now instead, an individual will find it optimal to quit even when $V^j(\Pi) > 0$. Since the condition $V^j(0) = 0$ no longer holds, we obtain $H_2^T \neq 0$.

Following the same procedure, let us write the worker's value function after his exit from the business sector as:

$$W(\Pi) = \frac{(1-\tau_w)w}{r} - (1 - \phi\tau_w)E. \tag{22}$$

Given (12), (21) and (22) we can now analyze an individual's decisions. Solutions are found backwards: we will first find the optimal exit point $\widetilde{\Pi}^j$ and then calculate the entry trigger point $\Pi^{**,j}$, for $j = CF, ACE$. As shown in Appendix G, we obtain

$$H_2^j = -\frac{1}{\beta_2}\frac{(1-\tau)}{r-\alpha}\left(\widetilde{\Pi}^j\right)^{1-\beta_2} > 0, \tag{23}$$

and

$$\widetilde{\Pi}^j = \begin{cases} \frac{\beta_2}{\beta_2-1}(r-\alpha)\left(\frac{1-\tau_w}{1-\tau}\frac{w}{r} - \frac{1-\phi\tau_w}{1-\tau}E\right) & \text{under} \quad CF, \\ \frac{\beta_2}{\beta_2-1}(r-\alpha)\left(\frac{(1-\tau_w)}{(1-\tau)}\frac{w}{r} - \frac{\rho}{r}\tau I - \frac{1-\phi\tau_w}{1-\tau}E\right) & \text{under} \quad ACE. \end{cases} \tag{24}$$

Given $H_2^j > 0$, we can calculate the value of entrepreneur's option to exit $H_2^j\Pi^{\beta_2}$. As can be seen, the trigger point $\widetilde{\Pi}^j$ is positively affected by the labor wage rate: i.e., the higher the wage, the higher the propensity to quit is. It is worth noting that $\widetilde{\Pi}^{CF} > \widetilde{\Pi}^{ACE}$. Under the ACE tax, indeed, the exit threshold point is reduced by the tax benefit $\frac{\rho}{r}\tau I$. Since such a benefit is lost whenever the individual decides to quit his business activity, he will be induced to delay the exit decision. Therefore, the higher the tax benefit $\tau\rho I$ is, the lower the point $\widetilde{\Pi}^j$ is, and the lower the probability of the exit will be.

To analyze the other effects of taxation, we use (24) and set $\tau_w = \tau = 0$, thereby obtaining the zero-tax-rate trigger point:

$$\widetilde{\Pi}_{LF} = \frac{\beta_2}{\beta_2 - 1} (r - \alpha) \left(\frac{w}{r} - E \right).$$

(25)

Comparing (24) with (25) we can say that:

Proposition 4 *Under the cash-flow tax, the exit decision is unaffected by taxation, i.e., $\widetilde{\Pi}^{CF} = \widetilde{\Pi}_{LF}$ if $\tau_w = \tau$, and $\phi = 1$. Under the ACE tax, even when $\rho = r$, $\tau_w = \tau$ and $\phi = 1$, the inequality $\widetilde{\Pi}^{ACE} < \widetilde{\Pi}_{LF}$ holds.*

According to Proposition 4, a uniform cash-flow tax is no longer neutral in terms of exit decisions, unless the exit costs are fully deductible. As we have pointed out, however, exit costs are at least partially unobservable. Given such an information problem, the implementation of a neutral cash-flow tax is *de facto* impossible.

Under the ACE taxation, the conditions of Proposition 4 are thus not sufficient for neutrality. Comparing (24) with (25), we immediately see that $\widetilde{\Pi}^{ACE} = \widetilde{\Pi}_{LF}$ only if a rebate $R = \frac{\rho}{r} \tau I$ is granted. In particular, if we set $\rho = r$, the neutral rebate is $R = \tau I$, which coincides with the cash-flow tax benefit ensured by an immediate write-off of the initial investment I.[35] Otherwise, the entrepreneur is induced to delay his exit.

Let us next analyze the optimal entry decision. As shown in Appendix H, the trigger point is equal to

$$\Pi^{**,j} = \begin{cases} \frac{\beta_1}{\beta_1 - 1} (r - \alpha) \left[\frac{1 - \tau_w}{1 - \tau} \frac{w}{r} + I + \left(1 - \frac{\beta_2}{\beta_1} \right) \frac{1}{\beta_2} \frac{1}{r - \alpha} \widetilde{\Pi}^{CF} \left(\frac{\widetilde{\Pi}^{CF}}{\Pi^{**,CF}} \right)^{-\beta_2} \right], \\ \frac{\beta_1}{\beta_1 - 1} (r - \alpha) \left[\frac{1 - \tau_w}{1 - \tau} \frac{w}{r} + \frac{1 - \frac{\rho}{r}\tau}{1 - \tau} I + \left(1 - \frac{\beta_2}{\beta_1} \right) \frac{1}{\beta_2} \frac{1}{r - \alpha} \widetilde{\Pi}^{ACE} \left(\frac{\widetilde{\Pi}^{ACE}}{\Pi^{**,ACE}} \right)^{-\beta_2} \right]. \end{cases}$$

(26)

Moreover, we have

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

(27)

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[35] Notice that a distortion may also arise if losses are carried forward at the risk-free rate, but future positive revenues are not sufficient to use all tax credit (see Ball and Bowers (1983)).

Despite the fact that (26) is not a closed-form solution, we can compare $\Pi^{**,j}$ with $\Pi^{*,j}$. Since it holds

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

the comparison of (15) and (16) with (26) allows us to conclude that $\Pi^{*,j} > \Pi^{**,j}$. This means that the exit option, that depends on the labor market characteristics, interacts with entry decisions. The intuition behind this result is this: the option to exit ensures some degree of business flexibility. Given partial reversibility, therefore, the cost of undertaking the business activity is lower. This reduces the optimal entry threshold.

The effect of partial reversibility on entry decisions can also be seen by comparing (17) with (27). Given inequality $\Pi^{*,j} > \Pi^{**,j}$, we have $(\Pi^{*,j})^{1-\beta_1} < (\Pi^{**,j})^{1-\beta_1}$. Moreover the term $\beta_2 H_2^j (\Pi^{**,j})^{\beta_2-1}$ is negative. It is therefore easy to state that $B_1^j < A_1^j$. In other words, the existence of the option to quit makes the individual's option to start partially reversible. This explains why the option is exercised earlier, i.e., $\Pi^{*,j} > \Pi^{**,j}$.

Given (26), we can show that:

Proposition 5 *The entry decision is unaffected by the cash-flow and ACE taxation only if exit is undistorted.*

As shown in (26), an entry decision indeed is affected by the exit option. According to Proposition 5, therefore, full neutrality is ensured only if quite restrictive conditions hold. In particular, the full deduction of exit costs is necessary. As we have pointed out, however, it is almost impossible to measure in practise all these costs. Due to informational problems, a neutral cash-flow or ACE tax is *de facto* not implementable.

5 Concluding remarks

The paper has shown that many investment neutral tax systems, if not the most, are not start-up neutral. Our paper has thus highlighted the argument that the idea of income tax neutrality is more often an illusion than reality. Many well-known neutral systems of taxing income from existing corporations typically distort the economic decisions both at the start-up

and at the liquidation stage. These results carry a frustrating message for tax economists not to mention policy-makers. In particular, taxation is more distortive when entry and exit costs are substantial. Similarly, less friction in the labor market may make taxation less distortive. The tax effects thus tend to depend on market conditions. In our view, the trouble with previous tax analyses has been that they have been based on overly simplified models focusing on long-term equilibria. Enterprises, however, typically have a life-cycle. No enterprise can start as a mature company. Each enterprise has its beginning and may have a death. Furthermore, given the substantial heterogeneity of (observable) entry and exit costs among countries (see World Bank (2011)), we can say that the implementation of a given tax system may have an impact that dramatically differs from one country to another.

A   The derivation of (6)

Expanding (4), applying Itô's Lemma, and rearranging gives the following non-arbitrage condition:

$$rO(\Pi) = w + \alpha\Pi O_{\Pi} + \frac{\sigma^2}{2}\Pi^2 O_{\Pi\Pi}. \tag{28}$$

As shown in Dixit and Pindyck (1994), equation (28) has the following general closed-form solution

$$O(\Pi) = A_0 + \sum_{j=1}^{2} A_j \Pi^{\beta_j}, \tag{29}$$

with $A_0 = \frac{w}{r}$ and the quadratic equation $\Psi\left(\beta_j\right) \equiv \frac{\sigma^2}{2}\beta_j(\beta_j-1)+\alpha\beta_j-r = 0$, with $j = 1, 2$, that has the following roots:

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

Given the boundary condition $O(0) = 0$, we have $A_2 = 0$. The worker's value function (29) thus reduces to

$$O(\Pi) = \frac{w}{r} + A_1\Pi^{\beta_1}. \tag{30}$$

We next expand the RHS of (5), apply Itô's Lemma, and rearrange to obtain:

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

Its general solution is

$$V(\Pi) = \frac{\Pi}{r} + \sum_{j=1}^{2} H_j \Pi^{\beta_j}, \text{ with } j = 1, 2. \tag{31}$$

Let us next calculate H_j for $j = 1, 2$. Given condition $V(0) = 0$, we have $H_2 = 0$. As explained by Dixit and Pindyck (1994), the term $H_1\Pi^{\beta_1}$ may be referred to as a speculative bubble. Without bubbles, we therefore have $H_1 = 0$ and the entrepreneur's value function reduces to the present value of a perpetual rent, i.e., $V(\Pi) = \frac{\Pi}{r}$.

Given these results, we can now calculate the optimal trigger point Π^*. Notice that when the worker enters the business activity he receives a net payoff equal to $V(\Pi^*) - I$. This means that the present value of the entrepreneurial project, net of both the investment cost I and the option value, is nil, i.e.,

$$V(\Pi^*) - I - O(\Pi^*) = 0. \tag{32}$$

Substituting (30) into Eq. (32), and solving for A_1 we obtain

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

Substituting this result into (30) gives (6), where Π^* is calculated by maximizing the start-up option, i.e., by solving the problem:

$$\max_{\Pi^*}\left[\left(\frac{\Pi}{\Pi^*}\right)^{\beta_1}\left[V(\Pi^*) - I - \frac{w}{r}\right]\right].$$

B   Proof of Proposition 1

Given the before-entry depreciation allowance δ_O, a worker's tax base is equal to[36]

$$B = w - \delta_O. \tag{33}$$

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[36] The depreciation or appreciation refers to a worker's productivity or skill as an entrepreneur.

Using (33) and applying dynamic programming, we can write the worker's value function as:

$$O^{JS}(\Pi) = \left[(1 - \tau_w)\,w + \tau_w \delta_O\right] w dt + e^{-(1-\tau)rdt} \xi \left[O^{JS}(\Pi + d\Pi)\right]. \qquad (34)$$

Expanding the RHS of (34), applying Itô's Lemma and rearranging gives:

$$\begin{aligned}
O^{JS}(\Pi) &= \left[(1 - \tau_w)\,w + \tau_w \delta_O\right] dt \\
&\quad + \left[1 - (1 - \tau)\,rdt\right] \left[O^{JS}(\Pi) + dO^{JS}(\Pi)\right] + o(dt),
\end{aligned} \qquad (35)$$

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

$$dO^{JS}(\Pi) = \left[\alpha \Pi O_\Pi^{JS} + \frac{\sigma^2}{2} \Pi^2 O_{\Pi\Pi}^{JS}\right] dt, \qquad (36)$$

with $O_\Pi^{JS} = \frac{\partial O^{JS}(\Pi)}{\partial \Pi}$, and $O_{\Pi\Pi}^{JS} = \frac{\partial^2 O^{JS}(\Pi)}{\partial \Pi^2}$. Substituting (36) into (35) gives

$$\begin{aligned}
O^{JS}(\Pi) &= \left[(1 - \tau_w)\,w + \tau_w \delta_O\right] dt + (1 - (1 - \tau)\,rdt)\,O^{JS}(\Pi) \\
&\quad + \left[\alpha \Pi O_\Pi^{JS} + \frac{\sigma^2}{2} \Pi^2 O_{\Pi\Pi}^{JS}\right] dt.
\end{aligned} \qquad (37)$$

Following Samuelson (1964) and using (7) we have

$$\delta_O dt = -\xi \left[dO^{JS}(\Pi)\right] = -\left[\alpha \Pi O_\Pi^{JS} + \frac{\sigma^2}{2} \Pi^2 O_{\Pi\Pi}^{JS}\right] dt.$$

Using (36) and rearranging (37) gives

$$(1 - \tau)\,rO^{JS}(\Pi) = (1 - \tau_w)\,w + (1 - \tau_w)\left[\alpha \Pi O_\Pi^{JS} + \frac{\sigma^2}{2} \Pi^2 O_{\Pi\Pi}^{JS}\right]. \qquad (38)$$

If $\tau = \tau_w$, the non-arbitrage condition (38) reduces to

$$rO^{JS}(\Pi) = w + \alpha \Pi O_\Pi^{JS} + \frac{\sigma^2}{2} \Pi^2 O_{\Pi\Pi}^{JS}. \qquad (39)$$

Let us next turn to the firm's value function. Under a comprehensive income tax system, the firm's tax base is equal to

$$\Pi^{JS} = \Pi - \delta_V. \qquad (40)$$

Using (40), we can write the firm's project value as:

$$V^{JS}(\Pi) = [(1-\tau)\Pi + \tau\delta_V]\, dt + e^{-(1-\tau)rdt}\xi\left[V^{JS}(\Pi + d\Pi)\right]. \qquad (41)$$

Expanding the RHS of (41) and applying Itô's Lemma gives the following differential equation

$$\begin{aligned}V^{JS}(\Pi) &= [(1-\tau)\Pi + \tau\delta_V]\, dt + [1-(1-\tau)\,r]\, dt V^{JS}(\Pi) \\ &\quad + \left[\alpha\Pi V_\Pi^{JS} + \tfrac{\sigma^2}{2}\Pi^2 V_{\Pi\Pi}^{JS}\right] dt + o(dt),\end{aligned} \qquad (42)$$

where $V_\Pi^{JS} = \frac{\partial V^{JS}(\Pi)}{\partial\Pi}$, $V_{\Pi\Pi}^{JS} = \frac{\partial^2 V^{JS}(\Pi)}{\partial\Pi^2}$. Using (8) we have $\delta_V\, dt = -\xi\left[dV^{JS}(\Pi)\right] = \left[\alpha\Pi V_\Pi^{JS} + \tfrac{\sigma^2}{2}\Pi^2 V_{\Pi\Pi}^{JS}\right] dt$. Rearranging (42) gives

$$rV^{JS}(\Pi) = \Pi + \alpha\Pi V_\Pi^{JS} + \frac{\sigma^2}{2}\Pi^2 V_{\Pi\Pi}^{JS}. \qquad (43)$$

Using (39) and (43), we can show that the non-arbitrage condition of the entrepreneurial project, net of the option, i.e.,

$$r\left[V^{JS}(\Pi) - O^{JS}(\Pi)\right] = (\Pi - w) + \alpha\Pi\left(V_\Pi^{JS} - O_\Pi^{JS}\right) + \frac{\sigma^2}{2}\Pi^2\left(V_{\Pi\Pi}^{JS} - O_{\Pi\Pi}^{JS}\right),$$

is unaffected by taxation. This means that the entrepreneurial decision is undistorted by a uniform-rate comprehensive income tax.

C   The calculation of (12)

Let us expand the RHS of (11) and apply Itô's Lemma. Following the same procedure as Appendix B gives

$$rO^j(\Pi) = (1-\tau_w)\, w + \alpha\Pi O_\Pi^j + \frac{\sigma^2}{2}\Pi^2 O_{\Pi\Pi}^j. \qquad (44)$$

with $O_\Pi^j = \frac{\partial O^j(\Pi)}{\partial\Pi}$ and $O_{\Pi\Pi}^j = \frac{\partial^2 O^j(\Pi)}{\partial\Pi^2}$. Equation (44) has the following general closed-form solution

$$O^j(\Pi) = A_0 + \sum_{i=1}^{2} A_i^j \Pi^{\beta_i}. \qquad (45)$$

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Substituting (45) into (44) and solving gives $A_0 = \frac{(1-\tau_w)w}{r}$, and the roots $\beta_1 > 1$ and $\beta_2 < 0$.

Let us next calculate A_2^j. Notice that when Π goes to zero it will remain zero in the case of a geometric Brownian motion.[37] This means that $\Pi = 0$ is an absorbing barrier, and therefore, the worker's value function reduces to

$$O^j(0) = \frac{(1 - \tau_w)\, w}{r}. \tag{46}$$

Notice that, given $\beta_2 < 0$, if *ab absurdo* $A_2^j \neq 0$, we would have $\lim_{\Pi \to 0} A_2^j \Pi^{\beta_2} = \infty$, and the condition (46) would fail to hold. This implies that we must set $A_2 = 0$. Equation (12) is thus obtained.

D   The calculation of (14)

Let us expand the RHS of (13). Applying Itô's Lemma and rearranging gives

$$rV^j(\Pi) = \Pi^j + \alpha \Pi V_\Pi^j + \frac{\sigma^2}{2}\Pi^2 V_{\Pi\Pi}^j. \tag{47}$$

where $V_\Pi^j = \frac{\partial V^j(\Pi)}{\partial \Pi}$ and $V_{\Pi\Pi}^j = \frac{\partial^2 V^j(\Pi)}{\partial \Pi^2}$. The solution of (47) has the following structure:

$$V^j(\Pi) = \begin{cases} \frac{(1-\tau)\Pi}{r-\alpha} + \displaystyle\sum_{j=1}^{2} H_i^{CF}\Pi^{\beta_i} & \text{under} \quad CF, \\[2em] \frac{(1-\tau)\Pi}{r-\alpha} + \frac{\rho}{r}\tau I + \displaystyle\sum_{j=1}^{2} H_i^{ACE}\Pi^{\beta_i} & \text{under} \quad ACE, \end{cases}$$

Let us next calculate H_i^j for $i = 1, 2$. As regards H_2^j, we know that $\Pi = 0$ is an absorbing barrier and that the condition $V^j(0) = 0$ holds. This implies that $H_2^j = 0$. Moreover, in the absence of bubbles, we have $H_1^j = 0$. We have thus obtained (14).

E   Optimal entry timing

To find the optimal trigger point above which entry is profitable ($\Pi^{*,j}$) we apply the Value Matching Condition (VMC) and the Smooth Pasting Condition (SPC). The VMC requires at point $\Pi = \Pi^{*,j}$ the equality between the

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

present value of the project, net of the investment cost, and the value of the option to delay investment, namely:

$$V^j(\Pi^{*,j}) - I = O^j(\Pi^{*,j}) \text{ with } j = CF, ACE. \tag{48}$$

The VMC (48) implies that when the option is exercised optimally (i.e., at point $\Pi = \Pi^{*,j}$) the entrepreneur receives a net payoff equal to $V(\Pi^{*,j}) - I$. The SPC requires the equality between the slopes of $[V^j(\Pi) - I]$ and $O^j(\Pi)$ at point $\Pi = \Pi^{*,j}$, i.e.,

$$\left. \frac{\partial [V^j(\Pi) - I]}{\partial \Pi} \right|_{\Pi=\Pi^{*,j}} = \left. \frac{\partial O^j(\Pi)}{\partial \Pi} \right|_{\Pi=\Pi^{*,j}}. \tag{49}$$

The SPC (49) 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. Substituting (12) and (14) into (48) and (49), and solving gives (15) and (16).

F   Proof of Proposition 3

As shown by Proposition 1, entry neutrality holds only when $\tau_w = \tau$ and when the economic depreciation of the worker's option to become an entrepreneur is deductible. To prove exit neutrality, it is thus sufficient to show that the same rule holds for the after-exit value function.

Under an income tax, the after-exit net present value is equal to

$$W^{JS}(\Pi) = \frac{(1 - \tau_w) w}{(1 - \tau) r} - (1 - \phi\tau_w) E. \tag{50}$$

By setting $\tau = \tau_w$ and $\phi = 0$, (50) collapses to (18). Given this result and Proposition 1, we can thus say that the joint application of a uniform taxation and economic depreciation ensures tax-rate invariance. This concludes the proof of Proposition 3.∎

G Optimal exit timing under consumption-based taxation

To find the optimal exit point, we substitute (21) and (22) into (48) and (49). Under cash-flow taxation we have

$$\frac{(1-\tau)\,\widetilde{\Pi}^{CF}}{r-\alpha} + H_2^{CF}\left(\widetilde{\Pi}^{CF}\right)^{\beta_2} = \frac{(1-\tau_w)\,w}{r} - (1-\phi\tau_w)\,E, \qquad (51)$$

and

$$\frac{(1-\tau)}{r-\alpha} + \beta_2 H_2^{CF}\left(\widetilde{\Pi}^{CF}\right)^{\beta_2-1} = 0. \qquad (52)$$

Under ACE taxation, we have the following two-equation system:

$$\frac{(1-\tau)\,\widetilde{\Pi}^{ACE}}{r-\alpha} + \frac{\rho}{r}\tau I + H_2^{ACE}\left(\widetilde{\Pi}^{ACE}\right)^{\beta_2} = \frac{(1-\tau_w)\,w}{r} - (1-\phi\tau_w)\,E, \quad (53)$$

$$\frac{(1-\tau)}{r-\alpha} + \beta_2 H_2^{ACE}\left(\widetilde{\Pi}^{ACE}\right)^{\beta_2-1} = 0. \qquad (54)$$

Solving the systems (51)-(52), and (53)-(54) for H_2^j and $\widetilde{\Pi}^j$, with $j = CF, ACE$, gives (23) and (24), respectively.

H Optimal start-up timing with the option to quit

The optimal start-up timing is obtained by substituting (20) and (21) into (48) and (49). Under the cash-flow taxation, we have:

$$\frac{(1-\tau)\,\Pi^{**,CF}}{r-\alpha} + H_2^{CF}\Pi^{**,CF^{\beta_2}} - I = \frac{(1-\tau_w)\,w}{r} + B_1^{CF}\Pi^{**,CF^{\beta_1}}, \qquad (55)$$

and

$$\frac{(1-\tau)}{r-\alpha} + \beta_2 H_2^{CF}\Pi^{**,CF^{\beta_2-1}} = \beta_1 B_1^{CF}\Pi^{**,CF^{\beta_1-1}}. \qquad (56)$$

Similarly, under the ACE taxation, we have

$$\frac{(1-\tau)\,\Pi^{**,ACE}}{r-\alpha} + \frac{\rho}{r}\tau I + H_2^{ACE}\Pi^{**,ACE^{\beta_2}} - I = \frac{(1-\tau_w)\,w}{r} + B_1^{ACE}\Pi^{**,ACE^{\beta_1}},$$

$$(57)$$

$$\frac{(1-\tau)}{r-\alpha} + \beta_2 H_2^{ACE} \Pi^{**,ACE^{\beta_2-1}} = \beta_1 B_1^{ACE} \Pi^{**,ACE^{\beta_1-1}}. \tag{58}$$

Next solve (55) and (56) for $\Pi^{**,CF}$ and B_1^{CF}. Similarly, solve (57) and (58) for $\Pi^{**,ACE}$ and B_1^{ACE}. We thus obtain (26) and (27).

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