Entrepreneurial Innovations and Taxation

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Abstract

Governments promote small businesses for the dual reasons of fostering major innovations and employment growth. In this paper we study the effects of tax and subsidy policies on entrepreneurs' choice of riskiness of an innovation project, and on their mode of commercializing the innovation (market entry versus sale). Limited loss offset provisions in the tax system induce entrepreneurs to choose projects with too little risk and this problem arises primarily when entrepreneurs market their product themselves. When innovations reduce only the fixed costs of production this leads to a fundamental policy trade-off between the declared goals of promoting employment and highly productive innovations in small, entrepreneurial firms. When innovations reduce variable production costs, policies to promote small businesses may even be unambiguously harmful.

1 Introduction

How to stimulate entrepreneurship is one of the pressing policy challenges facing many countries in the world today. In Europe, the European Commission (2008) launched the "Small Business Act for Europe" in June 2008, in response to this challenge. This document sets out a comprehensive policy framework for the EU and its member states to create an environment that rewards entrepreneurship, specifically mentioning taxation in this context. At present, several EU countries are reforming their tax systems to make them more compatible with entrepreneurship. In the Netherlands, for example, the 2011 Tax Plan comprises a whole set of measures explicitly aimed at encouraging entrepreneurship. Another example is Sweden, which is currently making the largest investigation of its corporate tax system in 20 years, with the main objective of making the tax system more conducive to entrepreneurship.[1]

The literature on entrepreneurship has emphasized the important role that new, entrepreneurial businesses play as providers of major inventions. Baumol (2004), for example, documents the importance of the different roles played by small entrepreneurial firms and large established firms in the innovation process in the United States, where small entrepreneurial firms create a large share of major inventions whereas large, established firms provide more routinized research and development (R&D). Similarly, a recent study by Henkel et al. (2010) undertakes a qualitative empirical study of the electronic design automation (EDA) industry, which is characterized by three large incumbents and numerous start-ups. They conclude that ".. as a stylized fact, entrants pursue more radical innovation projects than incumbents. That is, they pursue innovation projects that are both more likely to fail and, in case of success, be more valuable than those pursued by incumbents" (p. 21). These results reinforce earlier empirical findings indicating that small firms tend to account for a disproportionately large share of innovations relative to their size, and that - where data exist - they also tend to pursue more significant innovations than incumbents.[2]

This qualitative dimension of entrepreneurship has received only little attention so far in the literature that analyzes the effects of government policies on entrepreneurial

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[1]One of the proposed measures is to allow start-up firms to delay the payment of social security fees for several years. See the report "Tax incentives for venture capital", http://regeringen.se/sb/d/15680/a/185102 (in Swedish).

[2]See Cohen (2010, p. 137) and the references cited there.

decision-making.[3] The present analysis takes a step in filling this gap by analyzing how policies to promote entrepreneurship interact with important features of the tax system in shaping the risk-taking decision of entrepreneurs.

When evaluating the effects of taxes on entrepreneurial decisions, it is furthermore important to take into account that entrepreneurs not only commercialize their inventions or business ideas by entering the product market, but also by selling them to incumbent firms. Indeed, a substantial share of inventions made by independent innovators is commercialized through the sale or the licensing of a patent. Serrano (2010, Table 1) reports for the United States that entrepreneurs sold 17.5% of their patents during the period 1983-2001, and this share increases to 24% if the patents are quality-weighted with the number of citations received. Furthermore, a large-scale survey carried out in six EU countries suggests that roughly 10% of all patents are licensed (Giuri et al., 2007). We therefore endogenize the mode of commercializing the entrepreneurial innovation, in addition to modelling the entrepreneur's choice of R&D project.

Our analysis focuses on the tax and subsidy incentives that many governments offer to entrepreneurs in order to induce them to enter the product market. In most countries, governments provide various support schemes for start-ups and small businesses that cover all stages of the firms' development and range from initial research grants to the provision of subsidized loans and state guarantees to spur firm growth. Typically, however, entrepreneurs can only take advantage of the full range of support programs when they enter the market themselves. In the United States, for example, one of the main programmes to promote small businesses is the Technological Innovation Programme (TIP), which subsidizes the commercialization of successful prototypes with up to USD 3 million. But this support scheme is available only if the SME markets the product itself, or is the leading company in a joint venture (see OECD, 2010, p. 106).[4] Moreover, several countries support small, incorporated businesses by means of reduced corporate tax rates, as well as other tax breaks.[5] These provisions imply that most countries grant tax or subsidy advantages to entrepreneurs who market their inventions themselves, rather than selling out to an incumbent firm.

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[3]See Henrekson and Sanandaji (2011) for a recent survey of this literature.

[4]Similar programmes exist in many other countries. A summary of the most important support schemes for SMEs in all OECD member states is given in OECD (2010).

[5]See, e.g., the chapter on small business taxation in Mirrlees at al. (2011), which describes in detail the numerous tax privileges enjoyed by small, incorporated businesses in the United Kingdom.

At the same time, tax systems in all OECD countries incorporate a fundamental asymmetry as positive earnings are taxed immediately, whereas losses can only be offset against positive incomes.[6] The rationale for this asymmetry, which we take as given in our analysis, is to prevent tax fraud. The latter would be very likely to occur when governments made actual tax transfers to firms that claimed expenses without having concurrent business incomes. Small entrepreneurs, who are developing a single business idea, will therefore not be able claim a tax rebate when they invest in a project that turns out to be unsuccessful. In Germany, for example, restrictive loss offset provisions for entrepreneurs are regarded as one of the main obstacles for the development and growth of small, innovative businesses (EFI, 2011, p. 19). In contrast, restrictions on loss offset opportunities are less important when the project is sold to a large, incumbent firm, as the incumbent is more diversified and will likely be able to offset losses on a new investment against positive taxable profits earned in its other operations (see Mirrlees et al., 2011, p. 454).

There is substantial empirical evidence for the importance of this fundamental asymmetry in the corporate tax code. Auerbach (2007, Table 4) documents for the United States that the aggregate losses reported by corporations rose to 350-400 billion USD per annum in each of the years 2001-2003 (representing roughly two thirds of positive corporate profits in the same years), a large part of which was not tax deductible for the firms that incurred the losses. Econometric studies have furthermore shown that the asymmetric tax treatment of profits and losses has significant effects on entrepreneurial risk-taking (Cullen and Gordon, 2007), as well as on firms' investment incentives (Edgerton, 2010).

Against this background we study how existing tax and subsidy policies influence the interdependent decisions of the entrepreneur to select an R&D project, and to choose the mode of commercializing the innovation. A characteristic feature of our model is that the equilibrium sales price of the firm is explicitly derived from the valuation of the risky innovation by both the incumbents and the entrepreneur. These valuations

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[6]In contrast, Bond and Devereux (2003) stress that a business tax system that is neutral in the presence of uncertainty would require the government to pay a tax rebate equal to the full value of the initial investment in the case of default. Note also that the asymmetry in existing tax systems is still present when governments try to foster innovation by means of R&D tax credits. In this case, companies can immediately deduct all R&D expenditures (and sometimes even more than 100% of actual expenditures), but only when there are other sources of positive income.

are affected by the tax considerations described above. In particular, the entrepreneur will benefit from lower taxes and higher subsidies under market entry, but only if the project is successful. If the project fails, the entrepreneur will not be able to claim a loss offset under market entry, whereas selling the project to an incumbent firm ensures that investment costs are always tax-deductible.

In this setting we show that whenever the entrepreneur enters the market in equilibrium, she will choose an innovation that involves too little risk, in comparison to the socially desirable project. This distortion arises because there is an extra cost of failing in terms of lost tax deductions, and hence the entrepreneur finds it optimal to reduce the risk of being left with non-deductible investment outlays. In contrast, when innovating for sale the entrepreneur can sell her invention to an incumbent before all uncertainty is revealed. This guarantees a full deduction of her investment costs, whereas competitive bidding by incumbents ensures that the entrepreneur receives the true market value of the innovation. As a result, the entrepreneur will choose a project with efficient risk characteristics when innovating for sale.

Based on these results we analyze the implications for tax policies towards entrepreneurship. We show that policies to promote entrepreneurial market entry can be welfare-improving if and only if goods in the innovative sector are sufficiently differentiated. Moreover, one of the main objectives of a favourable tax treatment of new, small firms is the belief that they create additional jobs.[7] This objective is particularly relevant in countries suffering from inefficient labour markets and high unemployment. In our benchmark model, where innovations affect only the fixed costs of production, we show that there is a basic policy conflict between the goals of promoting output and employment in technology-intensive markets, and the desire of governments to foster risky, major inventions. In a model extension where innovations reduce variable production costs, it is even possible that policies to promote small businesses will be directly counterproductive by reducing *both* the degree of innovation and the level of production and employment in the innovative sector. Overall, our analysis therefore establishes a case for more tax neutrality in the treatment of large versus small firms, and for facilitating the sale of innovative companies to incumbents.

Our model brings together two different strands in the literature. On the one hand

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[7]A substantial part of the net employment growth in the SME sector comes from a small number of high-growth firms, so-called 'Gazelles', which are typically young and are represented in all industries (Henrekson and Johansson, 2010).

is the public finance literature that analyzes the effects of taxes on various decision margins of entrepreneurs. Several contributions focus on the progressiveness of the personal income tax schedule as an obstacle to entrepreneurial activity (e.g. Gentry and Hubbard, 2000). In contrast, Gordon (1998) stresses that start-up enterprises have the option of incorporating, thus benefiting from the widespread fall in corporate tax rates over the last few decades. Fuest et al. (2002) show that the presence of a substantial positive tax gap between the personal income tax and the corporation tax is a second-best solution to the problem of asymmetric information faced by new firms. Keuschnigg and Nielsen (2002, 2004) focus on the effects of various tax policies when entrepreneurs face financial constraints and set up a contract with a venture capitalist under conditions of one-sided or two-sided moral hazard. None of these contributions, however, incorporates a choice between different R&D projects, nor the option for the entrepreneur to sell her invention to an incumbent firm.

Several empirical studies have shown that the effect of taxes on entrepreneurial decisions are quantitatively important. Cullen and Gordon (2007) empirically estimate the effects of imperfect loss offset provisions and of rate differences in personal and corporate income taxation on entrepreneurial risk taking. Egger et al. (2009) analyze the incorporation decision of entrepreneurs and provide empirical evidence that a positive tax gap between personal and corporate tax rates favors incorporation. Bloom et al. (2002) and Ernst and Spengel (2011) show that R&D tax credits have positive and significant effects on the volume of R&D, but do not address the choice of quality (or riskiness) of an innovation project. Recent work has provided evidence in line with the policy trade-off stressed in our analysis, by showing that lower corporate taxes induce entry by new firms (Djankov et al., 2010; Da Rin et al., 2011), but also reduce the size and the capital intensity of the new entrants (Da Rin et al., 2010).

Secondly, this paper is also related to the literature on R&D and market structure, which mainly focuses on the choice of the level of R&D efforts.[8] Several papers study the type of R&D project undertaken by firms and entrepreneurs (e.g. Bhattacharya and Mookherjee, 1986). There is also a literature on entrepreneurship and innovations, which is summarized in Acs and Audretsch (2005). To our knowledge, the only analysis considering how the entry mode affects the type of R&D is Färnstrand Damsgaard et al. (2010). However, this paper focuses on the interaction between entrepreneurial

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[8]For overviews, see Reinganum (1989) and Gilbert (2006) and for specific models, see Rosen (1991) and Cabral (2003).

and incumbent innovations and abstracts from tax policies, which are central to the present study. Finally, there is a recent, small literature that focuses on the quality of entrepreneurs, and on their allocation between large and small firms. Thus, Hvide (2009) shows that entrepreneurs are more productive, on average, if they work in larger firms, whereas Friebel and Giannetti (2009) work out the implications for talented workers when large firms are more risk-averse, but also reject more good ideas.

The remainder of the paper is organized as follows. Section 2 outlines our benchmark model, where the innovation reduces only fixed costs. In Section 3, we solve the different stages of the model and determine the equilibrium allocation in different tax regimes. Section 4 analyzes the effects of tax policy on the equilibrium project choice and commercialization mode, as well as on welfare and employment in the industry. Section 5 analyzes the case where the innovation reduces variable costs of production. Section 6 discusses several other model extensions, including the role of venture capital financing. Section 7 concludes.

2   The framework

We consider an imperfectly competitive market with n identical incumbent firms. Entry costs deter further firms from entering the market, unless they have a superior technology. The focus of our analysis lies on the decisions of an independent innovator, or entrepreneur, who chooses a project with certain risk characteristics and decides whether to sell the invention or try to enter the market herself. In line with the evidence quoted in the introduction, we focus on entrepreneurs as providers of major inventions and assume that the incumbent firms do not innovate.[9] The sequence of events in our benchmark model is shown in Figure 1.

********* Figure 1 about here **********

In Stage 1, the entrepreneur makes a fixed monetary investment I in risky R&D, in or-

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[9]Similar results are obtained in a setting where incumbents are simultaneously allowed to innovate, and the entrepreneur can only make a profit when her innovation is successful, while the incumbents' innovation fails. In this setting - which is likely to hold in situations where the incumbents' initial advantage is sufficiently strong - the incumbents' ability to innovate does not affect the entrepreneur's choices, on which the focus of the present analysis lies (see Färnstrand Damsgaard et al., 2010).

der to develop an invention. We suppose that there is an infinite number of independent research projects that the entrepreneur may undertake, all requiring the same investment costs I. Hence, investment projects do not vary by the size of the investment, but by the riskiness of the chosen project. Each project (say project k) is characterized by a certain success probability p_k. Along the technological frontier, entrepreneurs face a choice between projects that have a high success probability p_k but deliver a small reduction in fixed costs in case of success, and projects that are more risky but also have a larger payoff, if successful. Importantly, we assume that the entrepreneur is risk-neutral and thus chooses the project which maximizes the expected net payoff from the investment.[10]

Our benchmark model assumes that a successful invention reduces only the fixed costs of production. This assumption greatly simplifies the exposition, as it implies that product market competition between all firms remains symmetric and the product market price does not depend on the chosen project.[11] To give an example, the fixed cost of producing a prototype part for a new airplane or a racing car can be reduced by small, low-risk improvements in existing technologies. A high-risk, high-return alternative is instead to develop a 3D printer which 'prints' the prototype part using titanium powder, causing virtually no waste of this precious material in the process.[12]

With projects differing by their degree of innovation, fixed production costs are

$$F(p_k) = \overline{F} - \Gamma(p_k), \tag{1}$$

where $\Gamma_k'(p_k) < 0$, $p_k \in (0, 1)$. Omitting the project index, the expected payoff $p\Gamma(p)$ is assumed to be strictly concave in p. Figure 2 illustrates the payoffs of different projects in terms of expected fixed costs reductions.

********* Figure 2 about here **********

As Figure 2 shows, there is a unique project with success probability $0 < \hat{p} < 1$ that maximizes the expected payoff of the invention (or minimizes the expected fixed costs

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[10]Hence, we eliminate the well-known effect that taxes may stimulate entrepreneurial risk-taking by making the government a silent partner in the (risky) operation (Domar and Musgrave, 1944). However, this effect is fully effective only when losses are tax-deductible. Since our analysis explicitly focuses on the limitations of loss offset provisions, the Domar-Musgrave effect is of lesser importance.

[11]Section 5 considers the more general case where the invention reduces variable production costs.

[12]See the article "The printed world" in *The Economist*, 10 February 2011.

with the invention), given from the first-order condition

$$\Gamma(\hat{p}) + \hat{p}\Gamma'(\hat{p}) = 0. \tag{2}$$

In the following, we will refer to an R&D project with a risk level of $\hat{p}$ as the 'cost-efficient' project. It is instructive to compare the project type chosen by the entrepreneur in equilibrium with this cost-efficient project. More formally, we introduce

Definition 1: *The cost-efficient project is given by $\hat{p} = \arg\max_p p\Gamma(p)$.*

In Stage 2, after investment I has been made and R&D project k has been chosen, the entrepreneur can either sell her invention to one of the incumbents or decide to market the invention herself. If the entrepreneur decides to sell her project, the acquiring incumbent will replace his initial technology with the innovative one. In this case, there will thus still be n firms in the market, though one firm (the acquirer of the innovation) may have a superior technology. In the case where the entrepreneur decides to enter the market, there will be $(n + 1)$ firms in the market, once more with one firm (the entrepreneur herself) having a possibly superior technology.

The entrepreneur's decision of whether to enter the market or sell the innovation to one of the incumbent firms is affected by tax considerations. We denote by t^e the effective tax rate, net of subsidies received, faced by the entrepreneur when she decides to enter the market, whereas τ gives the tax rate that is applicable on the income she receives when selling the project to an incumbent firm. As we have discussed in the introduction, many governments subsidize entrepreneurial market entry by means of various support programs at the marketing stage that are granted only when the entrepreneur enters the market herself. This effect tends to reduce t^e below τ and this is also the setting on which our further analysis is based.

There are, however, also important differences in the tax treatment of profits under alternative modes of commercializing the innovation. We assume that entrepreneurs producing for market entry will incorporate their business and are thus subject to the corporate income tax.[13] In contrast, entrepreneurs producing for sale will usually remain unincorporated and are thus subject to personal income taxation.

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[13]There is substantial evidence that the larger and the more successful among the new firms are more likely to incorporate (see e.g. Da Rin et al., 2011). In Sweden, for example, only 25% of all firms which started up in 2005 and were still active in 2008 were incorporated (of a total of almost 30,000 start-ups). Among the incorporated start-ups, however, about 72% were high-growth firms, as compared to 34% high-growth firms in other groups (see Tillväxtanalys, 2010).

Table 1: Taxation of business sale vs. corporate tax rate (2011)

country	classification of business sale [a]	tax rate for business sale (%) [b]	corporate tax rate (%) [c]
Austria	capital gain	25	25
Belgium	capital gain	16.5/33 [d]	34
Denmark	ordinary income	44.3	25
Finland	ordinary income	49	26
France	capital gain	29	34.4
Germany	ordinary income	45	30.2
Ireland	capital gain	25	12.5
Italy	ordinary income	44.9	27.5
Netherlands	ordinary income	52	25
Norway	ordinary income	40	28
Spain	ordinary income	43	30
Sweden	ordinary income	26.3/56.5 [e]	26.3
United Kingdom	capital gain	10/28 [f]	28
United States	capital gain	15	39.2

[a] including taxation of patent sales and royalties

[b] for capital gains: capital gains tax rate; for ordinary income: top national and representative sub-central tax rate, not including social security contributions

[c] regular central and sub-central corporate tax rate

[d] lower rate applicable to sale of business; higher rate applicable for sale of patents

[e] lower rate applicable to business income of individuals that is retained in a reserve fund

[f] lower rate applicable to the first GBP 5 million from sale of a business

Sources: European Tax Handbook (2011); OECD Tax Database: www.oecd.org/ctp/taxdatabase

Table 1 compares the tax treatment of the income received from selling a business or a patent to the taxation of corporate profits under market entry. Importantly, the sale of a business is classified as a capital gain by some countries, but as ordinary personal business income by others. In most - but not all - of the countries classifying the sale of a business as a capital gain, there will also be a tax advantage for this mode of commercialization that counteracts the higher subsidies received by entrepreneurs that enter the market. This is true, for example, in the United Kingdom and in the United States.[14] Most countries in continental Europe, however, tax the sale of a business as ordinary income and at tax rates that are substantially above the corporation tax.[15] Entrepreneurs residing in these countries, among them Germany, Italy, and the Nordic countries, thus face both a tax advantage and a subsidy advantage when they enter the market themselves, rather than sell their business to an incumbent firm.

A final argument leading to a tax advantage of market entry is that the income tax that is due under project sale incorporates the value of the entire firm or patent, whereas the profit tax paid under market entry is based only on current-period profits. Hence market entry also acts as a way to postpone the taxation of the valuable asset, and hence to reduce the present value of aggregate tax payments.[16]

In Stage 3, the uncertainty is revealed and it turns out whether the innovation is successful or not. If the entrepreneur has not sold her invention, she is free to enter the market at this stage. However, due to entry costs and fixed costs of production, entering the market will only be profitable when the innovation is successful (i.e. fixed production costs are low). If the project fails, the entrepreneur will not enter the market and she will lose all investment costs.

In Stage 4, oligopolistic product market competition occurs between either n or $(n+1)$ firms, depending on the commercialization decision of the entrepreneur in Stage 2 and (in case of market entry) on the success of the project in Stage 3. Equilibrium profits are paid out and taxes are collected on all income.

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[14]An exception in this category is Ireland where a business sale is classified as a capital gain, but there is still a tax disadvantage relative to market entry, due to the very low Irish corporation tax.

[15]This is at least partly due to the fact that corporate tax rates have fallen particularly strongly in Europe over the last decades, as a result of international tax competition. For empirical evidence see, e.g., Devereux et al. (2008).

[16]See Landsman and Shackelford (1995) and Ayers et al. (2003) for empirical evidence of this lock-in effect of capital gains taxation.

3 Equilibrium project choice and mode of commercialization

3.1 Stage 4: Product market interaction

We solve the model by backward induction and start with the interaction of firms in the product market. The industry we consider is characterized by fixed costs of production $\bar{F}$ (in the absence of an innovation) and by entry costs G. Free entry to the industry ensures that product market profits (sales revenues minus variable costs) will, in equilibrium, equal the sum of fixed production costs and entry costs. We assume that, in the absence of an innovation that reduces fixed costs, the industry will support n symmetric, incumbent firms. In addition, there is a single entrepreneur, who may enter the market on account of an innovation that reduces fixed production costs.

More specifically, let the set of firms in the industry be $\mathcal{J} = \{i_1, i_2...i_n, e\}$ where $i_1...i_n$ denotes the identical incumbent firms and e is the entrepreneur. The owner of the invention is denoted by $m \in \mathcal{J}$. In the product market interaction, firm j chooses an action x_j, which represents the setting of either a quantity or a price, to maximize its product market profit $\pi_j(x_j, \mathbf{x}_{-j}, m)$. This depends on its own and its rivals' market actions, x_j and $\mathbf{x}_{-j}$, and on the identity of the owner of the invention, m.

We assume that a unique Nash equilibrium $\{x_j^*(m), x_{-j}^*(m)\}$ exists at this stage, which results in positive product market profits. We can then set up a reduced-form for the product market profits of each firm j, taking as given ownership m:

$$\pi_j(m) \equiv \pi_j[x_j^*(m), x_{-j}^*(m), m] \quad \forall\, j \in \mathcal{J}. \tag{3}$$

Since incumbents are symmetric before the acquisition takes place, we need only distinguish between two types of ownership of the invention: *entrepreneurial* ownership ($m = e$) and *incumbent* ownership ($m = i$). Moreover, since the innovation affects only fixed production costs, the product market profit before deduction of fixed costs and taxes is always the same for all active firms in our benchmark model. Hence, there are only two possible levels of such profits: $\pi(i)$ is the profit of each incumbent when the entrepreneur does not enter the market, whereas $\pi(e)$ is the product market profit of incumbents *and* the entrepreneur in case of entry.

We assume that market entry by the entrepreneur will reduce the profit of each producer due to stronger competition, i.e. $\pi(i) > \pi(e)$. This assumption is met in standard models of imperfect competition, such as the oligopoly model of quantity competition in a homogeneous good, or the model of price competition with differentiated products.

As an example, which will be used in our welfare analysis in Section 4, consider quantity competition in differentiated products (Singh and Vives, 1984; Häckner, 2000). The utility of a consumer is then given by:

$$U(\mathbf{q}, Z) = \sum_{j=1}^{n(m)} a q_i - \frac{1}{2} \left(\sum_{j=1}^{n(m)} q_j^2 + 2\gamma \sum_{k \neq j} q_j q_k \right) + Z \tag{4}$$

where $\mathbf{q}$ is the vector of outputs, q_i denotes the output of a firm j, Z is a composite numeraire good and a is a constant. The parameter γ measures the substitutability between products, which is inversely related to the level of product differentiation. If $\gamma = 0$, each firm has monopolistic power, whereas if $\gamma = 1$, the products are perfect substitutes. Note finally that the number of firms is n for $m = i$ and $(n+1)$ for $m = e$. Utility maximization yields inverse demand functions

$$P_j = a - q_j - \gamma q_{-j}, \tag{5}$$

where P_j is the price of good j and $q_{-j} = \sum_{k \neq j} q_k$. Quantity competition between firms with constant marginal costs c leads to reduced-form profit expressions for each firm that are quadratic in equilibrium output and given by

$$\pi(m) = [q^*(m)]^2 = \left(\frac{a - c}{2 + \gamma[n(m) - 1]} \right)^2, \tag{6}$$

thus satisfying $\pi(i) > \pi(e)$.

3.2   Stage 3: Uncertainty revealed

At this stage, it is revealed whether the innovation turns out to be successful or not, where 'success' can either be interpreted in a technological or in a commercial sense. For example, this stage may describe the results of mechanical or medical tests, which determine whether a new, cost-saving technology is feasible. For other innovations, it may be revealed at this stage whether a small-scale market test shows a sufficient acceptance among prospective buyers to make the introduction of the new technology commercially viable.

If the innovation is successful, the superiority of the new product over the existing ones is reflected in reduced fixed costs of $F(p) < \bar{F}$ from (1). Under failure, the invention does not reduce the fixed costs for the owner and fixed production costs remain at $\bar{F}$. If the owner of the invention is an incumbent firm at this stage, then the success or failure of the innovation has no consequences other than affecting the profits of the acquiring firm. In contrast, if the entrepreneur decided in the previous stage not to sell the invention, the success or failure of the project will affect her decision to enter the market at this stage. Given the free-entry industry equilibrium with n incumbent firms, market entry will be unprofitable for the entrepreneur in case of project failure. To simplify the algebra in the following, it proves convenient to assume that the profits from market entry without an improved technology are just equal to zero for the entrepreneur, but market entry occurs only when profits are strictly positive.[17] This is formalized in

Assumption A1: When the innovation fails, net profits from entry are zero, $\pi(e) - \bar{F} - G = 0$, and the entrepreneur does not enter. When the innovation is successful, the entrepreneur receives positive net profits equal to $\pi(e) - [\bar{F} - \Gamma(p)] - G = \Gamma(p) > 0$ and enters the market.

In the case of project failure, the entrepreneur's initial investment costs I are lost entirely. To protect the income tax base and prevent fraud, existing tax codes allow the deductibility of expenses only in combination with positive income, but do not pay out negative taxes to the taxable entity in case of a loss.[18] Moreover, in the case of project failure it is also not possible for the entrepreneur to sell her unused tax credit to one of the incumbents. The reason is that in this case the tax authorities will not accept a link between an incumbent's positive income from existing assets and the losses incurred by the R&D project.

These tax rules imply that there is a tax advantage for the entrepreneur of selling the invention *before* the uncertainty is revealed. This ensures that the entrepreneur

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[17]This condition will be approximated when the number of incumbents is not too low. It implies that there is no 'entry hurdle' that would reduce the value of the innovation ($p\Gamma$) for the entrepreneur in case of market entry.

[18]Our static model abstracts from the possibility that the entrepreneur can carry forward the loss for a certain number of years. Empirical evidence suggests that failed start-ups are rarely able to use loss carry-forward provisions in subsequent years. See Auerbach and Altshuler (1990) and Auerbach (2007) for empirical evidence documenting the importance of unused tax credits among U.S. firms.

can deduct her investment outlays with probability one, because she will then have positive income from the sale with certainty. In contrast, if the entrepreneur were to sell the project only in Stage 3, after the resolution of uncertainty, then a positive sales price would be obtained only when the project is successful. Hence a tax deduction for the investment outlays could also be claimed only with probability p. This is the reason why, in our benchmark model, we assume that a possible project sale occurs before the resolution of uncertainty.[19]

3.3 Stage 2: Commercialization

In Stage 2, there is an entry-acquisition game where the entrepreneur decides whether to sell the invention to one of the incumbents or enter the market at the entry cost G, knowing that this is profitable only with a successful project. We assume that the entrepreneur and the incumbents are symmetrically informed about the success probability of the project, and will both base their valuations on the same level of p.[20]

The commercialization process is depicted as an auction where n incumbents simultaneously post bids and the entrepreneur either accepts or rejects these bids. If the entrepreneur rejects all bids, she will try to enter the market herself. Each incumbent announces a bid b_i for the invention and $\mathbf{b} = (b_1, ..b_i.., b_n)$ is the vector of these bids. Following the announcement of $\mathbf{b}$, the invention may be sold to one of the incumbents at the bid price, or remain in the ownership of entrepreneur. If more than one bid is accepted, the bidder with the highest bid obtains the invention. If there is more than one incumbent with such a bid, each such incumbent obtains the invention with equal probability.[21] The acquisition game is solved for Nash equilibria in undominated pure strategies.

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[19]In a Supplementary Appendix we extend the model by permitting the project to be sold either before or after the uncertainty is lifted. The implications of this extension are summarized in Section 6.

[20]In the set-up of our model, information asymmetries could work in either direction. While the entrepreneur knows the technical properties of her invention better than incumbents do, incumbents may have more experience in evaluating the likelihood that the innovation succeeds in the market. Given this ambiguity, assuming that the information about p is symmetric represents an intermediate case that has the obvious benefit of analytical simplicity. For an analysis of a project sale where the entrepreneur has an informational advantage, see Norbäck et al. (2010).

[21]We thus exclude multi-firm licensing in our model. There are several reason why multi-firm licensing might not be an optimal strategy, even if the invention reduces only fixed costs. A first reason is that the sale occurs before the resolution of uncertainty so that no 'product' can be licensed. Secondly,

As discussed in Section 2, the entrepreneur faces the effective tax rate t^e in case of market entry. We assume that this tax is levied at a proportional rate. Investment costs can be deducted from the tax base when there is positive income, but tax credits are not paid out when the project fails and the entrepreneur's income is thus negative. If the entrepreneur innovates for sale, she will be taxed at the tax rate τ on her capital gains, which are defined as the excess of the sales price over the investment costs. In this case the acquiring incumbent can always deduct the sales price from its positive operating profit, irrespective of whether the invention is successful or not. Using Assumption A1 and defining $\Delta_e(S)$ as the entrepreneur's net gain from selling the invention at price S over the alternative of market entry gives

$$\Delta_e(S) = \underbrace{S - \tau\,(S - I)}_{\text{Net profit from sale}} - [\,\underbrace{p\Gamma(p) - pt^e[\Gamma(p) - I]}_{\text{Net expected profit from entry}}\,]. \tag{7}$$

From (7), let the reservation price of the entrepreneur be $v_e = \min S,\ s.t\ \ \Delta_e(S) \geq 0$. That is, v_e is the minimum price S at which the entrepreneur is willing to sell. Solving for $\Delta_e(S) = 0$, we get:

$$v_e(p) = \frac{(1 - t^e)}{(1 - \tau)}\left[p\Gamma(p) - \frac{(\tau - pt^e)}{(1 - t^e)}I\right]\ . \tag{8}$$

The reservation price v_e in (8) gives the entrepreneur's product market profits, net of the effective corporate taxes t^e that she must pay under market entry, but grossed up by the personal income tax τ that is due under sale.

Next, we turn to the incumbent firms' valuations of the invention. When an incumbent acquires the invention, it is certain that there will only be n firms in the market in the final stage and hence its product market profit is always given by $\pi(i)$. When *not* acquiring the entrepreneurial firm, the invention can either remain in the hands of the entrepreneur ($m = e$) or it can be acquired by a rival incumbent firm ($m = i$). This difference will affect the profits of the non-acquiring incumbent if the invention is successful, because only in this case will the entrepreneur decide to enter the market. When the invention fails, the profit of each incumbent will always be $\pi(i)$ in the product

---

if the licensee and the licensor need to undertake post-licensing investments, free riding problems will likely be increased if there are many licensees. Third, if asymmetric information is present, then multi-firm licensing increases the risk that potential buyers can claim that an idea was already known, thus expropriating innovators once they have disclosed their invention to them (Anton and Yao, 1994). These are only some of the reasons why multi-firm licensing rarely occurs in practice.

market stage, irrespective of the ownership of the invention. The profits of incumbent firms are taxed at the rate t^i.[22] Finally, as discussed above, the sales price S is always tax-deductible for the acquiring firm.[23] Denoting the *net gain* for an incumbent firm of acquiring the entrepreneur's invention at a price S by $\Delta_{im}(S)$ for $m = e, i$ yields

$$
\Delta_{im}(S) = p(1 - t^i) \left[\underbrace{\underbrace{\pi(i) - (\overline{F} - \Gamma(p)) - S}_{\text{Profit with project}} - \underbrace{(\pi(m) - \overline{F})}_{\text{Profit without project}}}_{\text{Net expected value from a successful innovation}} \right]
$$

$$
+ (1 - p)(1 - t^i) \left[\underbrace{\underbrace{\pi(i) - \overline{F} - S}_{\text{Profit with project}} - \underbrace{(\pi(m) - \overline{F})}_{\text{Profit without project}}}_{\text{Net expected value from an unsuccessful innovation}} \right]
$$

$$
= (1 - t^i) \left\{ -S + p\Gamma(p) + p[\pi(i) - \pi(m)] \right\}, \tag{9}
$$

where we have expanded the right-hand side of (9) with $p\pi(i)$ to arrive at the final expression for $\Delta_{im}(S)$.

From (9), we can define an incumbent firm's valuation as $v_{im} \equiv \max S, \ s.t \ \Delta_{im}(S) \geq 0$. Solving for $\Delta_{im}(S) = 0$ gives $v_{im} = p\Gamma(p) + p[\pi(i) - \pi(m)]$ as the maximum price S at which an incumbent firm is willing to buy the entrepreneur's invention. Incumbent firms thus have two valuations: The first is a *takeover valuation*, which is an incumbent firm's value of acquiring the invention when this would otherwise remain in the hands of the entrepreneur. In this case $m = e$ and

$$
v_{ie}(p) = p\Gamma(p) + p[\pi(i) - \pi(e)], \tag{10}
$$

where $p\Gamma(p)$ is the expected fixed costs savings of the invention and $p[\pi(i) - \pi(e)] > 0$ is the expected increase in product market profits when the entrepreneur is prevented from entering the market.

---

[22]The tax rate t^i will typically exceed the tax rate t^e faced by the entrepreneur under market entry, because incumbents are not eligible for reduced tax rates or support schemes tied to small businesses. This difference is immaterial for all of our results, however.

[23]Our static model assumes that the full sales price S is immediately tax-deductible for the acquiring firm. In actual tax law, the sales price is treated like an investment that can only be deducted *pro-rata* over several years. Hence, in a dynamic model the present value of being able to deduct S would be somewhat lower for the acquiring firm, but this would not qualitatively alter our results.

The second valuation is a *competitive valuation*, which is an incumbent's value of acquiring the invention when a rival incumbent would otherwise obtain it. Then $m = i$ and

$$v_{ii}(p) = p\Gamma(p). \tag{11}$$

Since the invention only affects fixed production costs, the preemptive value in this case is simply the expected fixed cost savings of the invention. Comparing (10) and (11), it is obvious that $v_{ie} > v_{ii}$ since $\pi(i) > \pi(e)$. This describes the concentration effect of an acquisition when entry by the entrepreneur is prevented. Finally, note that the incumbent firms' valuations are unaffected by their profit tax rate t^i, because competitive bidding ensures that the equilibrium sales price will equal the expected increase in profits from acquiring the invention.

We can now proceed to solve for the Equilibrium Ownership Structure (EOS). Since incumbents are symmetric and $v_{ie} > v_{ii}$ always holds, there are three different regimes that we need to consider. The following lemma can then be stated:

Lemma 1 *The equilibrium ownership of the invention m^* and the acquisition price S^* are described in Table 2.*

Proof: See the Appendix.

Table 2: The equilibrium ownership structure and the acquisition price

Regime	Definition	Ownership	Acquisition price
$R1:$	$v_e(p) > v_{ie}(p) > v_{ii}(p)$	$m^* = e$	–
$R2:$	$v_{ie}(p) > v_e(p) > v_{ii}(p)$	$m^* = i$	$S^* = v_e(p)$
$R3:$	$v_{ie}(p) > v_{ii}(p) > v_e(p)$	$m^* = i$	$S^* = v_{ii}(p)$

Table 2 describes the equilibrium mode of commercialization as a function of the R&D project chosen by the entrepreneur in the first stage, characterized by its success probability p. In Regime 1 (R1 for short), the expected profit from entering the market is higher for the entrepreneur than selling the invention to one of the incumbents. In Regime 2 the entrepreneur will sell her invention, but the sales price is determined by the reservation price v_e of the entrepreneur. This is because if one incumbent firm bids the reservation price, all other incumbents will only be willing to bid the competitive valuation v_{ii}, which is below v_e in this regime. Hence, the equilibrium bid equals

v_e.[24] Finally, in Regime 3, the invention is also sold in equilibrium, but the sales price equals the competitive valuation v_{ii}. To see this, note that the reservation price v_e can no longer be the equilibrium price, since the incumbents' competitive valuation v_{ii} exceeds v_e. Competition among incumbents will then bid up the sales price to v_{ii}.

3.4   Stage 1: Project choice by the entrepreneur

In this section, we solve for the equilibrium project selected by the entrepreneur, given that she anticipates the mode of commercialization in the second stage of the game. Noting that investment costs I are independent of project choice, the entrepreneur chooses the project that maximizes the net reward in each regime. From Lemma 1 the net reward for the entrepreneur, denoted by $\Omega(p)$, can be written as

$$\Omega(p) = \begin{cases} (1 - t^e)p\Gamma - (1 - pt^e)I \equiv (1 - \tau)[v_e(p) - I] & \text{in R1} \\ (1 - \tau)[v_e(p) - I] & \text{in R2} \\ (1 - \tau)[v_{ii}(p) - I] & \text{in R3}. \end{cases} \quad (12)$$

Note that in Regime 1 the net reward is the entrepreneur's net expected profit from entry [see eq. (7)] less the investment costs I. By the construction of the reservation price v_e in (8), this is equal to the net reward in the (hypothetical) situation where the entrepreneur receives a sales price v_e and pays personal income taxes on the excess of this sales price over the investment costs I. This is also how the net reward is calculated in Regimes 2 and 3, where the sale actually takes place.

To derive the equilibrium project choices we start with Regime 3, where the entrepreneur sells her invention at price $S^* = v_{ii}(p)$. In this regime, the net reward is maximized by incorporating the corporate tax treatment of the *incumbent firms*. From eq. (12), the entrepreneur will choose the project $p_S^* = \arg\max_p(1 - \tau)(v_{ii}(p) - I) = \arg\max_p v_{ii}(p)$, where the subscript S stands for the project choice in the sales Regime 3. The associated first-order condition is:

$$\Gamma(p_S^*) + p_S^*\Gamma'(p_S^*) = 0. \quad (13)$$

---

[24]Note that the gains from an entry deterring acquisition in Regime 2 are unevenly distributed among incumbents, as the acquiring incumbent bears the cost of the entry deterrence while the other firms can free-ride on the acquisition. This raises the possibility of coordination failures among incumbents, if $v_{ie}(p) > v_e(p) > v_{ii}(p)$. We assume, however, that incumbents are able to coordinate by randomly selecting one firm to buy the innovation. Since $v_{ie}(p) > v_e(p)$, this selected firm will then find it profitable to purchase the innovation to prevent entrepreneurial market entry.

Since incumbents can fully deduct the investment costs from their taxable profits, the corporation tax is a lump-sum instrument in this regime. From the perspective of the entrepreneur, the sales price is therefore maximized by choosing the project that maximizes the expected fixed cost reduction, as given by $\hat{p}$ in equation (2).

Next, we consider the optimal project choice in Regimes 1 and 2. In Regime 1 the entrepreneur enters the market herself, whereas in Regime 2 she sells the invention, but the sales price is determined by her reservation price v_e (the expected profits in case of entry). In both regimes, the net reward $\Omega(p) = (1 - \tau)[v_e(p) - I]$ is thus maximized by incorporating the loss offset provisions that apply to the *entrepreneur*. The optimal project is given from $p_E^* = \arg\max_p (1 - \tau)[v_e(p) - I] = \arg\max_p v_e(p)$, where the project choice is denoted by the subscript E. The associated first-order condition is:

$$\Gamma(p_E^*) + p_E^* \Gamma'(p_E^*) = -\frac{t^e}{(1 - t^e)} I \ . \tag{14}$$

The negative term on the right-hand side of (14) shows that in Regimes 1 and 2, the entrepreneur will not choose the cost-efficient project $\hat{p}$ defined in (2). The distortion arises because the entrepreneur cannot deduct her investment costs from tax in the case of project failure. This will induce her to choose a project with an inefficiently low level of risk. This effect is the stronger, the higher is the effective tax rate t^e faced by the entrepreneur in case of market entry.

4   The effects of tax policy

4.1   Effects on project choice and commercialization mode

In this section, we analyze how the system of taxing and subsidizing entrepreneurial incomes affects the mode of commercialization and the entrepreneur's project choice. We focus on exogenous variations in the effective rate of corporate profit taxation that the entrepreneur faces in case of market entry. To simplify the notation, we drop the superscript e for this tax rate from here on, so that $t \equiv t^e$. In this analysis, we hold constant the personal income tax τ, which is levied in case of project sale. To ensure that all possible regimes derived in the preceding section can occur, we assume that market entry must be the entrepreneur's preferred mode of commercialization when $t = 0$. Effectively, this requires that τ must not be too low. This is formally stated in

Assumption A2: When $t = 0$, the entrepreneur's reservation value exceeds the incumbents' takeover valuation for any level of p, i.e. $v_e(p)|_{t=0} > v_{ie}(p)|_{t=0}$.

On the other hand, if the entrepreneur faced the same tax rate under the two modes of commercialization, she would always choose to sell her invention to an incumbent firm. This is seen from setting $\tau = t$ in (8), yielding

$$v_e(p)|_{t=\tau} = p\Gamma - \frac{t(1-p)}{(1-t)}I < v_{ii} = p\Gamma, \ \forall p \in [0, 1]. \tag{15}$$

In this case, the reservation value of market entry for the entrepreneur falls short of the competitive valuation by incumbents. This implies that, in equilibrium, the entrepreneur sells her invention at the price v_{ii}. By selling the invention, the entrepreneur saves the additional expected tax payments that result from the inability to deduct the investment costs in case of project failure. Since selling the invention yields at least the expected payoff of the invention in the competitive bidding auction modeled here, there are no offsetting benefits from market entry when $t = \tau$ holds.

In the following, we therefore consider effective corporate tax rates t (net of government subsidies) for the entrepreneur, which range from zero to the personal income tax rate τ. From our discussion in Section 2, raising t towards τ is equivalent to a policy that reduces tax concessions and specific subsidies exclusively granted to small firms. To proceed, we introduce two critical corporate tax rates t^{ED} and t^C, where the valuation of the project by the entrepreneur equals the entry deterring (or takeover) valuation and the competitive valuation by the incumbents, respectively.

Definition 2: *Let t^{ED} be defined from $v_e(p_E^*)|_{t=t^{ED}} = v_{ie}(p_E^*)|_{t=t^{ED}}$, and let t^C be defined from $v_e(p_E^*)|_{t=t^C} = v_{ii}(p_S^*)|_{t=t^C}$.*

The following proposition describes how the commercialization mode depends on the effective profit tax rate t.

Proposition 1 *(Commercialization mode). In equilibrium, the following holds:*

(i) commercialization by entry (Regime 1) occurs, if the profit tax rate is low, $t \in [0, t^{ED})$;

(ii) commercialization by sale occurs at the sales price $S^* = v_e(p_E^*)$ (Regime 2), if the profit tax rate is in the intermediate range $t \in [t^{ED}, t^C)$;

(iii) commercialization by sale occurs at the sales price $S^* = v_{ii}(p_S^*)$ (Regime 3), if the profit tax rate is sufficiently high, $t \in [t^C, 1]$.

The next proposition describes how project choice depends on the profit tax rate.

Proposition 2 (Project choice). *In equilibrium, the following holds:*

(i) *for low profit tax rates $t < t^C$, the entrepreneur chooses a project with a higher success probability than the cost-efficient one, $p^{opt} = p_E^* > \hat{p}$;*

(ii) *for sufficiently high profit tax rates $t \geq t^C$, the entrepreneur's project choice is efficient, $p^{opt} = p_S^* = \hat{p}$.*

To prove Propositions 1 and 2, it is convenient to first evaluate the net reward $\Omega(p)$ in equation (12) at the optimal project p^{opt}. Inserting the results from (13) and (14) gives:

$$\Omega(p^{opt}) = \begin{cases} (1-\tau)[v_e(p_E^*) - I] & \text{in R1} \\ (1-\tau)[v_e(p_E^*) - I] & \text{in R2} \\ (1-\tau)[v_{ii}(p_S^*) - I] & \text{in R3.} \end{cases} \tag{16}$$

The entrepreneur will choose the R&D project and the mode of commercialization to maximize the net reward $\Omega(p^{opt})$. From (16), we note that this is equivalent to maximizing the reward from the commercialization auction in Lemma 1. Thus, the entrepreneur will choose the optimal project p_E^* under market entry (or under sale at the reservation price), if the reward to this project exceeds the reward from choosing the optimal project p_S^* which induces a sale under bidding competition, $v_e(p_E^*) > v_{ii}(p_S^*)$.

******* Figure 3 about here ******

Panel (i) of Figure 3 depicts the reservation price $v_e(p_E^*)$ and the competitive valuation of incumbents $v_{ii}(p_S^*)$ as functions of the tax rate t. Note that the reservation price $v_e(p_E^*)$ is decreasing in t, as is seen from totally differentiating (8). At the same time, the incumbents' competitive valuation, evaluated at the optimal project choice p_S^*, is unaffected by taxes from (11). Hence there must exist a critical tax rate t^C such that $v_e(p_E^*)|_{t=t^C} = v_{ii}(p_S^*)|_{t=t^C}$. As shown in panel (i), when $t > t^C$ the entrepreneur will always choose p_S^* to induce a subsequent sale under bidding competition. If $t < t^C$ instead, she will choose a project p_E^* that maximizes the reservation price obtained either from commercialization by entry or from an entry-deterring acquisition.

We can now prove Proposition 2. From the above argument, the equilibrium project p^{opt} is given by

$$p^{opt} = \begin{cases} p_E^*, & t \in [0, t^C), \\ p_S^*, & t \in [t^C, 1]. \end{cases} \tag{17}$$

Implicitly differentiating (13) in Regime 3 and (14) in Regimes 1 and 2 then yields

$$\frac{dp^{opt}}{dt} = \begin{cases} \dfrac{-I}{(2\Gamma' + p_E^*\Gamma'')(1-t)^2} > 0 & t \in [0, t^C) \quad \text{in R1, R2,} \\ 0 & t \in [t^C, 1] \quad \text{in R3,} \end{cases} \tag{18}$$

where $2\Gamma' + p_E^*\Gamma'' < 0$ follows from the assumption that $p\Gamma(p)$ is strictly concave.

Panel (ii) of Figure 3 illustrates the relationship between the effective corporate tax rate t and the equilibrium project choice, p^{opt}, as given in (18). As long as $t < t^C$, raising the profit tax rate leads to a continuous increase in the success probability of the equilibrium project, because the rise in t makes the deductibility of the initial investment outlays more valuable, and this deductibility can only be used when the project is successful. At $t = t^C$, the entrepreneur sells the invention at price $S^* = v_{ii}$. At this point the success probability of the equilibrium project drops back to the efficient level $p_S^* = \hat{p}$, and it remains independent of t as the effective profit tax rate rises further. Overall, therefore, the equilibrium level of p adjusts in a non-monotonous way to the profit tax rate t.

Turning to the proof of Proposition 1, we can now apply Lemma 1 to the optimal projects p^{opt} given from Proposition 2. In panel (iii) of Figure 3, we depict the locus of the valuations v_e, v_{ie} and v_{ii} as reduced-form functions of the profit tax rate t, incorporating the equilibrium choices of p^{opt} that apply at each level of t. To determine the shape of the different curves, we totally differentiate (8), (10) and (11). This yields:

$$\frac{dv_r(p^{opt})}{dt} = \underbrace{\frac{\partial v_r}{\partial t}}_{\text{direct effect}} + \underbrace{\frac{\partial v_r}{\partial p}\frac{dp^{opt}}{dt}}_{\text{indirect effect}} \qquad \forall\, r \in \{e, ie, ii\}. \tag{19}$$

We turn first to the entrepreneur's reservation price v_e. By the direct effect, this is falling in the profit tax rate t across all regimes. The indirect effect operating through changes in the optimal project choice is zero for $t < t^C$ due to the envelope theorem. At $t = t^C$ the equilibrium project choice changes discretely to p_S^*. This leads to a discontinuous downward jump in v_e, as the equilibrium project no longer maximizes

the entrepreneur's reservation price.[25]

An analogous argument applies for the valuations of incumbents. The direct effect of t on both v_{ie} and v_{ii} is zero from equations (10) and (11). The indirect effects in eq. (19) consist of the induced changes in project choice, as given in (18), and the incumbents' valuation of these changes, $\partial v_{im}/\partial p$. The latter effects are zero in Regime 3 from the envelope theorem. In Regimes 1 and 2, these effects are given by

$$\frac{\partial v_{ie}}{\partial p} = \Gamma + p_E^*\Gamma' + \pi(i) - \pi(e), \qquad \frac{\partial v_{ii}}{\partial p} = \Gamma + p_E^*\Gamma'. \tag{20}$$

From equation (14), we know that the second of these terms is negative. Hence increases in the tax rate t (and thus in p_E^*) have a negative effect on the incumbents' competitive valuation v_{ii} for $t < t^C$. In contrast, the effect on the takeover valuation v_{ie} is ambiguous, due to the additional term $\pi(i) - \pi(e) > 0$. At $t = t^C$, there is an upward jump in the graphs of both v_{ii} and v_{ie}, because the discrete switch in the equilibrium project choice then maximizes the valuations of incumbents. Finally, note that since there exists a critical tax level t^C where $v_e(p_E^*)|_{t=t^C} = v_{ii}(p_S^*)|_{t=t^C}$, there must also exist a second critical level t^{ED} where $v_e(p_E^*)|_{t=t^{ED}} = v_{ie}(p_E^*)|_{t=t^{ED}}$ holds. Moreover, since $v_{ie}(p^{opt}) - v_{ii}(p^{opt}) = \pi(i) - \pi(e) > 0$, it also follows that $t^{ED} < t^C$.

We are now ready to prove Proposition 1. When the corporate tax rate is low, $t \in (0, t^{ED})$, the entry value $v_e(p_E^*)$ exceeds the incumbents' takeover valuation $v_{ie}(p_E^*)$ from Assumption A2. This leads to an equilibrium in Regime 1 with the entrepreneur retaining the ownership of her invention and entering the market in case the invention succeeds. As the profit tax rate increases, it reaches the first critical value t^{ED}, where the entrepreneur's reservation value equals the takeover valuation of the incumbents. At $t = t^{ED}$, the equilibrium switches to Regime 2 with an entry deterring acquisition taking place at the acquisition price $S^* = v_e(p_E^*)$. As t rises further, it reaches the second critical level t^C, where the entrepreneur's reservation value falls below the competitive valuation of the incumbent firms, $v_e(p_S^*) < v_{ii}(p_S^*) < 0$. This induces a bidding war between incumbents and results in Regime 3, where the sales price is fixed by the incumbents' valuation $v_{ii}(p_S^*)$. Further increases in t continue to reduce the entry value of the entrepreneur, which falls to its minimum value at $t = \tau$. The equilibrium commercialization pattern is summarized at the bottom of panel (iii). $\square$

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[25]Technically, the envelope theorem can no longer be applied at $t = t^C$, because the equilibrium project is then not chosen to maximize v_e.

To summarize, government policies that reduce the effective profit taxation of small businesses by granting reduced tax rates and various subsidies encourage market entry by entrepreneurs and foster competition in the innovative sector. At the same time, however, the entrepreneur's choice of project will be distorted whenever she produces for market entry. As is shown in panel (iii) of Figure 3, when profit tax rates are in the range $t \in [0, t^C)$, even risk-neutral entrepreneurs will choose projects that involve too little risk and fall short of maximizing the expected return from the investment. This effect arises from the imperfect loss offset that entrepreneurs face in case of project failure. We now turn to the welfare implications of this result.

4.2   Welfare and employment effects of tax policy

In this section we analyze how taxes impact expected welfare and employment by affecting the R&D project choice and the commercialization mode of the entrepreneur. To this end we measure welfare as the sum of aggregate industry profits, consumer surplus and tax revenue. In Regime 1, where the entrepreneur enters the market, the after-tax net reward is given by $(1 - t^e)[p_E\Gamma(p_E)] - (1 - pt^e)I$ in eq. (12). The expected income loss for the entrepreneur that arises from the inability to deduct investment cost from tax in case the project fails is, however, fully compensated by higher expected tax payments, $t^e p(\Gamma - I)$. Hence the sum of tax revenue and the entrepreneur's net reward equals the gross-of-tax reward from the innovation, net of investment costs, $p_E\Gamma(p_E) - I$. In Regimes 2 and 3, where the innovation is sold to an incumbent, the personal income tax τ is applied on the tax base $(v_e - I)$ and $(v_{ii} - I)$, respectively. Together with tax revenues, the social surplus is thus again $p_E\Gamma(p_E) - I$ in Regime 2 and $p_S\Gamma(p_S) - I$ in Regime 3. This yields the following expressions for expected welfare:

$$E[W] = \begin{cases} p_E^*\Gamma(p_E^*) - I + n\pi(i) + CS(i) + p_E^*\xi & \text{in R1} \\ p_E^*\Gamma(p_E^*) - I + n\pi(i) + CS(i) & \text{in R2} \\ p_S^*\Gamma(p_S^*) - I + n\pi(i) + CS(i) & \text{in R3.} \end{cases} \quad (21)$$

Here

$$\xi \equiv n\left[\pi(e) - \pi(i)\right] + CS(e) - CS(i) \lessgtr 0$$

is the net externality arising from the market entry of the entrepreneur in Regime 1, which increases the equilibrium number of firms from n to $(n + 1)$. This causes a decline in the incumbents' aggregate profits given by $n[\pi(e) - \pi(i)] < 0$ and an increase

in consumer surplus given by $CS(e) - CS(i) > 0$. Employing the model of quantity competition in differentiated products introduced in Section 3.1 [see eq. (4)] yields

$$
\begin{aligned}
CS(m) = {} & aQ^*(m) - \frac{1}{2}\left[n(m)(q^*(m))^2 + \gamma n(m)[n(m)-1](q^*(m))^2\right] \\
& - n(m)\left[a - q^*(m) - \gamma(n-1)q^*(m)\right]q^*(m) \quad \forall\, m \in \{i, e\}, \qquad (22)
\end{aligned}
$$

where $Q = \sum_j q_j$ and $n(m)[n(m)-1]/2$ is the number of unique cross-products terms $q_j^* q_k^*$ with $j \neq k$ in (4). From (22) and (6), the net externality ξ becomes

$$
\xi = \frac{1}{2}(a-c)^2 \frac{[-n^2\gamma^3 - n^2\gamma^2 + n\gamma^3 - 3n\gamma^2 + \gamma^2 - 4\gamma + 4]}{(n\gamma+2)^2\,(-\gamma+n\gamma+2)^2}, \qquad (23)
$$

where n is the number of incumbent firms. From (23) it is straightforward to infer that $\xi > 0$ for $\gamma = 0$, but $\xi < 0$ for $\gamma = 1$. Moreover, since ξ is continuous in γ, there must exist a critical level of product differentiation $0 < \gamma^c < 1$ such that $\xi = 0$.

Hence, if the goods produced by the incumbents and the entrepreneur are perfect substitutes ($\gamma = 1$), then entrepreneurial market entry has a negative net effect on surplus in the industry, because the reduction in producer surplus dominates the rise in consumer surplus. This is due to the additional fixed costs incurred by the new entrant, which leads to rising average costs in the industry (Mankiw and Whinston, 1986). If all firms are local monopolies, however ($\gamma = 1$) then the increase in consumer surplus will dominate, as consumers value the addition of a new product.

We can now discuss the overall welfare effects of tax policy. If $\xi < 0$ holds in Regime 1, then market entry by the entrepreneur unambiguously reduces aggregate welfare, relative to the alternative of selling the innovation. Recall that $p_E\Gamma(p_E)$ in Regimes 1 and 2 is below $p_S\Gamma(p_S)$ in Regime 3, because the entrepreneur's project choice is distorted in the first two regimes, but not in the third [eqs. (13) and (14)]. In this case, welfare is unambiguously highest in Regime 3, implying that the optimal policy is to tax the entrepreneur's profits under market entry at the same rate as the proceeds from the sale of the innovation to an incumbent firm.

In contrast, when $\xi > 0$, then an argument arises to tax-discriminate in favour of entrepreneurial market entry, as this will benefit consumers due to the additional variety. At the same time, market entry by the entrepreneur will imply a project choice that involves an inefficiently low level of risk-taking. This distortion of project choice will be the more severe, the larger is the (positively defined) elasticity with which the cost savings Γ respond to the success probability of the project, $\eta = -(\partial\Gamma/\partial p)(p/\Gamma)$. Hence

the optimal tax policy faces a trade-off between the net benefits from entrepreneurial entry that result in Regime 1, and the benefits from an efficient project choice that arise in Regime 3. A tax policy leading to an equilibrium in Regime 2 is never optimal, because this regime features neither entrepreneurial market entry nor an efficient project choice. We summarize these results in:

Proposition 3 *(Welfare effects of tax policy). Consider a model of Cournot competition in differentiated products. Then the following holds:*

(i) *if products are sufficiently close substitutes ($\gamma \to 1$), the optimal tax policy induces an equilibrium in Regime 3, with commercialization by sale at the competitive valuation of incumbents.*

(ii) *if products are strongly differentiated ($\gamma \to 0$), the optimal tax policy induces an equilibrium in Regime 1, with entrepreneurial market entry, when the net externality $\xi > 0$ is sufficiently large, relative to the elasticity of cost savings η. Otherwise, the optimal tax policy induces an equilibrium in Regime 3.*

The argument for promoting entrepreneurial market entry is strengthened when there are market failures in labour markets and countries suffer from unemployment. As we have discussed in the introduction, one of the main objectives of supporting small, entrepreneurial firms is the belief that they create additional jobs. It is straightforward to incorporate this argument into our analysis when we assume that aggregate employment in the industry is monotonously rising in aggregate output. The market entry of the entrepreneur will not displace incumbent firms, because the entry costs G are sunk for them. Hence, entrepreneurial market entry will increase aggregate output in the industry.[26] Moreover, given macroeconomic unemployment, a higher employment level in the innovative industry is unlikely to be fully compensated by employment reductions in other parts of the economy.

Summing up, a policy of promoting market entry of small, innovative firms is likely to lead to higher output and employment in the innovative sector, but the welfare effects of this policy are positive only when goods are sufficiently differentiated. The costs of an entry-promoting policy lie in the distortion of the entrepreneur's project choice, in the direction of inefficiently low levels of risk-taking. In our benchmark model, where

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[26]This is easily verified for the Cournot model with differentiated outputs by multiplying the per-firm outputs in eq. (6) for $m = i, e$ with n and $(n + 1)$, respectively.

the innovation affects only fixed production costs, this points to a basic policy trade-off between the declared goals of promoting employment in small, innovative businesses and the fostering of major, risky innovations.[27] The next section analyzes how the effects of an entry-promoting tax policy change when the choice of the R&D project also affects variable production costs.

5   Variable cost saving inventions

In this section, we show that if more risky projects lead to lower variable costs, rather than lower fixed costs, consumers may unambiguously prefer commercialization by sale over commercialization by entry. For this purpose, we briefly discuss how the analysis in the different stages changes when variable cost reductions are allowed for.

Stage 4: Consider a situation where the gains from a more risky project in case of success are given by larger variable cost savings for the possessor of the invention, while fixed costs are ignored. Let the acquiring incumbent's product market profit for a successful invention be $\pi_A(i, p)$, where p is the project choice in Stage 1. Similarly, let the entrepreneur's profit when entering be $\pi_E(e, p)$ and let a non-acquiring incumbent's profit be $\pi_{NA}(m, p)$. Note that we write these profits as reduced-form functions of the project choice p, indicating that the project has succeeded in Stage 3.

We then introduce[28]

Assumption A3: (i) $\dfrac{d\pi_A(i, p)}{dp} < 0, \dfrac{d\pi_E(e, p)}{dp} < 0$, (ii) $\dfrac{d\pi_{NA}(m, p)}{dp} > 0$, $m \in \{e, i\}$.

Assumption A.3 (i) states that the product market profit from a successful invention is smaller for the possessor (either the acquiring incumbent or the entrepreneur herself) when the riskiness of the project decreases. Assumption A.3 (ii) states that

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[27]A similar policy trade-off is found in the empirical analyses of Da Rin et al. (2010, 2011), who analyze the effects of a reduction in corporate tax rates on entrepreneurship. The authors show, in two separate studies, that this policy induces more market entry of new firms, but at the same time it reduces the size and capital intensity of entrants, thus leading to 'weaker' firms, on average.

[28]To illustrate, let c be the incumbents' initial marginal cost. If the entrepreneur's project succeeds in Stage 3, the marginal cost falls to $c_E(p) = c - (1 - p)$ in Stage 4, which is also an acquiring incumbent's marginal cost, $c_E(p) = c_A(p)$. Non-acquiring incumbents continue to have marginal costs of $c_{NA} = c$. Assuming linear demand and assuming Nash-Cournot competition, it is routine to show that the reduced-form profits fulfill Assumption A3.

non-acquiring incumbents see their profits increasing when the possessor has a safer project, since rivals then face less fierce competition from the owner of the invention.

Stage 3: At this stage, it is revealed whether the innovation turns out to be successful. We maintain Assumption A1 so that entry is profitable only if the project succeeds. Hence $\pi_E(e, p) - G \geq 0$, but $\pi_E(e, 0) - G = 0$, where $\pi_E(e, p)$ is the profit of the entrepreneur under entry with project p and $\pi_E(e, 0)$ is the profit with a failed project.

Stage 2: At the commercialization stage, the entrepreneur's reservation price defined in (8) becomes:

$$v_e = \frac{(1-t)}{(1-\tau)} \left\{ p[\pi_E(e, p) - G] - \frac{(\tau - pt)}{(1-t)} I \right\}. \tag{24}$$

The takeover and the competitive valuation of an incumbent in (10) and (11) become

$$v_{ie} = p\left[\pi_A(i, p) - \pi_{NA}(e, p)\right], \qquad v_{ii} = p\left[\pi_A(i, p) - \pi_{NA}(i, p)\right], \tag{25}$$

where again $v_{ie} > v_{ii}$ since $\pi_{NA}(e, p) < \pi_{NA}(i, p)$. From the latter inequality, it follows that the equilibrium commercialization mode can be solved by applying Lemma 1.

Stage 1: Turning to the entrepreneur's project choice, we assume that $p\pi_E(e, p)$ and $p\left[\pi_A(i, p) - \pi_{NA}(m, p)\right]$ are strictly concave in p, ensuring well-defined project choices. Introducing $E[\pi(m, p)] \equiv p\pi(m, p)$ as the expected value of the project and using Assumption A1, the first-order condition for the optimal project choice when innovating for entry or selling at the reservation price $S^* = v_e$ in Regimes 1 and 2 becomes:

$$\frac{dE[\pi_E(e, p)]}{dp} = 0 \quad \Longrightarrow \quad p_E^* \frac{d\pi_E(e, p_E^*)}{dp} = -\frac{t}{(1-t)} I. \tag{26}$$

As in our benchmark model [see eq. (14)], the inability to deduct the investment costs from tax in case of failure will induce the investor to choose a project with too little risk, other things being equal.

When innovating for sale under bidding competition in Regime 3, receiving the sale price $S^* = v_{ii}$ [see eq. (13)], the optimal project choice is given by

$$\frac{dE[\pi_A(i, p)]}{dp} - \frac{dE[\pi_{NA}(i, p)]}{dp} = \pi_A(i, p_S^*) + p_S^* \frac{d\pi_A(i, p_S^*)}{dp} - \pi_{NA}(i, p_S^*) - p_S^* \frac{d\pi_{NA}(i, p_S^*)}{dp} = 0. \tag{27}$$

The optimal project choice in Regime 3 is again independent of the effective tax rate. There is, however, an important difference to our benchmark case. With variable cost reductions, an entrepreneur that chooses an optimal project for sale will not only

consider how the expected product market profit of the acquirer is affected, but she will also take into account that choosing a safer project increases the expected profit for a non-acquirer (see Assumption A3). Since the incumbents' willingness to pay for the project is negatively affected by the profits of a non-acquirer [see eq. (25)], this gives a strategic incentive to the entrepreneur to choose a more risky project.

This strategic incentive is shown in the lower panel (ii) of Figure 4, where the slope of the marginal expected profit curve from a change in p is always steeper in Regime 3 as compared to Regimes 1 and 2. For this reason the difference in the risk characteristics of the projects chosen in Regimes 1 and 2 on the one hand and in Regime 3 on the other is even larger than in our benchmark case.

********* Figure 4 about here **********

The effects of tax policy on consumers. We now examine how tax rates affect consumers through the entrepreneur's choices of project and mode of commercialization. Maintaining Assumption A2, we proceed as in Section 4 and define reduced-form valuations $v_r(t) \equiv v_r[p^{opt}(t)]$. Taking the total derivative in t and applying the envelope theorem, it is straightforward to show that Propositions 1 and 2 continue to hold when more risky projects are associated with larger variable cost reductions.

Consider now the upper panel (i) of Figure 4. Let $\overline{CS}$ be the consumer surplus when the invention has failed. The expected consumer surplus under innovation by entry and under innovation by sale is then $E[CS(e,p)] \equiv pCS(e,p) + (1-p)\overline{CS}$ and $E[CS(i,p)] \equiv pCS(i,p) + (1-p)\overline{CS}$, respectively. For the same project p, innovation by entry always gives a higher expected consumer surplus since $CS(e,p) > CS(i,p)$ from the concentration effect of an acquisition. Assume that the expected consumer surplus is strictly concave in p, so that there exist optimal projects, from the perspective of consumers, given by $p_S^{CS} = \arg\max_p[pCS(p,i) + (1-p)\bar{C}S]$ and $p_E^{CS} = \arg\max_p[pCS(p,e) + (1-p)\bar{C}S]$. Note that, because of imperfect competition in the product market, the interests of producers and consumers are generally not aligned in our model. Regardless of entry mode, the entrepreneur will therefore not choose a project that maximizes the expected consumer surplus, so that in general $p_E^* \neq p_E^{CS}$ and $p_S^* \neq p_S^{CS}$ holds.

Suppose that we start from a high effective corporate tax rate for the entrepreneur, $t > t^C$. From Proposition 1, this implies that the entrepreneur will choose commercialization by sale at the sales price $S^* = v_{ii}$. This yields an expected consumer surplus of

$E[CS(e, p_S^*)]$, as shown by point S in Figure 4 (i). Suppose then that the effective tax rate is reduced to $t_1 < t^C$ so that the entrepreneur chooses instead commercialization by entry. With the new effective tax rate t_1 the entrepreneur will choose an overly safe project under market entry, due to the incomplete loss offset provisions of the corporate tax code. This project choice may yields only limited reductions in variable costs, and hence consumer prices, as given by the point E_1 in Figure 4 (i). A comparison of the points S and E_1 then reveals that the expected consumer surplus can be lower under market entry than under sale, even though the number of competitors is higher with market entry by the entrepreneur.

In this case the interests of consumers will be best served when the entrepreneur sells the innovation to an incumbent firm in Regime 3 and chooses a project that minimizes the expected variable costs of production. Moreover, commercialization by sale will also be preferred from the perspective of creating new jobs, as the lower consumer prices will generally be associated with higher total output and employment. We conclude, therefore, that in a setting where innovations reduce variable production costs, a policy of promoting the market entry of entrepreneurs by means of tax and subsidy advantages can be counterproductive from *both* an employment perspective and from the viewpoint of fostering highly productive innovations.

6   Discussion

In this section, we briefly discuss several further extensions and modifications of our benchmark model.[29]

Effort by the entrepreneur.   An important aspect of entrepreneurial innovation is that a substantial share of the initial investment may consist of effort put in by the entrepreneur. It is straightforward to incorporate this into our model by introducing a zero stage of the game, where the entrepreneur chooses an endogenous level of effort in order to generate a basic innovative idea. In this setting it can be shown that increased levels of taxation reduce the entrepreneur's effort to create innovative ideas. While the effort-reducing effects of taxes have been stressed in previous literature (e.g. Keuschnigg and Nielsen, 2004), this result is specified in our setting because different

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[29]A detailed analysis of the first three extensions is found in the supplementary appendix on our homepages.

taxes affect entrepreneurial effort under different equilibrium modes of commercialization. In particular, higher corporate tax rates are effort-reducing when the equilibrium is in Regimes 1 and 2, whereas higher income taxes reduce effort when the equilibrium is in Regime 3. All other results of our analysis are unaffected by this model extension.

Incorporation and transaction cost for sale. Another modification is to permit entrepreneurs that innovate for sale to incorporate, in order to benefit from lower corporate tax rates. For analytical simplicity, we focus on the extreme case where tax rates are identical when innovating for market entry or for sale, thus ignoring the fact that some government subsidies for SMEs are only available when entrepreneurs actually enter the market. In this setting the trade-off between market entry and sale arises from the fact that the sale of the innovation is subject to a fixed transaction cost. Market entry by the entrepreneur will thus be induced by the motive to save on transaction costs, rather than by tax advantages. It remains true, however, that the entrepreneur chooses an inefficiently low level of risk whenever she innovates for market entry, as a result of incomplete loss offset provisions.

It could further be argued that the transaction cost of a sale to incumbents is not fixed, but is rising in the degree of project risk. This could be due to potential moral hazard problems that arise from an information advantage that the entrepreneur has over the incumbents with respect to the characteristics of her innovation. Other things being equal, this risk-dependent transaction cost would then lead to a project choice with a lower level of risk-taking. At the same time, however, entry costs can also be argued to rise in the riskiness of the innovation project, due to the entrepreneur's lack of knowledge of market conditions (cf. footnote 20). As a result, the entrepreneur may opt for less risk under both modes of commercialization when these additional model elements are incorporated. In any case it remains true that incomplete loss offset provisions are an additional reason to reduce project risk under market entry, which is not present when the innovation is sold to an incumbent.

Post-uncertainty sales. As we have discussed in Section 3.2, there is a basic tax advantage for the entrepreneur, if she sells before the uncertainty is lifted. This is why our benchmark model has ruled out the possibility of a project sale after the resolution of uncertainty. In an extension we pursue the implications for the model's results, if this assumption is relaxed and *both* pre- and post-uncertainty sales are permitted.

This analysis becomes rather involved when we allow for independent draws of the incumbents selected to buy the innovation at the pre- and post-uncertainty stage (cf. footnote 24). In this case the incumbent drawn at the pre-uncertainty stage has an incentive not to buy the innovation and rely instead on the possibility that he is not drawn as the buyer at the post-uncertainty stage (provided that the innovation has been successful). As a result, post-uncertainty sales may occur in this extended model for some range of tax rates. In effect, this is a dynamic coordination failure as the incumbent who ends up buying the innovation post-uncertainty would have preferred a pre-uncertainty sale, in order to benefit from the tax advantage of the latter.

Importantly, however, even if post-uncertainty sales occur, the equilibrium project choices are unchanged from our benchmark analysis for all possible tax rates and Proposition 2 continues to hold. In particular, subsidies to entrepreneurial market entry ($t < t^C$) will still lead to project choices with inefficiently low levels of risk-taking, whereas sufficiently high tax rates for the market entry of the entrepreneur ($t > t^C$) will lead to efficient project choices. Hence, allowing for post-uncertainty sales does not change the fundamental trade-off for tax policy derived in our benchmark model.

Product innovation. Our model is based on a setting where the project chosen by the entrepreneur is a cost-reducing process innovation. It is conceptually straightforward, however, to alternatively consider a product innovation where the entrepreneur develops a new product in the first stage. The degree of innovation, and the risk associated with it, would then both rise in the distance that the new product has to existing ones as, for instance, in Salop's (1979) circular-city model of product differentiation. While this model would be more complex than the one used here, a concave expected return curve similar to the one in Figure 2 could also be obtained in this case. All other features of our model would also be preserved in such a changed setting. In particular, imperfect loss offset would again cause the entrepreneur to choose a project with too little risk, which would here imply a project that is "too similar" to existing ones.

Venture capital. Finally, we discuss in some more detail the effects of incorporating venture capitalists into our model. Our benchmark analysis has assumed that the entrepreneur is not able to obtain tax rebates for the investment costs incurred when she attempts to enter the market herself, but the project fails. These loss offset restrictions imply that the entrepreneur could gain from the cooperation with a financial partner,

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who has other income to deduct the losses against. In this case the investment cost I could be deducted as long as the partner has sufficient positive income, and the distortionary effect on project choice could thus be avoided. It is well known, however, that such financial partnerships are associated with severe adverse selection and moral hazard problems. Therefore, where financial partners exist, they almost always involve a highly specialized venture capitalist.

In most countries, however, only few projects are backed by venture capital. Even in the United States, where the venture capital market is by far the largest, only 14,000 portfolio companies worldwide received venture capital over a 30-year period from 1975 to 2005 (Lerner, 2010). Total venture capital investments in the United States amounted to 28.8 billion US-$ in 2008, corresponding to 0.20 percent of this country's GDP.[30] In Europe, the share of venture capital investments in GDP is much lower, equalling 0.07 percent of national GDP in Sweden, 0.05 percent in the United Kingdom and 0.03 percent of GDP in Germany (EFI, 2011, p. 19).

Moreover, even for start-up firms backed by venture capital (VC), the possibility to deduct losses for tax purposes is far from complete. On the one hand, entrepreneurs usually retain a substantial ownership share in the VC-backed company, in order to mitigate the moral hazard problems inherent in the relationship with the venture capitalist (see Keuschnigg and Nielsen, 2002, 2004). This implies that loss offset restrictions will still apply for the ownership share of the entrepreneur. In addition, some countries' tax laws also restrict the tax deduction of losses for venture capitalists. In Germany, for example, unused tax losses cannot be transferred when the venture capitalist sells her shares in the company - for example to another VC firm, which specializes in financing a different development phase of the start-up. These restrictive tax provisions are widely believed to hinder VC financing, but also the establishment and growth of innovative companies in Germany (EFI, 2011, p. 19).

In sum, bringing venture capital financing into the picture and accounting for its relative importance will introduce some qualifications to our assumption that an entrepreneur producing for market entry is not able to obtain any tax rebates for losses incurred in the investment phase. However, this extension will clearly not overturn our basic argument that loss offset restrictions are more severe when the entrepreneur produces for market entry, as opposed to selling her innovation to an incumbent firm.

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[30]See "Investment funding rose 5 percent in 2008", *VentureBeat*, 18 February 2009.

7   Conclusion

In this paper we have focused on two important decision margins of entrepreneurs that have received little analysis so far in a context of public policy. These are the entrepreneur's choice between innovations with different risk and return characteristics, and her decision of how to commercialize the innovation. In a setting where innovations affect only fixed production costs, we have shown that policies to support small, technology-intensive businesses can be welfare-increasing if and only if goods in the innovative sector are sufficiently differentiated. Moreover, these policies face a fundamental trade-off: they promote market entry by entrepreneurs and increase aggregate industry output, but at the same time lead to R&D choices that involve suboptimally low levels of risk-taking. This is due to the risk-reducing effect of limited loss offset provisions, which are particularly important for small, entrepreneurial firms. In that sense, the comparative advantage of new, entrepreneurial enterprises to create major innovations is thus compromised by such a policy. Inefficient project choices will have even more severe implications when innovations reduce marginal production costs. In this case it is possible that policies to induce entrepreneurial market entry are unambiguously harmful, reducing both output and employment, in addition to distorting the choice of the innovation project.

These results can be contrasted with existing policies to support entrepreneurship in the European Union and elsewhere. The Small Business Act for Europe (European Commission, 2008), for example, simultaneously aims at fostering risky innovations and employment growth through the promotion of SMEs. Our analysis shows that these goals are mutually incompatible, at best, when the interaction between the entrepreneur's project choice and the choice of commercialization mode is explicitly analyzed. Instead, the results from our model suggest to reduce or even eliminate the policy preference in favor or entrepreneurial market entry. On the one hand, this would involve a reduction in the specific subsidies granted exclusively to small businesses at the marketing stage. On the other hand it would imply to align the tax rates that are applicable for the sale of a business or patent, and for the profits earned by the entrepreneur under market entry. These arguments support the policy recommendations in the Mirrlees Review (2011), which stress - in the context of UK tax policy - the case for more tax neutrality in business taxation. A final part of the appropriate policy package would be to improve the legal framework and to reduce the transaction costs

for sales to incumbent firms, so as to ensure an effective bidding competition for target firms and their patents.

In addition to its normative implications, our analysis also leads to several hypotheses that can be tested empirically. As incentive schemes for small businesses have proliferated and corporate tax rates for incorporated start-ups have fallen sharply in many countries, this has led to a rising tax and subsidy advantage for market entry by entrepreneurs over the alternative of project sale. According to our analysis, these developments should have led to a rising share of innovations that are commercialized by the market entry of entrepreneurs and at the same time should have induced less risky, and also less efficient, innovation projects.

In concluding, we emphasize that our analysis is but a first step towards a more comprehensive study of the effects of public policies in the market for entrepreneurial innovations. A possible first extension of our framework is to endogenize optimal policies towards small businesses, including the extent of loss offset provisions that apply to new enterprises. In such a setting the disadvantages of restrictive loss offset opportunities that have been the focus of our study could be set against the possible tax revenue losses that arise from fraudulent claims for tax rebates. Another extension would be to introduce a more complex set of contractual arrangements between innovators, banks and venture capitalists, where the incentives for all agents may be distorted by asymmetric information. For instance, heavy reliance on debt financing can lead to excessive risk-taking by entrepreneurs, counteracting the distortion that arises from limited loss offset opportunities in the present paper. Finally, the analysis could be extended to a dynamic model, in order to capture the growth-promoting effect that is a core reason for the policy support to entrepreneurship.

Appendix: Proof of Lemma 1

First, note that $b_i \geq \max v_{il}$, $l = \{e, i\}$ is a weakly dominated strategy, since no incumbent will post a bid equal to or above its maximum valuation of obtaining the invention and that firm e will accept a bid iff $b_i > v_e$.

Regime 1: Consider equilibrium candidate $b^* = (b_1^*, b_2^*, ..., no)$, where $b_j^* < v_e \ \forall j \in J$. It then directly follows that no firm has an incentive to deviate and thus, b^* is a Nash equilibrium.

Then, note that the entrepreneur will accept a bid iff $b_j \geq v_e$. But $b_j \geq v_e$ is a weakly dominated bid in these intervals, since $v_e > \max\{v_{ii}, v_{ie}\}$. Thus, the assets will not be sold in these intervals.

Regime 2: Consider equilibrium candidate $b^* = (b_1^*, b_2^*, ..., yes)$. Then, $b_w^* > v_e$ is not an equilibrium since firm w would then benefit from deviating to $b_w = v_e$. Further, $b_w^* < v_e$ is not an equilibrium, since the entrepreneur would then not accept any bid. If $b_w^* = v_e - \varepsilon$, then firm w has no incentive to deviate. By deviating to $b_j' \leq b_w^*$, firm j's payoff does not change ($j \neq w, e$). By deviating to $b_j' > b_w^*$, firm j's payoff decreases since it must pay a price above its willingness to pay v_{ii}. Accordingly, firm j has no incentive to deviate. By deviating to *no*, the entrepreneur's payoff decreases since it foregoes a selling price above its valuation v_e. Accordingly, the entrepreneur has no incentive to deviate and thus, b^* is a Nash equilibrium.

Let $b = (b_1, , , b_n, yes)$ be a Nash equilibrium. If $b_w \geq v_{ii}$, then firm w will have the incentive to deviate to $b' = b_w - \varepsilon$. If $b_w < v_{ii}$, the entrepreneur will have the incentive to deviate to *no*, which contradicts the assumption that b is a Nash equilibrium.

Let $b = (b_1, ..., b_n, no)$ be a Nash equilibrium. The entrepreneur will then say *no* iff $b_h \leq v_e$. But incumbent $j \neq d$ will have the incentive to deviate to $b' = v_e + \varepsilon$ in Stage 1, since $v_{ie} > v_e$. This contradicts the assumption that b is a Nash equilibrium.

Regime 3: Consider equilibrium candidate $\mathbf{b}^* = (b_1^*, b_2^*, ..., yes)$. Then, $b_w^* \geq v_{ii}$ is a weakly dominated strategy. Also $b_w^* < v_{ii} - \varepsilon$ is not an equilibrium since firm $j \neq w, e$ then benefits from deviating to $b_j = b_w^* + \varepsilon$, since it will then obtain the assets and pay a price lower than its valuation of obtaining them. If $b_w^* = v_{ii} - \varepsilon$, and $b_s^* \in [v_{ii} - \varepsilon, v_{ii} - 2\varepsilon]$, then no incumbent has an incentive to deviate. By deviating to *no*, the entrepreneur's payoff decreases, as she foregoes a selling price exceeding her entry valuation v_e. Accordingly, the entrepreneur has no incentive to deviate and thus, b^* is a Nash equilibrium.

Let $b = (b_1, ..., b_n, no)$ be a Nash equilibrium. The entrepreneur will then say *no* iff $b_h \leq v_e$. But incumbent $j \neq e$ will then have the incentive to deviate to $b' = v_e + \varepsilon$ in Stage 1, since $v_{ie} > v_e$. This contradicts the assumption that $\mathbf{b}$ is a Nash equilibrium.

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Stage 1. Project choice:

*The entrepreneur chooses a project p
(projects that are more likely to succeed give lower
reductions in fixed operation costs)*

Entrepreneur, e

p

Entrepreneur, e

Stage 2: Commercialization decision
*The entrepreneur can sell the project to an
incumbent firm, or keep it (and potentially
enter the product market in stage 3)*

Sell

$(l = i)$

Keep

$(l = e)$

**Stage 3: Project uncertainty
resolved**

*Project p is revealed to be a
success or failure for the
possessor.*

Success

Failure

Success

Failure

Entrepreneur, e

*(Entrepreneur can enter with
successful project)*

Enter

Not enter

Stage 4. Oligopoly market;

*Product-market interaction
between firms on the market*

$\mathcal{I} = \{1, 2, .., i, ..., n\}$

$\mathcal{J} = e \cup \mathcal{I}$

$\mathcal{I} = \{1, 2, .., i, ..., n\}$

(taxes paid on profits and income)

Figure 1

Figure 2

(i) Commercialization by entry versus sale

Net reward

$v_e(p_E^*)|_{t=0}$

C

$v_{ii}(p_S^*)$

$v_e(p_E^*)$

0 t^{ED} t^C τ tax rate, t

(ii) Optimal project choice

Project, p

1

p^{opt}

$p_E^* = \arg\max_p v_e(p)$

ED   C

$\hat{p}$

$p_S^* = \arg\max_p v_{ii}(p)$

R1   R2   R3

0

0 t^{ED} t^C τ tax rate, t

(iii) Commercialization mode and optimal project

Valuations

$v_e(p_E^*)|_{t=0}$

$v_{ie}(p_S^*)$

ED

$v_{ie}(p^{opt})$

$p^{opt}[\pi(i) - \pi(e)]$ {

C

$v_{ii}(p^{opt})$

$v_{ii}(p_S^*)$

$v_e(p^{opt})$

Entry:

Sale:
$S^* = v_e$

Sale:
$S^* = v_{ii}$

0 t^{ED} t^C τ tax rate, t

Figure 3

Expected consumer surplus

E^{CS}

S^{CS}

$E[CS(i,p_S^*)]$

S

(i) Project choices and expected consumer surplus

$E[CS(e,p)]$

E_1

$E[CS(i,p)]$

$E[CS(e,p_{E_1}^*)]$

$\bar{CS}$

0

0   p_S^{CS} p_E^{CS} $p_{E_1}^*$ 1 p

Marginal expected profit

$\dfrac{dE[\pi_A(i,p)]}{dp} - \dfrac{dE[\pi_{NA}(i,p)]}{dp}$

(ii): The entrepreneur's choice of project

$p\dfrac{d\pi_E(e,p)}{dp}$

0   S

$G - \dfrac{t_1}{(1-t_1)}I$

0   p_S^* $p_{E_1}^*$ 1 p

E_1

$\dfrac{dE[\pi_E(e,p_E^*)]}{dp} = 0$

Figure 4