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Entrepreneurial innovations and taxation[1]

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Abstract

In many countries entrepreneurship is promoted through tax reductions for small businesses and by various government support schemes. We analyze the effects of such policies to subsidize small businesses in a setting where both the risk-return characteristics of the selected innovation project and the mode of commercialization chosen by entrepreneurs (market entry versus sale to an incumbent firm) are endogenous. We show that government programs to support small businesses foster market entry by entrepreneurs but, at the same time, give an incentive to choose low risk projects, due to the existence of limited loss offset provisions. This points to a basic trade-off between the goals of raising competition in technology-intensive markets and the desire of governments to foster risky 'breakthrough' innovations.

Keywords: business taxation, innovation, market entry

JEL Classification: H25, L13, M13, O31

1 Introduction

In the last few decades, entrepreneurship has emerged as a key issue in the policy arena.[1] In the European Union, for instance, the Commission launched the "Small Business Act for Europe" in June 2008, which explicitly recognizes the central role of small and medium-size enterprises (SMEs) in the EU economy and sets out a comprehensive policy framework for the EU and its member states. Among other measures, the Commission proposes that member states should create an environment that rewards entrepreneurship, and specifically mentions taxation in this context.[2]

One of the main reasons for the support of entrepreneurship comes from the important role they play as providers of "breakthrough" inventions. Baumol (2002), 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 breakthrough inventions whereas large, established firms provide more routinized R&D.[3] The importance of the level of riskiness in firms' R&D strategies and its relation to firm type is illustrated in a recent study by Henkel et al. (2010). They undertake a qualitative empirical study of the electronic design automation (EDA) industry, which is characterized by three large incumbents and numerous start-ups. The authors 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).

At the same time, during the last few decades a substantial share of these breakthrough inventions has been commercialized through sales to incumbent firms. Blonigen and Taylor (2000, Table 1) report that high-technology industries have been responsible for

[1] *The Economist* (14th March 2009) recently published a special report on entrepreneurship, "Global Heroes", describing this phenomenon.

[2] See Commission of the European Communities (2008). The Small Business Act applies to all companies which are independent and have less than 250 employees, representing 99% of all European businesses.

[3] See also Scherer and Ross (1990) who list a large number of break-through inventions made by independent innovators and state that "new entrants without a commitment to accepted technologies have been responsible for a substantial share of the really revolutionary new industrial products and processes"(p. 653). The authors refer to a large number of studies indicating the importance of entrepreneurs as providers of breakthrough inventions.

a disproportionately large share of firm acquisitions in the U.S. manufacturing sector during the 1990s. For example, the industries of electronic/electrical equipment and medical/photographic equipment accounted only for 3.1% and 2.2% of all U.S. manufacturing firms during this period, but made up 8.9% and 10.2% of all manufacturing acquisitions.

Entrepreneurs typically face different taxes and subsidies when entering the product market and when selling the invention. Many start ups choose incorporation and are thus subject to corporate income taxation, whereas entrepreneurs selling out to incumbent firms are typically liable to personal income taxation on the capital gains earned. As corporate tax rates have fallen significantly below personal income taxes during the last decades, this constitutes a first important tax advantage in favor of market entry.[4] Moreover, to support entrepreneurship, many countries grant special tax provisions to small businesses. Table 1 collects data for several OECD countries that offer small, incorporated businesses reduced corporate tax rates on their profit income below a certain threshold (see OECD, 2010a). Finally, governments provide various support schemes to start-ups and small businesses that cover all stages of the firms' development, ranging from initial research grants to the provision of subsidized loans and state guarantees to spur firm growth (see Lerner 1999, Table 1 for the United States, and OECD, 2010b). Taken together these provisions imply that an entrepreneur will typically face lower taxes and higher subsidies if she enters the market herself, as compared to the alternative of selling her innovation to an incumbent firm.

The above-mentioned developments suggest that it is important for a study of government support schemes to small businesses to endogenize both the project choice of the entrepreneur and the mode of commercializing the entrepreneurial innovation. This is the main purpose of the present paper. We study how the system of taxes and subsidies influences the risk-return characteristics of entrepreneurial R&D projects, and how it affects the entrepreneur's decision of whether to enter the market herself, or sell the innovation to an incumbent firm. Hence, government policy influences both the potential of entrepreneurs to make breakthrough inventions, and the market structure in imperfectly competitive markets characterized by technological innovations.

[4]The degree of incorporation differs substantially across countries, as a result of diverging national regulations, for example with respect to minimum capital requirements for corporation. The evidence also suggests, however, that incorporation has risen, on average, in response to falling corporate tax rates (de Mooij and Nicodème, 2008).

Table 1: Small business corporate tax rates (2010)[a]

country	regular tax rate (%)	small business tax rate (%)	amount of tax-favored income[b]
Belgium	34.0	25.0	Euro 25.000
Canada	29.5	15.5	CND 500.000[c]
France	34.4	15.0	Euro 38.000
Hungary	19.0	10.0	HUF 50 million
Japan	39.5	25.5	Yen 8 million
Korea	24.2	11.0	KRW 200 million
Netherlands	25.5	20.0	Euro 200.000
Spain	30.0	25.0	Euro 120.000
United Kingdom	28.0	21.0	GBP 300.000
United States	39.2	20.2	USD 50.000

[a] Combined tax rates of all levels of government.

[b] Corporate income to which small business tax rate is applicable. Total income of the SME may exceed this amount, as long as firm size remains below critical thresholds (number of employees, turnover etc.)

[c] Only for Canadian-controlled private corporations.

Sources: OECD Tax Database (2010a); Canada Revenue Agency (www.cra.gc.ca)

Our analysis is based on the following model. In the first stage, the entrepreneur makes an investment and chooses among projects with different risk and return characteristics associated with developing the invention. In the second stage, before the success of the project is revealed, the investor decides to either sell her invention to one of the incumbent firms in the market, or to enter the market herself. These decisions are influenced by the tax system. If the project is successful, the entrepreneur will benefit from lower taxes and additional government support when entering the market herself. If the project fails, however, the entrepreneur will not be able to claim a loss offset, as no profits are generated from which R&D spending can be deducted. In contrast, when the project is sold to an incumbent firm the investment outlays are always tax-deductible, because incumbents have other profits from which to deduct R&D expenses. In a setting with competitive bidding by incumbents this tax advantage will be reflected in a higher sales price offered to the entrepreneur. In the third stage, the uncertainty is lifted. If the investor has decided not to sell her patent and if the invention is successful, she will enter the market. In the final stage, there is competition between all active firms in the market, with or without the entrepreneur and with one firm possibly having access to a superior technology.

The results of our analysis reveal two different effects of tax policy. On the one hand, tax concessions and subsidies confined to small businesses make market entry by the entrepreneur more likely in equilibrium, fostering competition in these markets. At the same time, however, the entrepreneur's project choice is distorted whenever she produces for market entry. In particular, when the rate of effective profit taxation is not too low, the entrepreneur will choose an inefficiently low-risk project in order to minimize the risk of being left with non-deductible investment outlays. This points to a basic policy conflict between the goals of raising competition in technology-intensive markets, and the desire of governments to foster risky 'breakthrough' inventions.

In our benchmark model, innovations affect only the fixed costs of production. In an extension, we show that allowing for variable cost reductions as a result of a successful innovation strengthens the importance of an efficient project choice among entrepreneurs. This may lead to consumers favoring the sale of the entrepreneurial innovation to incumbent firms, despite the higher market concentration that this entails.

Our model brings together two different strands in the literature. First, there is a relatively small yet established public finance literature that analyzes the effects of taxes on various decision margins of entrepreneurs.[5] An early contribution is Poterba (1989) who critically discusses the view that reducing capital gains taxes is an efficient way of promoting entrepreneurship. Several contributions in this literature focus on the progressiveness of the personal income tax schedule as an obstacle to entrepreneurial activity (Gentry and Hubbard, 2000, 2005; Asoni and Sanandaji, 2009). In contrast, Gordon (1998) and Cullen and Gordon (2007) stress that start-up enterprises have the option of incorporating and thus benefiting from the fall in corporate tax rates over the last few decades. This shifts the focus of attention from the progressiveness of the income tax schedule to the imperfectness of loss offset provisions under the corporate income tax. Fuest et al. (2002) show that the existence of a positive tax gap between the personal income tax and the corporation tax favors equity finance and counteracts a distortion in the firms' financial decision arising from asymmetric information. 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. Egger et al. (2009) analyze the incorporation decision of entrepreneurs and provide empirical evidence that higher personal income taxes favor incorporation, whereas higher corporate tax rates reduce the probability of incorporating. Finally, Ernst and Spengel (2011) empirically determine that both R&D tax credits and corporate tax reductions increase the number of patent applications. None of these papers, however, incorporates a choice between different R&D projects to be undertaken, nor the option for the entrepreneur to sell her invention to an incumbent.

Second, 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.[6] 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), and Bianchi and Henrekson (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 and incumbent innovations and abstracts from tax policies, which are central to the present study.

[5] See Henrekson and Sanandaji (2011) for a recent survey.

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

This paper is organized as follows. Section 2 presents the general framework of 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 R&D project choice of the entrepreneur and on her commercialization mode. Section 5 analyzes a model extension where the innovation reduces variable costs of production. Section 6 discusses several other model extensions. 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. To focus on entrepreneurs as providers of breakthrough inventions, we assume that the incumbent firms do not innovate.[7] The sequence of events in our benchmark model is depicted in Figure 1.

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

In Stage 1, the entrepreneur makes a fixed monetary investment I in risky research and development (R&D) in order to develop an invention. We suppose there to be 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.[8]

[7]See Gromb and Scharfstein (2002) and Färnstrand Damsgaard et al. (2010) for models where innovation takes place both in start-ups and in established firms.

[8]Hence, we eliminate the well-known effect that taxes may stimulate entrepreneurial risk-taking

Our benchmark model assumes that a successful invention of type k 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 that the product market price does not depend on the chosen project.[9] 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.[10]

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. The upper panel of Figure 2 illustrates the payoffs of different projects in terms of expected fixed costs reductions.[11]

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

As shown in Figure 2(i), there is a unique project with success probability $0 < \hat{p} < 1$ that maximizes the expected payoff of 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 'socially efficient' project. It is instructive to compare the project type chosen by the entrepreneur in equilibrium with this socially efficient project. More formally, we introduce

Definition 1: *The socially 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

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.

[9] In Section 5 we consider the more general case where the invention reduces variable production costs.

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

[11] The lower panel of Figure 2 will be discussed in Section 3.4 below.

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, in the sense of facing lower fixed production costs.

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 tax rate faced by the entrepreneur when she decides to enter the market herself, whereas τ gives the tax rate that is applicable on the income she receives when selling the project to an incumbent firm. For the reasons given in the introduction, our analysis is based on a policy setting where $t^e \leq \tau$ and there is a tax advantage from market entry. We assume that entrepreneurs incorporate their business when producing for market entry.[12] Hence t^e represents an effective corporate tax rate for the entrepreneur, which incorporates reduced tax rates for incomes below a certain threshold (see Table 1) and government programs to subsidize the commercialization of innovations in small, high-tech firms. On the other hand, we assume that an entrepreneur who produces for sale will not incorporate her business and will thus be subject to the capital gains tax rate τ.[13] This equals the marginal individual income tax rate in some countries, whereas other countries subject capital gains to lower tax rates than other forms of personal income. In any case, however, τ is very likely to exceed t^e.

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

[12]According to de Mooij and Nicodème (2008, Table 1), roughly 35% of all businesses in the European Union were incorporated during the period 1998-2003, with wide divergences across countries. Interestingly, however, the average share of incorporation was slightly higher among new firms than among established firms (36.8% vs. 35.7%), despite the fact that established firms are, on average, much larger. Moreover, selection effects can be clearly observed in the data. 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 29 795 start-ups). Among the incorporated start-ups, however, about 72% were high-growth firms, as compared to 34% high-growth firms in other groups. This indicates that successful innovators are substantially more likely to use incorporation (see Tillväxtanalys, 2010).

[13]In Section 6.3 we analyze an alternative setting where entrepreneurs that innovate for sale will also incorporate, but the sale to an incumbent is subject to transaction costs.

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.

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. Let the set of firms in the industry be $\mathcal{J} = e \cup \mathcal{I}$, where $\mathcal{I} = \{i_1, i_2 ... i_n\}$ is the set of identical incumbent firms and e is the entrepreneur. The owner of the invention is denoted by $l \in \mathcal{J}$. In the product market interaction, firm j chooses an action $x_j \in R^+$ to maximize its product market profit net of fixed costs, $\pi_j(x_j, \mathbf{x}_{-j}, l) - F_j$. This depends on its own and its rivals' market actions, x_j and $\mathbf{x}_{-j}$, the identity of the owner of the invention, l, and the fixed cost F_j to serve the market. If firm j owns the invention, and if the project is successful, its fixed cost is $F(p)$. All other firms have fixed production costs $\overline{F}$. This is also the fixed cost of the firm possessing the invention, in case the invention has failed.

We consider firm j's action x_j as setting either a quantity or a price. We assume that a unique Nash-Equilibrium $\mathbf{x}^*(l) = \{x_j^*(l), x_{-j}^*(l)\}$ exists at this stage, which is defined as:

$$(1 - t^l)\pi_j(x_j^*, x_{-j}^*, l) \geq (1 - t^l)\pi_j(x_j, x_{-j}^*, l), \quad \forall x_j \in R^+, \tag{3}$$

where t^l is the tax rate on each firm's profits, which may differ for incumbents $(l = i)$ and for the entrepreneur $(l = e)$. We assume product market profits to be positive.

From (3), we can define a reduced-form *product market profit* (before deduction of fixed costs) for a firm j, taking as given ownership l:

$$\pi_j(l) \equiv \pi_j[x_j^*(l), x_{-j}^*(l), l]. \tag{4}$$

Since incumbents $i_1, i_2, ..., i_n$ are symmetric before the acquisition takes place, we need only distinguish between two types of ownership of the invention: *entrepreneurial* ownership ($l = e$) and *incumbent* ownership ($l = i$). 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 basic oligopoly model of quantity competition in a homogeneous good, or the model of price competition with differentiated products.

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 ownership of the invention, the success or failure of the project will affect her decision to enter the market at this stage. We assume that there are entry costs G to the imperfectly competitive market, which are sufficiently high to render market entry unprofitable in the case of project failure.

There is a further consideration for the entry decision of the entrepreneur, which derives from the loss offset provisions for the initial investment outlays I under the corporation tax. 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.[14] 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. Since the tax credit on the investment outlays, tI, is thus lost in case of non-entry, this term must be included in the entrepreneur's receipts from entering the market. With this additional term, and using equation (1), the assumptions that specify the entry decision of the entrepreneur are formalized in:

Assumption A1: The entrepreneur receives a positive net profit from entering the market when the innovation is successful, $\pi(e) - [\bar{F} - \Gamma(p)] + tI - G > 0$, but the net profits from entry are negative when the innovation fails, $\pi(e) - \bar{F} + tI - G < 0$.

Assumption A1 implies that the entrepreneur will not enter the market when unsuccessful, as the receipts are insufficient to cover fixed production and entry costs. Hence, there will be $(n+1)$ firms in the final stage of the game only if the entrepreneur does not sell the invention in Stage 2, and if the project is successful. The second part in Assumption A1 also ensures that the initial market structure is stable, since no competitor can profitably enter the market given the existing technology with fixed costs $\bar{F}$ and entry cost G.

Note that our sequence of events implies that the entrepreneur cannot sell her firm after the uncertainty has been lifted. In Section 6.2 we will relax this assumption and show that if a sale has not already occurred in Stage 2, there will also be no post-uncertainty sale in Stage 3, no matter whether the project turns out to be successful or not.

[14] 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 (2006) for empirical evidence documenting the importance of unused tax credits among U.S. firms.

3.3 Stage 2: Commercialization

In Stage 2, there is an entry-acquisition game where the entrepreneur can decide whether to sell the invention to one of the incumbents or enter the market at the fixed cost G, knowing that this is profitable only when the project is successful. The commercialization process is depicted as an auction where n incumbents simultaneously post bids and the entrepreneur then 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 $\mathbf{b} = (b_1, ..b_i.., b_n) \in R^n$ 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 e. 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. The acquisition game is solved for Nash equilibria in undominated pure strategies. There is a smallest amount, ε, chosen such that all inequalities are preserved if ε is added or subtracted. To solve the commercialization game, it will be useful to define $\Delta_e(S)$ as the net gain for the entrepreneur of selling the invention at a sales price S, over the alternative of market entry.

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 produces 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. With these specifications, the entrepreneur's net gain from selling the invention at price S over the alternative of market entry is

$$\begin{aligned}\Delta_e(S) \quad = \quad & \underbrace{S - \tau\,(S - I)}_{\text{Net profit from sale}} \\ & -\{\underbrace{p[\pi(e) - \left(\overline{F} - \Gamma(p)\right) - G] - pt^e[\pi(e) - \left(\overline{F} - \Gamma(p)\right) - G - I]}_{\text{Net expected profit from entry}}\}. \quad (5)\end{aligned}$$

From (5), 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:

$$v_e(p) = \frac{(1-t^e)}{(1-\tau)} \left\{ p[\pi(e) - \big(\overline{F} - \Gamma(p)\big) - G] - \frac{(\tau - pt^e)}{(1-t^e)} I \right\} . \tag{6}$$

The reservation price v_e in (6) 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 capital gains tax τ that is due under sale.

Next, we turn to the incumbent firm's 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 reduced 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 ($l = e$) or it can be acquired by a rival incumbent firm ($l = i$). 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 market stage, irrespective of the ownership of the invention. The profits of incumbent firms are taxed at the rate t^i.[15] Finally, as discussed above, the sales price S is always tax-deductible for the acquiring firm. Denoting the *net gain* for an incumbent firm of acquiring the entrepreneur's invention at a certain price S by $\Delta_{il}(S)$ for $l = e, i$ then yields

$$\begin{aligned}
\Delta_{il}(S) \quad &= \quad \underbrace{p(1-t^i)\left[\underbrace{\pi(i) - (\overline{F} - \Gamma(p)) - S}_{\text{Profit with project}} - \underbrace{\big(\pi(l) - \overline{F}\big)}_{\text{Profit without project}}\right]}_{\text{Net expected value from a successful innovation}} \\
&\quad \underbrace{+(1-p)(1-t^i)\left[\underbrace{\pi(i) - \overline{F} - S}_{\text{Profit with project}} - \underbrace{\big(\pi(i) - \overline{F}\big)}_{\text{Profit without project}}\right]}_{\text{Net expected value from an unsuccessful innovation}} \\
&= (1-t^i)\left\{-S + p\Gamma(p) + p[\pi(i) - \pi(l)]\right\}, \qquad (7)
\end{aligned}$$

where we have expanded the right-hand side of (7) with $p\pi(i)$ to arrive at the final expression for $\Delta_{il}(S)$.

[15] 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.

From (7), we can define an incumbent firm's valuation as $v_{il} \equiv \max S$, $s.t$ $\Delta_{il}(S) \geq 0$. Solving for $\Delta_{il}(S) = 0$ gives $v_{il} = p\Gamma(p) + p[\pi(i) - \pi(l)]$ 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 $l = e$ and

$$v_{ie}(p) = p\Gamma(p) + p[\pi(i) - \pi(e)], \tag{8}$$

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.

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

$$v_{ii}(p) = p\Gamma(p). \tag{9}$$

Since the invention only affects fixed production costs, the preemptive value is in this case simply the expected fixed costs savings of the invention. Comparing (8) and (9), 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. These are summarized in Table 2. The following lemma can then be stated:

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

Proof: See the Appendix.

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

Table 2: The equilibrium ownership structure and the acquisition price

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

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 will be 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, which is below v_e in this regime. Hence, the equilibrium bid equals the reservation price of the entrepreneur. In Regime 3, the invention is also sold in equilibrium, but the price equals the competitive valuation v_{ii}. Since all incumbents are simultaneously willing to bid this price, it is also the equilibrium sales price in Regime 3, where one of the incumbents is drawn as the acquirer.

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 $v_{ie}(p) > v_e(p) > v_{ii}(p)$. If a coordination failure occurs, the entrepreneur may enter the market even though $v_{ie}(p) > v_e(p)$. This can be shown by extending the acquisition auction to allow for mixed strategy equilibria. In a mixed strategy equilibrium incumbents can bid $v_e(p)$ with some probability. There are then two possible outcomes. In the first, at least one incumbent bids $v_e(p)$ and an entry deterring acquisition takes place. In the second, no incumbent bids for the project and the entrepreneur enters the market.

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. Since the rewards differ across regimes, the equilibrium project chosen by the entrepreneur has to be determined independently for each regime. Noting that investment costs I are independent of project choice, the entrepreneur simply 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

$$\Omega^*(p) = \begin{cases} (1-t^e)p\,[\pi(e) - (\bar{F} - \Gamma) - G] - (1-pt^e)I \equiv (1-\tau)[v_e(p) - I] & \text{in R1} \\ (1-\tau)[v_e(p) - I] & \text{in R2} \\ (1-\tau)[v_{ii}(p) - I] & \text{in R3.} \end{cases} \tag{10}$$

Note that in Regime 1 the net reward equals the entrepreneur's net expected profit from entry, as given in the second line of eq. (5). By the construction of the reservation price v_e in (6), however, this is equal to the net reward in the (hypothetical) situation where the entrepreneur receives a sales price v_e and pays capital gains 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. (10), 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:

$$\Gamma(p_S^*) + p_S^* \Gamma'(p_S^*) = 0. \tag{11}$$

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 efficient 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 $\Omega^* = (1-\tau)[v_e(p) - I]$ 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

$$\Gamma(p_E^*) + p_E^* \Gamma'(p_E^*) = \underbrace{G - [\pi(e) - \overline{F}]}_{(+)} \underbrace{- \frac{t^e}{(1-t^e)} I}_{(-)} \ . \tag{12}$$

The two non-zero terms on the right-hand side of (12) show that in Regimes 1 and 2, the entrepreneur will not generally choose the efficient project $\hat{p}$ defined in (2). The first term on the RHS is positive from Assumption A1. Other things equal, this effect leads to the choice of a project that is more risky, relative to the one under sale. The reason is that by choosing a more risky project, the entrepreneur reduces the expected value of entry costs G, which must be paid only when the project is successful (and hence the entrepreneur enters the market). On the other hand, the second term on the RHS of (12) is negative for a positive level of the corporation tax. This effect arises because the entrepreneur cannot deduct her investment costs from tax in the case of project failure. Other things equal, this will induce her to choose a project with an inefficiently low level of risk. Note that this last effect is the stronger, the higher is the effective tax rate t^e faced by the entrepreneur in case of market entry.

The equilibrium project choices in the different regimes are shown in the lower panel (ii) of Figure 2. In Regime 3, the equilibrium project choice is at S. This is efficient as a small increase in the success probability p of the project would yield zero changes in expected fixed cost savings. The two possible cases that can arise in Regimes 1 and 2 are shown by the project choices E_1 and E_2, where the tax rates corresponding to these regimes are related by $t_1^e > t_2^e$. At E_1 the negative effect on the RHS of (12) dominates and the chosen level of p is too high, so that a decrease in the success probability of the project would generate additional expected costs savings. At E_2 the opposite is true and p should be raised in order to maximize expected cost savings from a social perspective.

4 The effects of tax policy

In this section, we analyze how the system of taxing and subsidizing entrepreneurial incomes affects the mode of commercialization and the project choice by the entrepreneur. We focus on exogenous variations in the effective rate of 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 capital gains tax rate τ, which is levied in the 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, relative to the entry costs G. This is formally stated in:

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

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 (6), yielding

$$v_e(p)|_{t=\tau} = p\Gamma + p[\pi(e) - \bar{F} - G] - \frac{t(1-p)}{(1-t)} I < v_{ii} = p\Gamma, \ \forall p \in [0,1], \tag{13}$$

where $p[\pi(e) - \bar{F} - G] < 0$ from Assumption A1. 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 both the entry costs G and the additional 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 tax rates are equal under the two alternative modes of commercialization.[16]

In the following, we therefore consider effective profit tax rates t for the entrepreneur, which range from zero to the capital gains 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 $v_e(p_E^*)|_{t=t^C} = v_{ii}(p_E^*)|_{t=t^C}$.*

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

[16] In this case, a trade-off for the commercialization decision of the entrepreneur can still arise, however, when selling the invention to the incumbents is associated with high transaction costs. This case is analyzed in Section 6.3 below.

Proposition 1 *: Assume that t^{ED} and t^C exist. Then: (i) commercialization by entry (Regime 1) occurs, if the effective rate of profit taxation is low, $t \in [0, t^{ED})$; (ii) commercialization by sale occurs at the sales price $S^* = v_e$ (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 $S^* = v_{ii}$ (Regime 3), if the profit tax rate is sufficiently high, $t \in [t^C, 1]$.*

Proposition 1, in turn, leads to a proposition describing how project choice depends on the tax rate. For this purpose, we need to introduce a further critical tax rate.

Definition 3: *Let $\tilde{t}$ be the tax rate where the entrepreneur just chooses the socially efficient project in Regimes 1 and 2, i.e.* $[\Gamma(p_E^*) + p_E^* \Gamma'(p_E^*)]|_{t=\tilde{t}} = 0$.

We then get:

Proposition 2 *: Suppose that Proposition 1 holds and $\tilde{t}$ exists. Then: (i) when the profit tax rate is very low, $t < \tilde{t} < t^C$, the entrepreneur chooses a project that has a lower success probability than the project that minimizes expected costs, $p^{opt} = p_E^* < \hat{p}$; (ii) for an intermediate range of tax rates $\tilde{t} < t < t^C$, the entrepreneur chooses a project with a higher success probability than the efficient one, $p^{opt} = p_E^* > \hat{p}$; (iii) for high tax rates $t > t^C$, the entrepreneur's project choice is efficient, $p^{opt} = p_S^* = \hat{p}$.*

Project choice and taxes. Let us first prove Proposition 2. Consider the effects of a change in t on project choice, taking as given how taxes affect the commercialization mode. Implicitly differentiating (11) in Regime 3 and (12) in Regimes 1 and 2 yields

$$\frac{dp^{opt}}{dt} = \begin{cases} \dfrac{-I}{(2\Gamma' + p_E^* \Gamma'')(1-t)^2} > 0 & \text{in R1, R2,} \\ 0 & \text{in R3,} \end{cases} \tag{14}$$

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

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

The upper panel of Figure 3 illustrates the relationship between the effective corporate tax rate t and the equilibrium project choice, as characterized by the success probability p. From Proposition 1 (and thus anticipating the proof below), Regime 1 arises for low effective corporate tax rates $t < t^{ED}$, Regime 2 arises for intermediate tax rates

$t^{ED} < t < t^C$, and Regime 3 arises for high tax rates $t > t^C$. To interpret panel (i) of Figure 3, recall from our discussion of eq. (12) that there are two counteracting effects, in general, which may cause the entrepreneur's project choice to differ from the efficient project $\hat{p}$. At $t = 0$ the negative effect on the RHS of (12) is absent and the chosen project is therefore unambiguously too risky. As t is increased, the success probability of the equilibrium project continuously rises throughout Regimes 1 and 2, $dp_E^*/dt > 0$ [see eq. (14)]. This is because the rise in t makes the deductibility of the initial investment outlays more valuable, but this deductibility can only be used when the project is successful. To determine at which tax rate the equilibrium project switches to one with too little risk, we solve for the tax rate $\tilde{t}$ where the right-hand-side of (12) equals zero. This yields

$$\tilde{t} = \frac{-[\pi(e) - \overline{F} - G]}{[I - (\pi(e) - \overline{F} - G)]} < 1. \tag{15}$$

Note that the numerator in (15) is positive since $\pi(e) - \overline{F} - G < 0$ from Assumption A1. For the same reason, the denominator is also positive and larger in absolute size than the numerator. Hence, there is a critical tax rate $\tilde{t} < 1$, beyond which a project with an inefficiently low risk is chosen, if the relevant valuation of the invention is v_e and thus the critical tax rate $\tilde{t}$ is still in Regimes 1 or 2. In Figure 3, we assume that this is indeed the case.

In Regime 3, the entrepreneur sells the invention at price $S^* = v_{ii}$ and the optimal project choice is independent of the effective profit tax rate, $dp_S^*/dt = 0$. Overall, therefore, the equilibrium level of p adjusts in a non-monotonous way to the profit tax rate t, rising continuously throughout Regimes 1 and 2 and then dropping to the efficient level $p_S^* = \hat{p}$ at the switch to Regime 3.

Commercialization mode and taxes. Let us now prove Proposition 1. Panel (iii) of Figure 3 depicts the valuations $v_e(p^{opt})$, $v_{ie}(p^{opt})$ and $v_{ii}(p^{opt})$ as functions of the profit tax rate t. All valuations incorporate the optimal project choice p^{opt}, which is given by

$$p^{opt} = \begin{cases} p_E^*, & t \in [0, t^C), \\ p_S^*, & t \in [t^C, 1]. \end{cases} \tag{16}$$

To see how the different valuations depend on the profit tax rate, we need to determine both the direct effect of t and the indirect effect through the optimal project choice

p^{opt} in (16):

$$\frac{dv_r(p^{opt})}{dt} = \underbrace{\frac{\partial v_r}{\partial t}}_{\text{direct effect}} + \underbrace{\frac{\partial v_r}{\partial p}\frac{dp^{opt}}{dt}}_{\text{indirect effect}} \qquad \forall\, r \in \{e, ie, ii\}. \tag{17}$$

We start by evaluating eq. (17) for the entrepreneur's reservation price v_e, as given in (6). In Regimes 1 and 2, which arise for $t < t^C$, the indirect effect in (17) is zero due to the envelope theorem, $\partial v_e/\partial p = 0$. In Regime 3, which occurs for $t > t^C$, the indirect effect is also zero because $dp^{opt}/dt = 0$ from eqs. (16) and (11). Hence, within each regime, only the direct effect $\partial v_e/\partial t$ is operative. Therefore:

$$\frac{\partial v_e(p^{opt})}{\partial t} = \frac{-p^{opt}}{(1-\tau)}\left\{\pi(e) - [\overline{F} - \Gamma(p^{opt})] - G - I\right\} < 0, \tag{18}$$

where the term in curly brackets is positive since the entrepreneur must earn a positive net reward on her investment when the project is successful. It follows that within each regime, the entrepreneur's reservation price $v_e(p^{opt})$ is monotonously falling in the profit tax rate t. This can be seen in panel (iii) of Figure 3.[17]

Let us now turn to the valuations of incumbents, v_{il}. The direct effect of t on both v_{ie} and v_{ii} is zero from (8) and (9), so we must have $\partial v_{il}/\partial t = 0$ in eq. (17). Then, note that the indirect effect in eq. (17) consists of the induced changes in project choice, as given in (14), and the incumbents' valuation of these changes, $\partial v_{il}/\partial p$.[18] The latter are relevant only in Regimes 1 and 2 and are given by

$$\frac{\partial v_{ie}}{\partial p} = \Gamma + p_E^*\Gamma' + \pi(i) - \pi(e), \qquad \frac{\partial v_{ii}}{\partial p} = \Gamma + p_E^*\Gamma'. \tag{19}$$

For low levels of taxes $t \in [0, \tilde{t})$, both of these terms are unambiguously positive from (12) and the assumption that $\pi(i) > \pi(e)$. As the profit tax rate rises beyond $\tilde{t}$, further increases in t (and thus p) have a negative effect on v_{ii} and an ambiguous effect on v_{ie}. At the switch to Regime 3 at $t = t^C$, there is a jump in the valuation of incumbents due to the discrete change in optimal project choice from eq. (16). Thus, as shown by panel (iii) of Figure 3, the competitive valuation $v_{ii}(p^{opt})$ is first increasing in t and reaches a local maximum in point B for $t = \tilde{t}$. It then decreases until the switch

[17] Note that the envelope theorem can only be used in Regimes 1 and 2, where the optimal project chosen by the entrepreneur is based on the maximization of v_e. Hence, if the project choice changes discretely at the tax rate t^C, the value of v_e may exhibit a jump at this point.

[18] The envelope theorem can *not* be applied to determine the effect of t on the incumbents' valuations, because the project is not chosen to maximize v_{ie} or v_{ii} in Regimes 1 and 2.

to Regime 3 at $t = t^C$, where v_{ii} jumps up to $v_{ii}(p_S^*) > v_{ii}(p_E^*)$. The takeover valuation $v_{ie}(p^{opt})$ has a similar overall pattern and will also exhibit a jump at $t = t^C$.

The equilibrium commercialization pattern is shown by panel (ii) of Figure 3. When the corporate tax rate is low, $t \in (0, t^{ED})$, the entry value v_e exceeds the incumbents' takeover valuation v_{ie}. 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, denoted 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 $S^* = v_e$. Other incumbents will not preempt a rival's acquisition in the range $t \in [t^{ED}, t^C)$, since the net value of preemption is negative, $v_{ii} - v_e < 0$. As t rises further, it reaches the second critical level, denoted $t = t^C$, where the entrepreneur's reservation value falls to the competitive valuation of the incumbent firms. This induces a bidding war between incumbents and results in Regime 3 where the sales price of the invention is fixed by the competitive valuation of the incumbents. Further increases in t continue to reduce the entry value of the entrepreneur, which falls to zero at $t^{max} < 1$ as a result of the fixed entry costs G. $\square$

The trade-off for tax policy. From Propositions 1 and 2, a basic trade-off for tax policy becomes apparent. Government policies that reduce the effective profit tax rate by granting reduced tax rates and capital subsidies to small businesses encourage market entry and foster competition. At the same time, however, the entrepreneur's choice of project will be distorted whenever she produces for entry.[19] As shown in panel (i) of Figure 3, when profit tax rates are in an intermediate range $t \in \{\tilde{t}, t^C\}$, 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. Very low tax rates $t < \tilde{t}$ would instead involve excessive risk-taking by entrepreneurs, but such low tax rates are often not feasible (or not desirable) for other reasons. In particular, if tax and subsidy discrimination in favor of small, entrepreneurial firms becomes very strong, this creates powerful incentives for larger firms to outsource some of their operations into small, independent units, in order to free-ride on these advantages.

[19] This is also true when a mixed strategy equilibrium results in Regime 2, as a result of a coordination failure between incumbents. Recall our discussion at the end of Section 3.3.

In contrast, when market entry by entrepreneurs is not placed at a tax advantage in comparison to selling the invention to an established firm, then market concentration remains high. However, entrepreneurs producing for sale at the competition valuation of incumbents will anticipate that their sales price incorporates a complete loss offset and hence, they will carry out projects with efficient risk and return characteristics. Thus, holding other instruments constant, government policy towards small firms has to make a choice between the goals of competition policy on the one hand, and fostering 'breakthrough' inventions on the other.

Finally, we briefly turn to the capital gains tax, which has so far been held constant. Differentiating v_e in (6) with respect to τ and noting that indirect effects through the choice of p are absent in all regimes yields

$$\frac{dv_e}{d\tau} = \frac{\partial v_e}{\partial \tau} = \frac{(1-t)p^{opt}[\pi(e) - (\overline{F} - \Gamma(p^{opt})) - G] - (1-pt)I}{(1-\tau)^2} > 0. \tag{20}$$

This is positive whenever the investment has a positive expected return, even if the asymmetric treatment of positive and negative income under the corporation tax is accounted for. Hence, an increase in τ shifts the graph of v_e upwards in panel (iii) of Figure 3, moving the cut-off tax levels t^{ED} and t^{C} to the right. This implies that an increase in the capital gains tax rate raises the likelihood that the innovator enters the market, by making it less attractive for her to sell the invention to incumbent firms. At the same time, however, optimal project choices are also affected by this shift. Accordingly, an increase in τ widens the range of effective corporate tax rates t for which the entrepreneur chooses an inefficient project in equilibrium.

5 Variable cost saving inventions

In our benchmark model, innovations only reduced the fixed costs of production but left the marginal costs unchanged. One implication of this is that consumers will always prefer commercialization by entry, even though this commercialization mode will typically lead to inefficient project choices (see Proposition 2). The reason is that market entry by the entrepreneur increases competition and lowers consumer prices. In contrast, the gains from an efficient project choice only accrue to the entrepreneur, but do not benefit consumers because product market choices will depend only on marginal costs.

A full analysis of the welfare effects of tax policy is outside the scope of this paper. In this section, we show, however, that if more risky projects are associated with larger reductions in variable costs (or improvements in quality), consumers may prefer commercialization by sale over commercialization by entry. For this purpose we briefly discuss how the analysis in the different stages of the game changes when variable cost reductions are allowed for.

Stage 4: Consider a situation where the invention reduces the variable cost, while fixed costs are ignored. Hence the gains from a more risky project in case of success are now given by larger variable cost savings for the possessor of the invention. Let the acquiring incumbent's product market profit for a successful invention be $\pi_A\left(i,p\right)$, where p is the project choice in Stage 1. Similarly, let the entrepreneur's profit when entering be $\pi_E\left(e,p\right)$ and let a non-acquiring incumbent's profit be $\pi_{NA}\left(l,p\right)$. We then introduce

Assumption A3: (i) $\dfrac{d\pi_A\left(i,p\right)}{dp} < 0, \quad \dfrac{d\pi_E\left(e,p\right)}{dp} < 0, \quad$ (ii) $\dfrac{d\pi_{NA}\left(l,p\right)}{dp} > 0, \quad l = \left\{e,i\right\}.$

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 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. These assumptions will, for instance, hold for a process innovation where a more risky innovation leads to a larger reduction in the marginal cost of selling and producing for the product market.

Stage 3: At this stage, it is again revealed whether the innovation turns out to be successful. We maintain Assumption A1 so that entry is only profitable if the project succeeds. Hence $\pi_E\left(e,p\right) - G + tI > 0$, but $\pi_E\left(e\right) - G + tI < 0$, where $\pi_E\left(e\right)$ denotes the profit the entrepreneur would attain under entry with a failed project.

Stage 2: At the commercialization stage, the entrepreneur's reservation price defined in (6) becomes:

$$v_e = \frac{(1-t)}{(1-\tau)}\left\{p[\pi_E(e,p) - G] - \frac{(\tau - pt)}{(1-t)}I\right\}, \tag{21}$$

where $\pi_E(e,p)$ is the profit of the entrepreneur under entry with project p.

The takeover valuation and the competitive valuations of an incumbent defined in (8) and (9) become

$$v_{ie} = p\left[\pi_A(i,p) - \pi_{NA}(e,p)\right], \qquad v_{ii} = p\left[\pi_A(i,p) - \pi_{NA}(i,p)\right], \tag{22}$$

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 $p\left[\pi_A(i,p) - \pi_{NA}(l,p)\right]$ are strictly concave in p, ensuring well-defined project choices. Introducing $E[\pi(l,p)] \equiv p\pi(l,p)$ as the expected value of the project, 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:

$$\frac{dE[\pi_E(e,p)]}{dp} = 0 \implies \pi_E(e,p_E^*) + p_E^* \frac{d\pi_E(e,p_E^*)}{dp} = G - \frac{t}{(1-t)}\,I\ . \tag{23}$$

As in our benchmark model [see eq. (12)] the entrepreneur's choice of project will deviate from the project that maximizes her expected product market profits $p\pi_E(.)$ by two effects: the existence of entry costs will make her more willing to choose a risky project, whereas the inability to deduct the investment costs from tax in case of failure will induce her to choose a safer project, other things being equal.

When innovating for sale under bidding competition in Regime 3, receiving the sale price $S^* = v_{ii}$ [see eq. (11)], the optimal project choice is given by

$$\frac{dE[\pi_A(i,p)]}{dp} - \frac{dE[\pi_{NA}(i,p)]}{dp} = \pi_A(i,p_S^*) + p_S^* \frac{d\pi_A(i,p_S^*)}{dp} - \pi_{NA}(i,p_S^*) - p_S^* \frac{d\pi_{NA}(i,p_S^*)}{dp} = 0. \tag{24}$$

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. (22)], 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 equilibrium project chosen in Regime 3 is very likely to be riskier than the project chosen in Regimes 1 and 2, no matter which of the counteracting effects on the RHS of (23) dominates in the latter regimes ($p_S^* < p_{E_2}^* < p_{E_1}^*$).

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

The effects of tax policy on consumers. Let us now examine how effective tax rates affect consumers through the entrepreneur's choice of project and the 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 effective taxes t and applying the envelope theorem, it is straightforward to show that Propositions 1 and 2 are also fulfilled 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 $p_S^{CS} = \arg\max_p[pCS(p,i)+(1-p)\bar{C}S]$ and $p_E^{CS} = \arg\max_p[pCS(p,e) + (1-p)\bar{C}S]$ from the perspective of consumers. Note that, because of imperfect competition in the product market, the interests of producers and consumers are generally not aligned in our model. As shown in panel (i) of Figure 4, the entrepreneur will therefore – regardless of entry mode – 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. If the new effective tax rate t_1 is larger than some tax rate $\hat{t}$, where $\hat{t}$ is the tax rate for which the RHS of (23) is zero, then 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, however, yields only limited reductions in variable costs, and hence consumer prices, in case it succeeds. A comparison of the points S and E_1 in Figure 4 (i) reveals that the expected consumer surplus will be lower under market entry than under sale, $E[CS(e, p^*_{E_1})] < E[CS(i, p^*_S)]$, even though the number of competitors is higher with market entry by the entrepreneur.

If, instead, the effective tax rate were further lowered to the level t_2, then the distorting effect of limited loss offset provisions would be mitigated and the entrepreneur would choose the project characterized by $p^*_{E_2}$. With this project choice, expected consumer surplus might then be higher under market entry than under sale, as shown by the comparison of the points E_2 and S. As we have discussed in the previous section, however, such large corporate tax reductions might not be desirable, because they create strong incentives for larger firms to free-ride on these tax advantages.

6 Discussion and further extensions

In this section, we discuss our results further by introducing several other extensions or modifications of our benchmark model.

6.1 Stage 0: Entrepreneurial choice of effort

An important aspect of entrepreneurial innovation not covered by our benchmark model is that a substantial share of the initial investment may consist of effort put in by the entrepreneur. We incorporate this aspect by introducing a zero stage of the game where the entrepreneur chooses an endogenous level of effort, denoted by ρ, in order to generate a basic innovative idea. We then study how taxes affect this choice variable.

The entrepreneur's effort level ρ determines the probability of succeeding with a basic invention that is necessary for being able to start an R&D project in Stage 1. For simplicity, assume that the probability of succeeding with a basic invention is simply the effort, i.e. $\rho \in [0, 1]$, and that effort is associated with an increasing and convex cost $y(\rho)$, i.e. $y'(\rho) > 0$, and $y''(\rho) > 0$. Efforts are not deductible when paying taxes. Then, let $\Omega^*(p^{opt})$ be the reduced-form expected profit given from equation (10). Define $\Pi = \rho\Omega^*(p^{opt}) - y(\rho)$ as the expected net profit of a basic invention. The optimal effort level ρ^* is then given from:

$$\frac{d\Pi}{d\rho} = \Omega^*(p^{opt}) - y'(\rho^*) = 0, \tag{25}$$

with the associated second-order condition $d^2\Pi/d\rho^2 = -y''(\rho) < 0$.

Applying the implicit function theorem in (25), we can state the following Lemma:

Lemma 2 *The equilibrium effort by the entrepreneur in stage 0, ρ^*, and hence the probability of succeeding with a basic invention, increases in the net reward for the invention, i.e. $d\rho^*/d\Omega^*(p^{opt}) > 0$.*

To determine the effects of taxes on the entrepreneur's effort level, we start with the effective corporate tax rate t. Note from eq. (10) that the reduced-form net reward is $\Omega^*(p_E^*) = (1-\tau)[v_e(p_E^*) - I]$ for $t \in [0, t^C]$, and $\Omega^*(p_S^*) = (1-\tau)[v_{ii}(p_S^*) - I]$ for $t > t^C$. The reservation price is decreasing in corporate taxes from eq. (18), whereas the competitive valuation of incumbents is independent of corporate taxes from eq. (17). Thus, it follows that an increase in corporate tax only decreases the incentives to provide effort when corporate taxes are so low that an equilibrium in Regime 1 or 2 results. In contrast, if corporate taxes are sufficiently high so that a sale takes place under bidding competition (Regime 3), the net reward is independent of corporate taxes. This is illustrated in Figure 5.

********* Figure 5 about here **********

Turning to the capital gains tax τ, differentiating the net reward $\Omega^*(p_l^*)$ in (10) with respect to τ, using (6) and once more noting that indirect effects through the choice of p are absent in all regimes yields

$$\frac{d\Omega^*(p_E^*)}{d\tau} = 0 \quad \text{for } \ t \in [0, t^C] \tag{26}$$

$$\frac{d\Omega^*(p_S^*)}{d\tau} = \frac{\partial\Omega^*(p_S^*)}{\partial\tau} = -[v_{ii}(p_S^*) - I] < 0 \quad \text{for } \ t > t^C. \tag{27}$$

Hence, an increase in the capital gains tax reduces the net reward for the innovation in Regime 3, but not in Regimes 1 and 2. Using Lemma 2, we can then summarize our results as follows:

Proposition 3 *Increased corporate taxes (in Regimes 1 and 2) and increased capital gains taxes (in Regime 3) reduce the effort to create innovative ideas.*

Proposition 3 shows that the disincentive effects of a particular tax on entrepreneurial effort will generally depend on the commercialization mode in our model. This complements existing results in the literature which have emphasized the effort-reducing effects of capital gains taxes, in particular, but not in a setting with an endogenous commercialization choice (e.g. Keuschnigg and Nielsen, 2004).

6.2 Post uncertainty sale

As illustrated in Figure 1, our benchmark model assumes that the entrepreneur can only sell the invention in Stage 2. Hence, we have ruled out the option for the entrepreneur to sell the invention after the uncertainty has been lifted in Stage 3. In this section, we demonstrate that such post-uncertainty sales will not occur in equilibrium.

If the project is revealed to be a success at the beginning of Stage 3, this information is private and cannot be credibly revealed to incumbents. The superiority of the entrepreneur's cost structure can only be verified in Stage 4, when the profits from product market interaction become public information through accounting laws and accounting standards. We proceed to show that if an acquisition has not occurred in Stage 2, there will not be an acquisition post-uncertainty in Stage 3. We assume that the acquisition auction in Stage 3 is once more a first-price perfect information auction with externalities and solve for Nash equilibria in undominated pure strategies. The entrepreneur's net gain from selling the invention at price S over the alternative of market entry is now

$$\begin{aligned} \Delta_e(S) \;&=\; \underbrace{S - \tau\,(S - I)}_{\text{Net profit from sale}} \\ &\quad - \{\underbrace{[\pi(e) - \left(\overline{F} - \Gamma(p^*)\right) - G] - t[\pi(e) - \left(\overline{F} - \Gamma(p^*)\right) - G - I]}_{\text{Net expected profit from entry}}\}. \qquad (28) \end{aligned}$$

Solving for $\Delta_e(S) = 0$, we obtain the reservation price post-uncertainty in Stage 3:

$$w_e(p) = \frac{(1-t)}{(1-\tau)} \left\{ [\pi(e) - \left(\overline{F} - \Gamma(p^*)\right) - G] - \frac{(\tau - t)}{(1-t)} I \right\}. \qquad (29)$$

Comparing (29) and (6) shows that $w_e(p) > v_e(p)$: the reservation price of the entrepreneur has risen because the success probability is one from her point of view. However, incumbents cannot infer the quality of the project so that their valuations remain at v_{ie} and v_{ii}, as defined in (8) and (9). If no acquisition occurred in Stage 2, this implies that $v_e > v_{ie} > v_{ii}$. But then, an acquisition in Stage 3 cannot be profitable from $w_e(p) > v_e$.

6.3 Innovation for sale and incorporation

We have assumed that entrepreneurs that innovate for sale never incorporate. In practice, we observe that some entrepreneurs incorporate before selling their invention. What would be the effect of allowing entrepreneurs that innovate for sale to incorporate, in order to face a lower tax rate?

For analytical simplicity, we focus on the extreme case where tax rates are identical when innovating for market entry or for sale, i.e. $t = \tau$.[20] In order to still have a trade-off between market entry and sale in this case, we add a tax-deductible transaction cost T for incumbents when acquiring. This cost could correspond to, for instance, legal fees and due diligence.

An incumbent's net gain then becomes:

$$\begin{aligned}\Delta_{il}(S) \quad = \quad & \underbrace{p(1-t^i)\left[\underbrace{\pi(i) - (\overline{F} - \Gamma(p)) - S}_{\text{Profit from buying}} - T - \underbrace{\left(\pi(l) - \overline{F}\right)}_{\text{Profit from not buying}}\right]}_{\text{Net expected value from a successful innovation}} \\ & \underbrace{+(1-p)(1-t^i)\left[\underbrace{\pi(i) - \overline{F} - S}_{\text{Profit from buying}} - T - \underbrace{\left(\pi(i) - \overline{F}\right)}_{\text{Profit from not buying}}\right]}_{\text{Net expected value from an unsuccessful innovation}} \\ & = (1-t^i)\left\{-S - T + p\Gamma(p) + p[\pi(i) - \pi(l)]\right\}. \end{aligned} \tag{30}$$

Then, use that an incumbent firm's valuation is $v_{il} \equiv \max S$, $s.t\ \Delta_{il}(S) \geq 0$. Solving for $\Delta_{il}(S) = 0$ gives $v_{il} = p\Gamma(p) + p[\pi(i) - \pi(l)] - T$ as the maximum price S at which an incumbent firm is willing to buy the entrepreneur's invention. The takeover valuation and the competition valuation are

$$v_{ie}(p) = p\Gamma(p) + p[\pi(i) - \pi(e)] - T, \qquad v_{ii}(p) = p\Gamma(p) - T. \tag{31}$$

[20]Hence the specification in this section ignores the fact that some of the tax breaks or subsidies are only available for entrepreneurs when they actually enter the market.

Note that the fixed cost T has no effect on the optimal project choices in eq. (16). Hence, the entrepreneur's reservation price is once more given by (6), which simplifies to

$$v_e(p)|_{t=\tau} = p\Gamma + p[\pi(e) - \bar{F} - G] - \frac{t(1-p)}{(1-t)}\, I. \tag{32}$$

It then directly follows from eqs. (31)-(32) that if transaction costs T become sufficiently large, the reservation price of the entrepreneur will be higher than incumbents' valuations, even if $t = \tau$. This holds in equilibrium when we incorporate optimal project choices, which are unaffected by transaction costs and given in eq. (16).[21] Hence, when the entrepreneur produces for entry, she will still choose an inefficient project. Moreover, the equilibrium project is again more likely to bear too little risk, if the tax rate t is sufficiently high and the effect of incomplete loss offset provisions is thus important.

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 policies. These are the decision of the entrepreneur to choose between projects with different risk and return characteristics, and her decision of how to commercialize the innovation. In this framework government policies to support small, technology-intensive businesses by means of reduced corporate tax rates and various subsidy programs promote market entry by entrepreneurs over the alternative of selling out the innovation to incumbent firms. At the same time, however, the entrepreneur's choice of innovation project will be distorted whenever she produces for entry, due to the existence of both limited loss offset provisions and market entry costs. This points to a basic trade-off for the government between an entry-promoting competition policy in technology-intensive markets, and the goal of fostering innovations that maximize expected cost reductions. The importance of entrepreneurs making socially efficient project choices is greatest in a setting where innovations lead to reductions in variable costs, so that cost savings are passed on to consumers in the industry equilibrium.

Our analysis holds several testable implications. As corporate tax reductions have been enacted in many countries over the last two decades and incentive schemes for small

[21] This can be illustrated in panel (iii) of Figure 3, where transaction costs would merely shift down the locus of the takeover valuation $v_{ie}(p^{opt})$ and the competitive valuation $v_{ii}(p^{opt})$.

businesses have proliferated, there has been a rising tax 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. At the same time, these development should have led to less risky - and perhaps also smaller - innovation projects.

Our results can be contrasted with existing policies to support entrepreneurship in the European Union and elsewhere. Existing EU policies, for example, focus to a large extent on fostering the growth of small firms, as exemplified in the Small Business Act for Europe (Commission of the European Communities, 2008). At the same time, there is a relative lack of policies stimulating ownership transfers to large established firms. Such a policy focus is appropriate when the welfare losses to consumers primarily arise from market imperfections. However, the same policy might be counterproductive when the welfare losses to consumers instead mostly arise from distorted project choices by entrepreneurs. In this case, the appropriate policy is to improve the market for mergers and acquisitions by ensuring an effective bidding competition for target firms. This could be achieved by making the tax system more neutral with respect to the choice of retaining or selling a firm, and by improving the legal system to reduce the transaction costs for a sale to incumbent firms.

Finally, it should be emphasized that our analysis is but a first step towards a more comprehensive study of the effects of public policies on the market for entrepreneurial innovations. A first limitation of our analysis is the lack of an explicit welfare analysis, where the competing government objectives are integrated in a unified welfare-theoretic framework. As a consequence, we have not derived optimal policies towards entrepreneurship in this paper. A further important restriction is that our analysis has been static in nature, even though a core reason for the support of entrepreneurial innovations is their growth-promoting effect. We leave the analysis of these and other extensions to future research.

Appendix: Proof of Lemma 1

First, note that $b_i \geq \max v_{il}$, $l = \{\text{e}, \text{i}\}$ 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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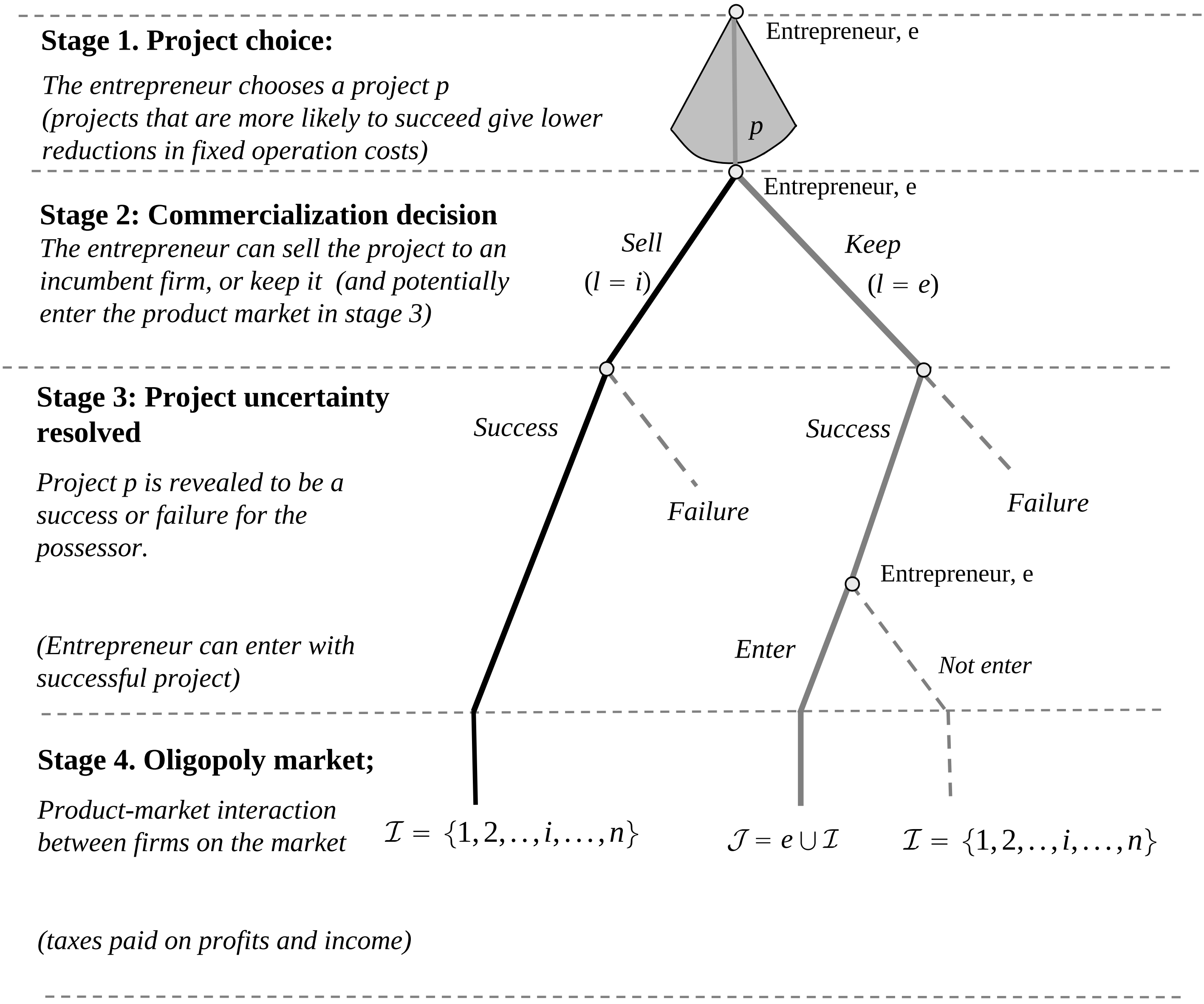

Stage 1. Project choice:
The entrepreneur chooses a project p
(projects that are more likely to succeed give lower reductions in fixed operation costs)
Entrepreneur, e
p
Stage 2: Commercialization decision
The entrepreneur can sell the project to an incumbent firm, or keep it (and potentially enter the product market in stage 3)
Entrepreneur, e
Sell
($l = i$)
Keep
($l = e$)
Stage 3: Project uncertainty resolved
Project p is revealed to be a success or failure for the possessor.
(Entrepreneur can enter with successful project)
Success
Failure
Success
Failure
Entrepreneur, e
Enter
Not enter
Stage 4. Oligopoly market;
Product-market interaction between firms on the market
(taxes paid on profits and income)
$\mathcal{I} = \{1, 2, .., i, ..., n\}$
$\mathcal{J} = e \cup \mathcal{I}$
$\mathcal{I} = \{1, 2, .., i, ..., n\}$

Figure 1

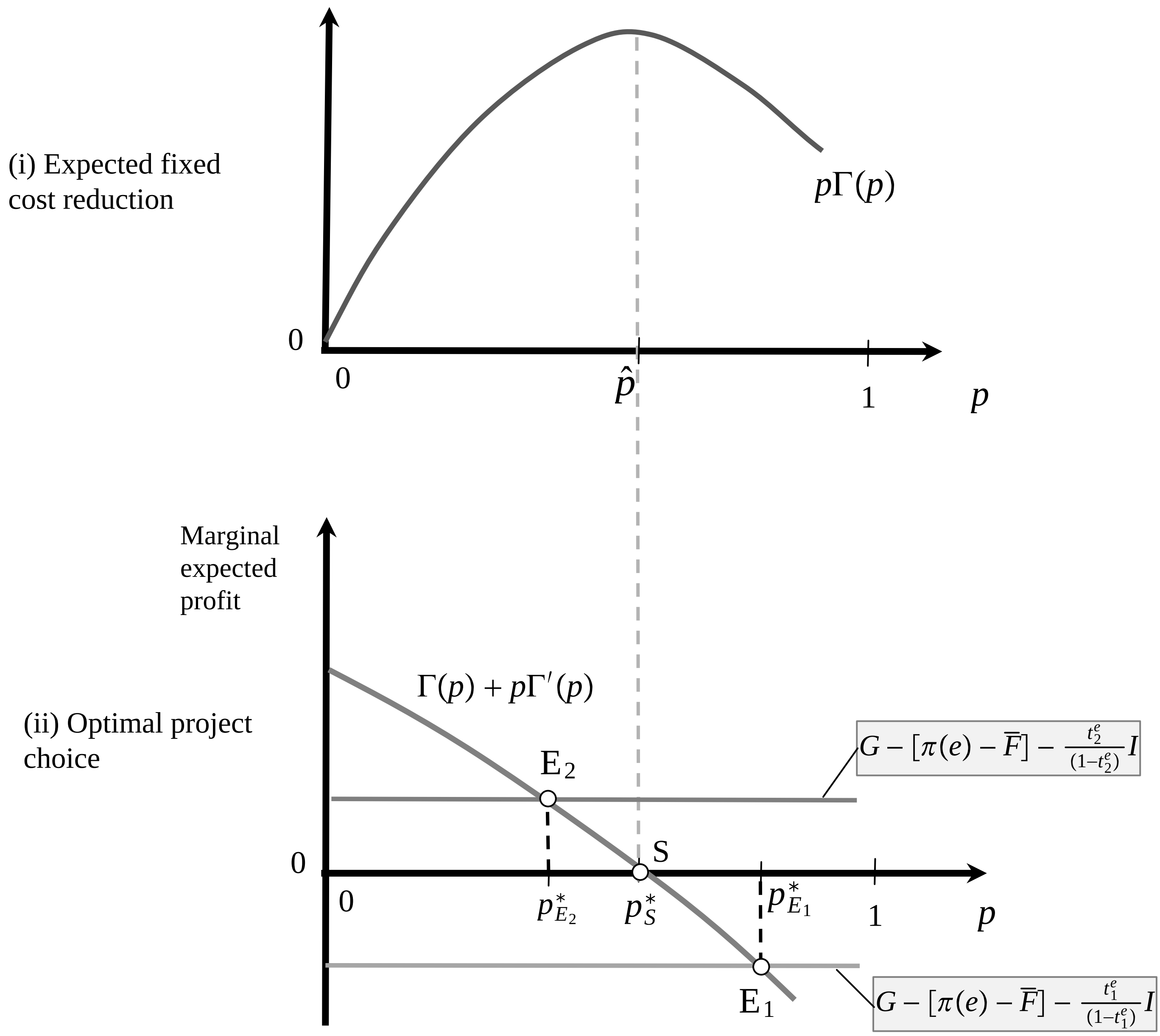
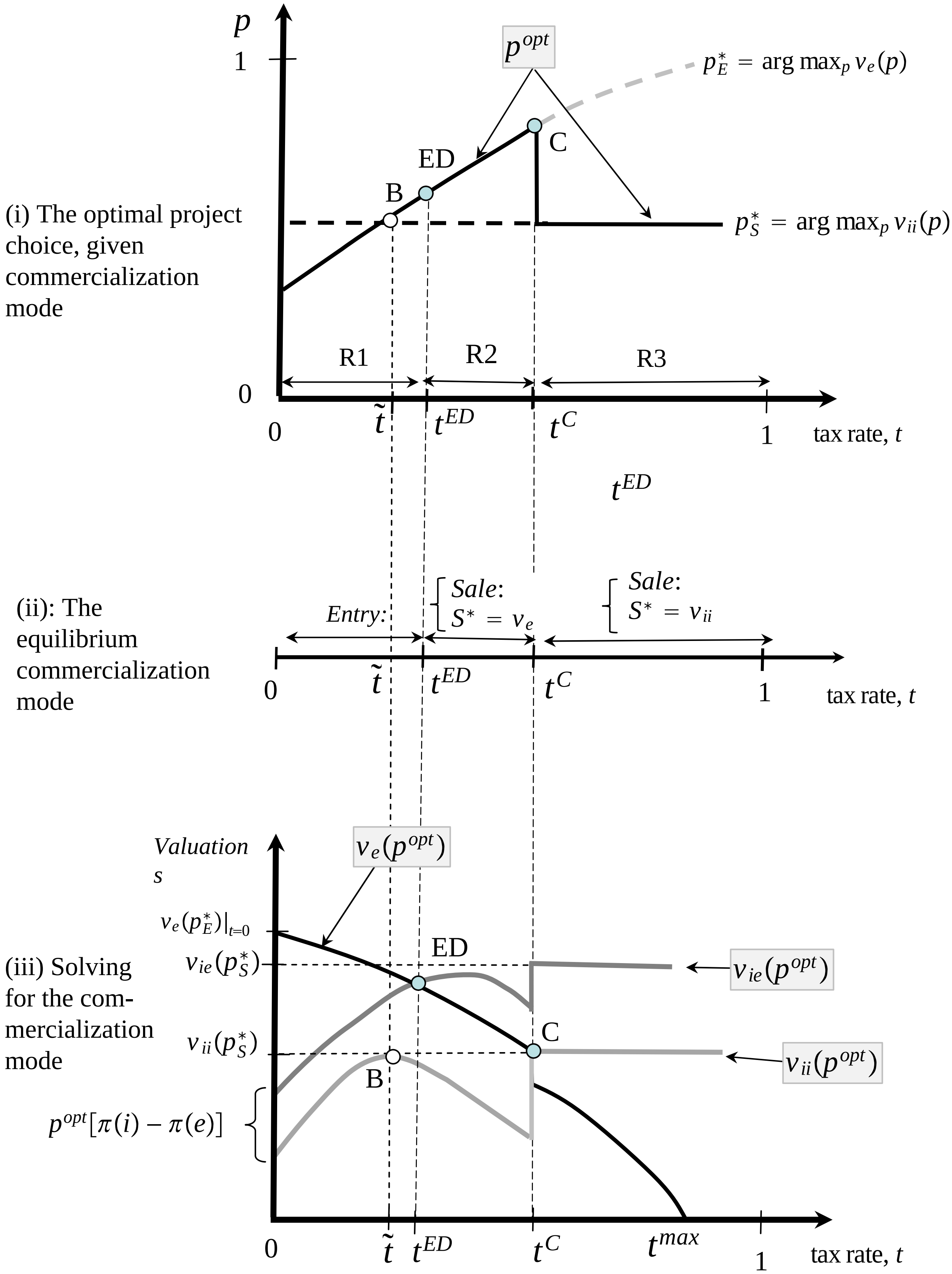

(i) Expected fixed cost reduction
$p\Gamma(p)$
0
0
$\hat{p}$
1
p
Marginal expected profit
(ii) Optimal project choice
$\Gamma(p) + p\Gamma'(p)$
E_2
$G - [\pi(e) - \overline{F}] - \frac{t_2^e}{(1-t_2^e)}I$
0
S
0
$p^*_{E_2}$
p^*_S
$p^*_{E_1}$
1
p
E_1
$G - [\pi(e) - \overline{F}] - \frac{t_1^e}{(1-t_1^e)}I$

Figure 2



p
1
p^{opt}
$p_E^* = \arg\max_p v_e(p)$
C
ED
B
(i) The optimal project choice, given commercialization mode
$p_S^* = \arg\max_p v_{ii}(p)$
R1
R2
R3
0
0
$\tilde{t}$
t^{ED}
t^C
1
tax rate, t
t^{ED}
(ii): The equilibrium commercialization mode
Entry:
Sale: $S^* = v_e$
Sale: $S^* = v_{ii}$
0
$\tilde{t}$
t^{ED}
t^C
1
tax rate, t
Valuations
$v_e(p^{opt})$
$v_e(p_E^*)|_{t=0}$
ED
$v_{ie}(p_S^*)$
$v_{ie}(p^{opt})$
(iii) Solving for the commercialization mode
$v_{ii}(p_S^*)$
C
$v_{ii}(p^{opt})$
B
$p^{opt}[\pi(i) - \pi(e)]$
0
$\tilde{t}$
t^{ED}
t^C
t^{max}
1
tax rate, t

Figure 3

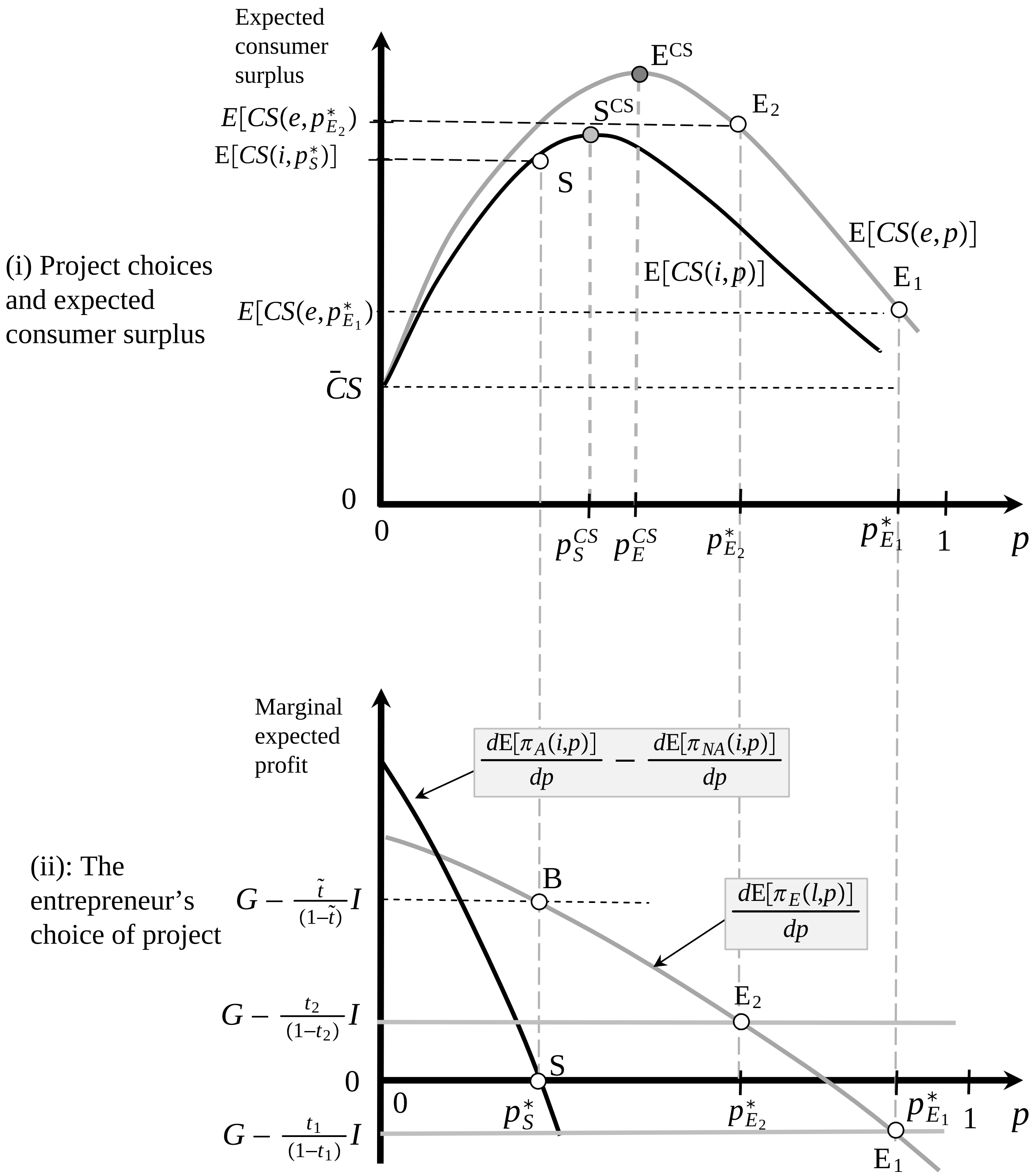

Expected consumer surplus
(i) Project choices and expected consumer surplus
$E[CS(e,p^*_{E_2})$
$\mathrm{E}[CS(i,p^*_S)]$
$E[CS(e,p^*_{E_1})$
$\bar{C}S$
0
E^{CS}
S^{CS}
E_2
S
$\mathrm{E}[CS(e,p)]$
$\mathrm{E}[CS(i,p)]$
E_1
0
p_S^{CS}
p_E^{CS}
$p^*_{E_2}$
$p^*_{E_1}$
1
p
Marginal expected profit
(ii): The entrepreneur's choice of project
$\frac{d\mathrm{E}[\pi_A(i,p)]}{dp} - \frac{d\mathrm{E}[\pi_{NA}(i,p)]}{dp}$
$\frac{d\mathrm{E}[\pi_E(l,p)]}{dp}$
$G - \frac{\tilde{t}}{(1-\tilde{t})}I$
$G - \frac{t_2}{(1-t_2)}I$
0
$G - \frac{t_1}{(1-t_1)}I$
B
E_2
S
0
p^*_S
$p^*_{E_2}$
$p^*_{E_1}$
1
p
E_1

Figure 4

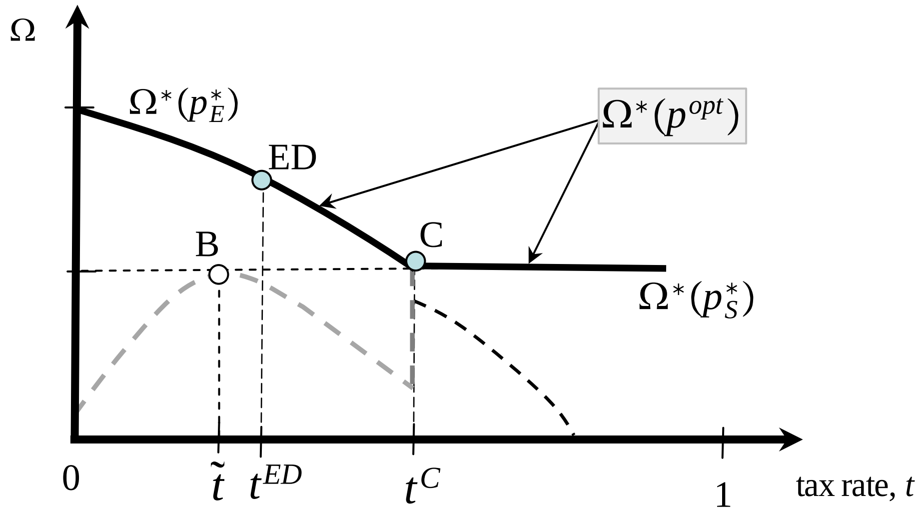


Figure 5