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Entrepreneurial Elites: Industry Structure, Investment, and Welfare Effects of Incubating New Businesses

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ABSTRACT

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We compare two institutional regimes in which individuals with complementary task abilities found entrepreneurial partnerships: corporate spin-offs of initially randomly matched production teams and the rational matching of such teams in an incubator organization. The alternative consists of seeking employment in industrial firms which pay a certain wage. This wage reflects the expected team quality assuming that all professionals who do not found firms themselves are randomly matched in production teams. Each institutional setting gives rise to a unique efficient competitive equilibrium such that both industrial and entrepreneurial firms coexist. The efficient incubator equilibrium induces a larger entrepreneurial sector in the industry. However, simulations show that neither of the two regimes unambiguously yields higher industry-wide investments. Higher degrees of risk-aversion (interest-rates) render the efficient spin-off (incubator) equilibrium welfare dominant.

Keywords: complementary abilities, entrepreneurial partnership, spin-off, incubator organization, random vs. rational matching

JEL-Classfication: L22, M55, L53

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1 Introduction

When Cooper and Bruno (1977) coined the term firm “incubator”, they referred to the spin-off possibilities for high-profile employees of research-intensive industrial corporations. More recently, Bhidé (2000, p. 54) reports that 71% of the founders included in the *Inc. 500* 1989 start-up survey actually “*replicated or modified an idea encountered during their previous employment*”. At the same time, 83% of these entrepreneurs possess at least a four-year college degree.[1] It is also well-known that such spin-offs occur more frequently and are more successful if the industrial firms cooperate with or are situated close to a research university.[2] Thus, industrial and higher education policies increasingly recognize the importance of matching high-profile individuals with different skills in entrepreneurial activities.[3] Universities operate technology transfer and entrepreneurship centers.[4] Often, these agencies offer specific study programs to equip academics of various scientific backgrounds with the necessary business knowledge.[5] Moreover, following the so-called *Silicon Valley* experience, technology or science parks have been set up in many regions of the world.[6]

Clearly, such formal incubator institutions or organizations aim at improving the quality of matches between potential high-tech entrepreneurs.[7] Typically - and regularly so in continental Europe, for instance - these organizations receive significant direct and, with a participating public university or research institute, indirect governmental subsidies. Yet, a “European *Silicon Valley*” does not emerge. The incubator organizations themselves fail economically and require ongoing public support for their survival.[8] Thus, current political agendas rather emphasize the general benefits of public-private research partnerships in fostering regional competitiveness in a globalized market environment.[9] However, the fundamental question remains whether formal incubators constitute dominant institutions to organize entrepreneurial activities in an industry. Hence, we investigate the effects of the matching technology associated with such organizations on the relative intensity of entrepreneurial activities, industry-wide investments, efficiency of occupational choices, and societal

[1] Bhidé (2000, p. 94)

[2] See Löfsten and Lindelöf (2002) and Audretsch et al. (2006) for overviews and recent findings.

[3] According to Bhidé (2000, p. 282-288) again, recruiting matching team members constitutes a key success factor for innovative start-ups.

[4] See, for instance, Carayannis et al. (1998) and Colyvas et al. (2002).

[5] See Katz (2004) for a report on the growth of endowed chairs for entrepreneurship at US universities and the corresponding teaching loads.

[6] See the papers collected in Kenney (2000), for instance.

[7] Cooper (1985).

[8] For a survey see Callan (2001). Quere (1997) provides a detailed account of France's so-called *Sophie-Antipolis* experiment - one of the most ambituous science park projects in Europe. It included the relocation of (parts of) a university.

[9] Examples of such statements can be found in EU Commisssion (2006) and CORDIS (2006), for instance.

welfare.

The starting point of our analysis almost constitutes a tautology: by definition, entrepreneurs take risk. In innovative or high-tech new firms the entrepreneurial risk is even reinforced by the necessity to combine necessary and complementary human skills to develop a scientific application into a marketable product.[10] Risk-sharing within entrepreneurial firms is typically achieved by founding partnerships among the members of the production team.[11] Alternatively, the respective high-profile professionals needed for this production process may, however, join (or remain employed in) industrial firms. Such industrial employment promises a certain income. Yet, this income reflects only the expected productivity within the group of non-entrepreneurs since verifiable employment contracts cannot be conditioned on professional abilities.[12] Thus, the occupational choices of high-tech professionals - i.e. either becoming a member of an entrepreneurial partnership or seeking industrial employment - are governed by a trade-off between the necessity to take risk and the chances to benefit from their individual abilities.[13]

In competitive self-selection equilibrium the value of industrial employment - more precisely, the expected ability of industrial employees - is therefore endogenously determined by the quality of matches in entrepreneurial firms. This equilibrium effect also drives the analysis by Lazear (2004) who assumes that risk-neutral individuals may only become either single entrepreneurs or employees. According to the so-called "jack-of-all-trades"-hypothesis, only individuals with balanced - though possibly mediocre - ability levels will become entrepreneurs. Being randomly matched in production teams that combine two complementary human tasks, such individuals are best team-mates for high-ability but specialized employees. However, as shown by Hart and Moore (1996, 1999), the partnership of owners constitutes a dominant governance structure if contracts cannot be conditioned on necessary human assets. With risk-neutral individuals such partnerships would then implement first-best investment decisions and dominate single-entrepreneurship as well as industrial employment.[14]

Hence, the current analysis follows Fabel (2004a) by drawing on the so-called "*O-Ring*"-

[10] According to Rajan and Zingales (2000, 2001a) today's innovations typically originate from human rather than inanimate assets.

[11] Audretsch and Thurik (2001) report that ownership-like incentive schemes constitute one of the most important characteristics associated with innovative, so-called "New Economy" start-ups.

[12] Bhidé (2000, p. 324) notes that corporate policies in well-established firms to "*recruit individuals who will fit their culture and norms to promote cooperation and team work [...] limit their ability to employ the best indvidual for a given task*".

[13] The seminal work by Kihlstrom and Laffont (1979, 1983) analyzes self-selection equilibria with sorting according to risk-preferences. In contrast, the current approach is based on risk-type heterogeneity among agents.

[14] This conjecture also constitutes a "by-product" of our formal anaylsis. See section 5.2.3 below.

theory of production[15] according to which the probability of project failure equals the probability that one of two necessary tasks is carried out imperfectly. Members of entrepreneurial partnerships can observe their respective abilities upon being matched and before production takes place. In contrast, the management of industrial firms owned by outside investors cannot enforce ability-contingent labor contracts. With risk-averse individuals, there always exists at least one competitive equilibrium such that less able individuals become employees in industrial firms and high-ability individuals - hence, the industry's elite professionals - found entrepreneurial partnerships.[16] This setting further allows to contrast equilibria characterized by random matching in production teams prior to deciding on whether to spin-off an entrepreneurial firm with equilibria resulting from informed, rational matching in incubator organizations. In each case there is a unique efficient equilibrium. We show that the entrepreneurial sector is always smaller in efficient "spin-off"-equilibrium compared to the efficient "incubator"-equilibrium.

Assuming CRRA-utility and independently, uniformly distributed abilities, we then proceed by simulating equilibrium outcomes. The marginal entrepreneurial firms founded in "incubator"-equilibrium can be shown to be relatively small in terms of capital usage. Further, comparing populations of professionals which differ in their risk-attitude, neither of the two regimes yields higher industry-wide capital input in general. Moreover, welfare conclusions - assuming that (societal) welfare is defined as the expected utility of an individual who does not yet know her own ability profile - are generally ambiguous. Yet, for a reasonable value of the elasticity of capital in production, higher degrees of risk-aversion render the efficient "spin-off"-equilibrium welfare dominant. Clearly, such equilibria entail better risk-sharing. Higher interest rates increase the number of entrepreneurs in both efficient "spin-off" and "incubator"-equilibrium. This effect reflects that the *ex-post* income-spread between successful and unsuccessful entrepreneurial firms decreases due to the adjustment of the optimal capital input. However, it then also implies that production generally becomes less capital-intensive.

The paper is organized as follows: the next section introduces the model framework. Sections 3 and 4 derive the characteristics of "spin-off" and "incubator" equilibria. Section 5 compares the two institutional regimes. The final section contains a concluding discussion.

[15] Kremer (1993).

[16] Moreover, while the benefits of industrial employment are associated with the possibility of risk-sharing, Fabel (2004b) further shows that the prospect to become an entrepreneur is essential for the incentives to invest in human capital. Similarly, Rajan and Zingales (2001b) conclude that the opting-out option limits the exploitation risk and enhances the incentives for task specialization within the team.

2 The model

2.1 Basic assumptions and notations

We focus on an industry in which each firm produces a single unit of an output good. Higher-quality variants of this good require higher capital input K. The market price of capital is ρ. For parsimony, the revenue associated with successful completion of the production process is given by $r = K^{\gamma}$, with $0 < \gamma < 1$. This process also combines two necessary human tasks, indexed $t = 1, 2$ in the following. Imperfect performance of either of these two tasks renders the production process incomplete. The output resulting from an incomplete process possesses zero market value. Hence, the firm's revenue equals zero if one of the two tasks is not performed perfectly.

There exists a pool of professionals who are trained in the two tasks. Professional i's ability in performing task t is denoted a^{ti}. These abilities constitute realizations of two random variables $\tilde{a}^{ti}$ which are each drawn from the interval $A = [a_L, 1]$. Let $S = \{(a^{1i}, a^{2i}) \mid a^{ti} \in A\,,$ $t = 1, 2\}$ then denote the set of possible ability profiles of industry professionals. The joint density function $f(a^1, a^2) > 0$, for individual profiles $(a^1, a^2) \in S$, and $f(a^1, a^2) = 0$, for $(a^1, a^2) \notin S$, constitutes common knowledge of all economic agents. The corresponding joint distribution function is denoted $F(a^1, a^2)$. For mere technical reasons, the common lower bound on ability realizations a_L is positive. Yet, a_L can be arbitrarily small and in the limit approach zero.

Individual task ability is measured by the respective probability of perfect task performance. In particular, suppose that two professionals are teamed up such that individual i performs task 1 and individual j carries out task 2. Then, the team realizes revenue r with probability $a^{1i}a^{2j}$. The revenue equals zero with probability $(1 - a^{1i}a^{2j})$. According to this so-called "*O-Ring*" production technology, differences in individual task abilities thus imply differences in team success probabilities.

Individual preferences are characterized by the identical utility function $u(y)$ where $y \geqq 0$ denotes income. As usual, $u'(y) > 0$, $u''(y) \leqq 0$, for $y > 0$, and $\lim_{y \to 0} u'(y) = \infty$. It is assumed that all individuals possess an identical initial wealth income $Y > 0$.

2.2 Entrepreneurial firms

Suppose two individuals i and j have decided to become entrepreneurs and subsequently form a production team. Specifically, they found a partnership of equals.[17] Due to their professional expertise, they can observe each other's task abilities. Let $\bar{a}^{ij} = \{(a^{1i}, a^{2i}), (a^{1j}, a^{2j})\}$ denote the corresponding set of ability profiles within such a team. Clearly, the partners will allocate tasks to economize on their respective comparative advantages. Hence, the project success probability is given by $q^E(\bar{a}^{ij}) = \max\{a^{1i}a^{2j}, a^{1j}a^{2i}\}$.

It follows that the partnership promises identical expected utility

$$\begin{aligned} U^E(q^E(\bar{a}^{ij});\rho) = {} & q^E(\bar{a}^{ij})u(Y + \frac{1}{2}[\left(K^E(q^E(\bar{a}^{ij});\rho)\right)^\gamma - \rho K^E(q^E(\bar{a}^{ij});\rho)]) \\ & + (1 - q^E(\bar{a}^{ij}))u(Y - \frac{1}{2}\rho K^E(q^E(\bar{a}^{ij});\rho)) \end{aligned} \tag{1}$$

for each of the two partners where the capital input $K^E(q^E(\bar{a}^{ij}))$ is implicitly determined by the first-order condition

$$\begin{aligned} & q^E(\bar{a}^{ij})u'(Y + \frac{1}{2}[\left(K^E\right)^\gamma - \rho K^E])[\gamma(K^E)^{(\gamma-1)} - \rho] = \\ & (1 - q^E(\bar{a}^{ij}))u'(Y - \frac{1}{2}\rho K^E)\rho\ . \end{aligned} \tag{2}$$

2.3 Industrial firms and competition

Industrial firms are organized on behalf of outside investors who supply the capital K and claim the residual income. Outside investors are assumed to be risk-neutral. However, they cannot verify their employees' abilities. Such investors are therefore indifferent with regard to the task allocation over their two employees. Competition for task assignments among the employees then implies that the (certain) wages associated with each task must be identically equal.

Assumption 1 *Before occupational choices are made, all economic agents - professionals as well as outside investors -* a priori *believe that the expected success probability in industrial firms is given by* $q^I \in [(a_L)^2, 1]$.

The opportunity costs of becoming an entrepreneur are given by the foregone certain utility of employment in an industrial firm. Hence, professionals must know the wage offers

[17] Lemma 3 proved in the appendix shows that, within a Nash-bargaining framework, the partnership of equals actually constitutes the dominant organizational form for entrepreneurial firms.

of industrial firms in order to make rational occupational choices. These offers are taken to constitute binding commitments by outside investors.

Definition 1 *A competitive equilibrium in the industry's labor market is characterized by the following properties:*

(a) Before production commences, all members of the industry's pool of professionals are either employed by outside investors or have become entrepreneurs.

(b) The occupational choices maximize the professionals' expected utilities.

(c) The a priori *beliefs concerning the expected success probability q^I in industrial firms are confirmed by the induced occupational choices of the professionals.*

(d) Outside investors can freely enter and leave the industry at no costs.

The free-entry condition (d) ensures that competition for profitable investment opportunities within the industry will increase wage-offers until outside investors believe to earn only the market rate of return on their investment. Thus, let w^* denote the unique wage offer by outside investors in such competitive equilibrium. Given Assumption 1, all such investors maximize their expected profit

$$\pi = q^I K^\gamma - \rho K - 2w^*. \tag{3}$$

which yields the first-order condition

$$\gamma q^I (K)^{(\gamma-1)} - \rho = 0, \tag{4}$$

Let $K^I = K^I(q^I;\rho)$ then denote the optimal capital input which satisfies (4).

Then, part (d) of Definition 1 implies that the reservation wage for potential entrepreneurs can be determined as

$$\begin{aligned} w^* &= w^*(q^I;\rho) \\ &= \frac{1}{2}\left[q^I \left(K^I(q^I;\rho)\right)^\gamma - \rho K^I(q^I;\rho)\right] \\ &= \frac{(1-\gamma)\, q^I}{2}\left(K^I(q^I;\rho)\right)^\gamma \end{aligned} \tag{5}$$

upon insertion from (4) into (3) above and setting $\pi = 0$. Let $U^I(q^I;\rho) = u(Y + w^*(q^I;\rho))$ denote the corresponding certain utility of an employee in competitive equilibrium. Figure 1 then illustrates the professionals' occupational choice.

INSERT FIGURE 1 ABOUT HERE!

3 Self-selection in "spin-off"-equilibria

Industrial firms may serve as incubators for spin-offs. Hence, while already employed and cooperating in production teams, professionals learn about each other's ability profiles. Given this information, they may decide to spin off a new firm. This argument is taken to imply the following information and decision structure:

Assumption 2 *All professionals first apply for employment in industrial firms and are randomly matched to form production teams. Each team member then observes her colleague's ability profile. Subsequently, the members of such teams can opt out of their employment contract and found an entrepreneurial firm before production commences.*

The option to spin-off an entrepreneurial firm thus constitutes a means to align the interests of two randomly matched team members in making their occupational choices. All teams of professionals i and j for which

$$U^E(q^E(\bar{a}^{ij});\rho) \geqq U^I(q^I;\rho) \tag{6}$$

will choose to found an entrepreneurial firm. From (6) define $\bar{q}$ such that

$$U^E(\bar{q}(q^I);\rho) = U^I(q^I;\rho)\ . \tag{7}$$

Given every *a priori* belief $q^I \in [(a_L)^2, 1]$, (7) implicitly defines a continuous, monotonically increasing function $\bar{q}(q^I) \geqq q^I$. Clearly, $\bar{q}(q^I) > q^I$ if professionals are risk-averse and $q^I \in (0,1)$.

Let $q^I(\bar{q}) = \bar{q}^{-1}(q^I)$. Since task assignments in industrial firms constitute independent drawings, equilibrium occupational choices must confirm that

$$q^I(\bar{q}) = \begin{cases} \frac{1}{\int_{a_L}^1 f_{\tilde{a}^2}(a^2)F_{\tilde{a}^1}(\frac{\bar{q}}{a^2})da^2} \times \int_{a_L}^1 \int_{a_L}^{\frac{\bar{q}}{a^2}} a^1 f_{\tilde{a}^1}(a^1)da^1 a^2 f_{\tilde{a}^2}(a^2)da^2 & , \quad \bar{q} \geq a_L \\ \frac{1}{\int_{a_L}^1 f_{\tilde{a}^2}(a^2)F_{\tilde{a}^1}(\frac{\bar{q}}{a^2})da^2} \times \int_{a_L}^{\frac{\bar{q}}{a_L}} \int_{a_L}^{\frac{\bar{q}}{a^2}} a^1 f_{\tilde{a}^1}(a^1)da^1 a^2 f_{\tilde{a}^2}(a^2)da^2 & , \quad \bar{q} < a_L \end{cases} \tag{8}$$

where $F_{\tilde{a}^t}(a^t)$ and $f_{\tilde{a}^t}(a^t)$, $t = 1, 2$, denote the unconditional marginal distribution and density functions, respectively. From (7), all teams realizing $q^E(\bar{a}^{ij}) \geqq \bar{q}(q^I)$ will found entrepreneurial firms.

Proposition 1 *If professionals are risk-averse, Assumption 2 implies that both firm types coexist in every competitive equilibrium. There exists at least one such equilibrium.*

Proof. (a) If beliefs were such that all randomly matched teams of professionals should remain employed in industrial firms $q^I(1) = \int_{a_L}^1 a^1 dF_{\tilde{a}^1}(a^1) \int_{a_L}^1 a^2 dF_{\tilde{a}^2}(a^2) < 1$. However,

$$\lim_{a^1 \to 1, a^2 \to 1} [U^E(a^1 a^2; \rho) - U^I(q^I(\bar{q}); \rho)] \tag{9}$$
$$= u\left(Y + \frac{1}{2}\left[\left(K^I(1;\rho)\right)^\gamma - \rho K^I(1;\rho)\right]\right)$$
$$-u\left(Y + \frac{1}{2}\left[q^I(1)\left(K^I(q^I(1);\rho)\right)^\gamma - \rho K^I(q^I(1);\rho)\right]\right) > 0$$

since $\lim_{a^1 \to 1, a^2 \to 1} K^E(a^1, a^1; \rho) = K^I(1; \rho)$ and, according to (4), $\partial K^I(q;\rho)/\partial q > 0$.

In contrast, suppose that all randomly matched teams of professionals would spin off entrepreneurial firms in equilibrium. Then, for $0 < (a_L)^2 < 1$,

$$\lim_{a^1 \to a_L, a^1 \to a_L} [U^E(a^1 a^2; \rho) - U^I(q^I(\bar{q}); \rho)] \tag{10}$$
$$= (a_L)^2 u\left(Y + \frac{1}{2}[\left(K^E((a_L)^2;\rho\right)^\gamma - \rho K^E((a_L)^2;\rho)]\right)$$
$$+(1-(a_L)^2)u(Y - \frac{1}{2}\rho K^E((a_L)^2;\rho))$$
$$-u\left(Y + \frac{(a_L)^2}{2}\left[\left(K^I((a_L)^2;\rho)\right)^\gamma - \rho K^I((a_L)^2;\rho)\right]\right) < 0.$$

since, according to (4) and (2), $K^E((a_L)^2;\rho) < K^I((a_L)^2;\rho)$ if professionals are risk-averse. An industrial firm offering $w^*((a_L)^2)$ would therefore attract some employees and earn positive expected profits. Thus, (9) and (10) rule out competitive equilibria in which the entire industry consists of only one firm-type.

(b) Notice that $U^E(\bar{q};\rho)$ and $U^I(q^I(\bar{q});\rho)$ are both monotonically increasing in $\bar{q}$ and $q^I(\bar{q})$, respectively. Also, (8) yields $\partial q^I(\bar{q})/\partial \bar{q} > 0$. Given part (a) above, there must exist at least one $\bar{q}$ which satisfies (7) and (8). ■

Inequality (9) shows that even if the self-selection criterion for entrepreneurial teams $\bar{q}$ approaches unity, top ability professionals still found partnerships. Since the probability of project failure converges to zero for such teams, they choose the first-best capital input and receive the corresponding certain utility. In contrast, industrial firms can only expect to realize average ability in their teams. Although the capital input would also be chosen according to the first-best rule, the respective capital level and the corresponding certain utility of their employees would still be lower than in entrepreneurial firms founded by top-ability professionals.

As the self-selection criterion $\bar{q}$ approaches its positive lower bound, the pooling risk in industrial firms vanishes. Hence, inequality (10) reflects that outside investors would then only employ a single - e. g. the lowest - ability-type in both tasks. Outside investors would therefore choose the first-best capital input level conditional on the highest project risk which can possibly be realized. Exactly this project risk would also be realized in the respective marginal entrepreneurial firms. However, the partners in such firms are risk-averse and would, thus, choose a lower capital input.

Since both the expected utility of marginal entrepreneurs and the certain utility of employees monotonically increase if the self-selection of entrepreneurs becomes more restrictive, these arguments suffice to establish a crossing property. Moreover,

$$\frac{\partial^2 U^E(\bar{q};\rho)}{(\partial \bar{q})^2} = \frac{1}{2}\Big[u'(Y+\frac{1}{2}[\left(K^E(\bar{q};\rho)\right)^\gamma - \rho K^E(\bar{q};\rho)])\left(\left(K^E(\bar{q};\rho)\right)^{(\gamma-1)} - \rho\right) \qquad (11)$$
$$+u'(Y-\frac{\rho}{2}K^E(\bar{q};\rho)])\rho\Big]\frac{\partial K^E(\bar{q};\rho)}{\partial \bar{q}} > 0$$

due to (2). However, from (5) and the definition of $U^I(q^I(\bar{q});\rho)$,

$$\frac{\partial^2 U^I(q^I(\bar{q});\rho)}{\left(\partial q^I(\bar{q})\right)^2} = u''(Y+w^*(q^I;\rho))\left[\frac{\left(K^I(q^I;\rho)\right)^\gamma}{2}\frac{\partial q^I(\bar{q})}{\partial \bar{q}}\right]^2 \qquad (12)$$
$$+ u'(Y+w^*(q^I;\rho)\frac{\gamma\left(K^I(q^I;\rho)\right)^{(\gamma-1)}}{2}\left[\frac{\partial q^I(\bar{q})}{\partial \bar{q}}\right]^2$$
$$+ u'(Y+w^*(q^I;\rho))\frac{\left(K^I(q^I;\rho)\right)^\gamma}{2}\frac{\partial^2 q^I(\bar{q})}{(\partial \bar{q})^2}.$$

From (8) $\partial q^I(\bar{q})/\partial \bar{q} > 0$. Yet, the sign of $\partial^2 q^I(\bar{q}) \big/ (\partial \bar{q})^2$ depends on the specific distributional assumptions. Hence, a single-crossing property cannot be taken for granted. The competitive equilibrium is therefore not necessarily unique.

Proposition 2 *There exists a unique efficient competitive equilibrium. Given Assumption 2, the respective self-selection criterion $\bar{q}^*$ satisfies*

$$\bar{q}^* = \arg \max_{\bar{q}\in((a_L)^2,1)} q^I(\bar{q}) \qquad (13)$$
$$\textit{subject to (7) and (8).}$$

Proof. An efficient self-selection equilibrium must solve the above optimization problem, since $U^I(q^I(\bar{q});\rho)$ is increasing in $q^I(\bar{q})$ and all entrepreneurs' expected utilities satisfy (6). Let $h^i = h(a^{1i}, a^{2i}; \bar{q})$ denote the probability that a professional with ability profile (a^{1i}, a^{2i}) will found an entrepreneurial firm. Then $\bar{q}^*$ maximizes

$$V^i = h(a^{1i},a^{2i};\bar{q})E_{(\tilde{a}^1,\tilde{a}^2|a^1 \geqq \frac{\bar{q}}{a^{2i}} \vee a^2 \geqq \frac{\bar{q}}{a^{1i}})}\left\{U^E(q^E(\bar{a}^i;\rho))\right\} \qquad (14)$$
$$+\left(1-h(a^{1i},a^{2i};\bar{q})\right)U^I(q^I(\bar{q});\rho)$$

for all professionals i. According to Proposition 1, $\bar{q} \in ((a_L)^2, 1)$ and the constraint (7) must be binding. Uniqueness immediately follows from $\partial U^E(\bar{q};\rho)/\partial \bar{q} > 0$, $\partial q^I(\bar{q})/\partial \bar{q} > 0$, and (9). These conditions imply the existence of a value $\bar{q}^*$ such that $U^E(\bar{q};\rho) > U^I(q^I(\bar{q});\rho)$ for all $\bar{q} \in (\bar{q}^*, 1]$. Hence, $\bar{q} > \bar{q}^*$ cannot characterize a competitive equilibrium and all possible competitive equilibria with $\bar{q} < \bar{q}^*$ are Pareto-dominated. ■

Risk-aversion induces an endogenous separation of professionals into two groups providing industrial and entrepreneurial labor. Hence, the efficient competitive equilibrium maximizes the team-quality in industrial firms. This equilibrium implements a second-best trade-off. Risk-shifting by joining industrial firms can only be achieved at the expense of foregoing some of the allocative benefits associated with rational task-assignments in entrepreneurial firms.

4 Self-selection in "incubator"-equilibria

4.1 Rational ability-matching by choosing partners

In the "spin-off"-setting above, professionals cannot choose partners since, by assumption, they have already been assigned to a particular production team in an industrial firm. In contrast, formal incubator organizations seek to establish pools of professionals to coordinate entrepreneurial activities. Hence, they allow to observe abilities prior to contracting, to search for partners, and aim at reducing the respective information and search costs. In this section, Assumption 2 is therefore replaced by:

Assumption 3 *All professionals observe each others' ability profiles before making occupational choices.*

Given such perfectly informed professionals, part (b) of Definition 1 implies that, in competitive equilibrium, potential entrepreneurs maximize their expected utility by choosing partners.

Lemma 1 *Given Assumption 3, superior realizations of the success probabilities in entrepreneurial firms reflect that both tasks are performed perfectly with higher probabilities.*

Proof. Suppose four professionals denoted k, ℓ, m, and n decide to become entrepreneurs. Without loss of generality, they are taken to team up in two partnerships between k and ℓ, respectively m and n and realize $q^E(\bar{a}^{k\ell}) \leqq q^E(\bar{a}^{mn})$. Given that these individuals have maximized their expected utilities,

$$\begin{array}{l} \text{(a) } q^E(\bar{a}^{k\ell}) = a^{1k}a^{2\ell} \text{ and } q^E(\bar{a}^{mn}) = a^{1m}a^{2n} \Longrightarrow a^{1k} \leqq a^{1m} \wedge a^{2\ell} \leqq a^{2n}, \\ \text{(b) } q^E(\bar{a}^{k\ell}) = a^{1\ell}a^{2k} \text{ and } q^E(\bar{a}^{mn}) = a^{1m}a^{2n} \Longrightarrow a^{1\ell} \leqq a^{1m} \wedge a^{2k} \leqq a^{2n}, \\ \text{(c) } q^E(\bar{a}^{k\ell}) = a^{1\ell}a^{2k} \text{ and } q^E(\bar{a}^{nm}) = a^{1n}a^{2m} \Longrightarrow a^{1\ell} \leqq a^{1n} \wedge a^{2k} \leqq a^{2m}, \\ \text{(d) } q^E(\bar{a}^{k\ell}) = a^{1k}a^{2\ell} \text{ and } q^E(\bar{a}^{nm}) = a^{1n}a^{2m} \Longrightarrow a^{1k} \leqq a^{1n} \wedge a^{2\ell} \leqq a^{2m}. \end{array} \tag{15}$$

At least one inequality must be strict in cases (a) - (d), if $q^E(\bar{a}^{k\ell}) < q^E(\bar{a}^{mn})$. Further, $q^E(\bar{a}^{k\ell}) = q^E(\bar{a}^{mn})$ implies equalities everywhere. Otherwise, $a^{ti} > a^{tj}$ for one $t = 1, 2$, with $i = k, \ell$ and $j = m, n$, in (15 (a) - (d)) would imply that either k or ℓ could team up with m or n to found a partnership which would yield higher expected utility for both individuals. ■

The expected utility maximizing behavior of potential entrepreneurs in choosing partners induces a ranking of abilities across the respective production teams. The professional with highest ability in task 1 teams up with the professional who is characterized by the highest ability in task 2. Then, the professional with next to top ability in task 1 founds an entrepreneurial firm with the professional whose ability in task 2 is second-ranked as well. Professionals are ranked by their ability in the task they perform relatively better, since in an efficient allocation the other task will be performed by the production partner.

4.2 Competitive equilibria with perfectly informed entrepreneurs

In equilibrium, all individuals with ability profiles that allow them to become part of an entrepreneurial production team of quality $q \geq \bar{Q}$ where

$$U^E(\bar{Q};\rho) = U^I(q^I(\bar{Q});\rho) \tag{16}$$

will opt for the entrepreneurial sector.

Lemma 2 *Competitive equilibria only support* a priori *beliefs of the type*

$$S^I = S^I(\bar{Q}) = S^I(z_1, z_2) = \{(a_1, a_2) \in S \mid a_1 < z_1 \leqq 1 \vee a_2 < z_2 \leqq 1\} \tag{17}$$

where S^I denotes the set of ability profiles characterizing industrial employees. In equilibrium, the expected quality of a randomly matched team in industrial firms is therefore given by

$$q^I(\bar{Q}) = q^I(z^1, z^2) = \frac{\int_{a_L}^{z^2}\int_{a_L}^{z^1} a^1 f(a^1,a^2)da^1da^2}{\int_{a_L}^{z^2}\int_{a_L}^{z^1} f(a^1,a^2)da^1da^2} \frac{\int_{a_L}^{z^1}\int_{a_L}^{z^2} a^2 f(a^1,a^2)da^2da^1}{\int_{a_L}^{z^1}\int_{a_L}^{z^2} f(a^1,a^2)da^2da^1} . \tag{18}$$

Proof. According to Lemma 1, $z_1, z_2 \in [a_L, 1]$ are uniquely defined by $z_1 z_2 = \bar{Q}$ such that z_t, $t = 1, 2$, constitutes the ability level all professionals performing task t in marginal entrepreneurial firms. Hence, every professional k with either $a^{1k} \geq z_1$ or $q^{2k} \geq z_2$ will become an entrepreneur. She can find a partner to realize a team quality $q^E \geq \bar{Q}$. Professionals l where both $a^{1l} < z_1$ and $a^{2l} < z_2$ will opt for industrial employment, i.e. all professionals with ability profile $(a^1, a^2) \in S^I$ as defined above. Such *a priori* beliefs then imply (18). ■

With rational matching, equilibrium beliefs must anticipate that high-ability specialists will always found entrepreneurial firms. Again, all elite industry professionals - regardless of their degree of task-specialization - will become entrepreneurs.[18]

Proposition 3 *Given Assumption 3, there exists at least one competitive equilibrium. Both firm-types coexist in all such equilibria.*

Proof. (a) To begin with, assume $a_L < z^t < 1$ for $t = 1, 2$. Recall that $\partial U^E(q^E)/\partial q^E > 0$. Thus, $\partial U^E(q^E(\bar{a}^{ij}))/\partial a^{pt} = \frac{\partial U^E(q^E)}{\partial q^E} \frac{\partial q^E}{\partial a^{pt}} \geqq 0$, for each of the two partners $p = i, j$ and both tasks t. Strict inequality follows if partner p actually carries out task t in the entrepreneurial firm. By Lemma 2, equilibrium occupational choices support *a priori* beliefs of type (17). Then, $U^E(\bar{Q}; \rho)$ defined in (16) above constitutes an upper bound on the expected utilities of all professionals i characterized by abilities $a^{it} = z^t$ and $a^{i\tau} < z^\tau$ where $t, \tau = 1, 2$ and $t \neq \tau$.

(b) It is easily verified that $\lim_{z^1 \to 1, z^2 \to 1} [U^{Ez}(z^1, z^2; \rho) - U^I(q^I(z^1, z^2); \rho)]$ yields inequality (9) derived in part (a) of the proof of Proposition 1 already. Also, $\lim_{z^1 \to a_L, z^1 \to a_L} [U^{Ez}(z^1, z^2; \rho) - U^I(q^I(z^1, z^2); \rho)]$ only restates (10) from above. Consequently, due to $\partial U^E(q^E)/\partial q^E > 0$ and Lemma 2, there must exist a combination (z^1, z^2), with $a_L < z^t < 1$ for at least one task $t = 1, 2$ such that (16) is satisfied. Hence, competitive equilibria with either only entrepreneurial or only industrial firms are ruled out. ■

Given Assumption 2 as well as Assumption 3, professionals first observe each others' ability profiles and then decide whether to found an entrepreneurial firm. As discussed in the preceding section, this argument alone suffices to establish a competitive equilibrium in which both firm-types coexist. To a considerable extent the proof of Proposition 3 therefore only restates results from the proof of Proposition 1.

The important difference arises due to the fact that the probability to found an entrepreneurial firm is now either equal to unity or zero contingent only on the professional's own

[18] In contrast, Lazear's (2004) "jack-of-all-trade"-hypothesis implies that entrepreneurs are drawn from the set $S^E = S^E(\bar{Q}) = S^E(z_1, z_2) = \{(a_1, a_2) \in S \mid z_1 \leqq a_1 \leqq 1 \wedge z_2 \leqq a_2 \leqq 1\}$. This separation of professional-types is obviously ruled out by Lemma 2.

ability profile. In particular, top-ability task-specialists will always be able to find a partner and found an entrepreneurial firm such that both partners' expected utility is higher than in industrial employment. Thus, "interdisciplinary" self-selection criteria are not compatible with competition for better partners among informed professionals.

INSERT FIGURES 2 AND 3 ABOUT HERE!

Although Proposition 3 establishes a crossing property for the expected utilities associated with occupational choice, a single-crossing property again does not necessarily follow.

Proposition 4 *Given Assumption 3, an efficient competitive equilibrium is characterized by selection criteria* (ζ^1, ζ^2) *such that*

$$(\zeta^1, \zeta^2) = \arg \max_{z^1 \in (a_L, 1), z^2 \in (a_L, 1)} q^I(z^1, z^2) \ , \tag{19}$$

subject to (16) and (18)

Efficient competitive equilibrium uniquely determines the success probability $\overline{Q}^* = \zeta^1 \zeta^2$ *in the marginal entrepreneurial firm.*

Proof. From Proposition 3, a competitive equilibrium only supports belief structures of type (17) with $z^t \in (a_L, 1)$, for $t = 1, 2$. The arguments pursued in part (b) of the proof of this proposition imply that (16) constitutes a binding constraint if $q^I(z^1, z^2)$ is given by (18). Then, assume that there exist two competitive equilibria characterized by self-selection criteria $(\hat{\zeta}^1, \hat{\zeta}^2)$ and (ζ^1, ζ^2) and $q^I(\hat{\zeta}^1, \hat{\zeta}^2) < q^I(\zeta^1, \zeta^2)$.

Due to $\partial U^I(q^I, \rho)/\partial q^I > 0$, it follows that $U^I(q^I(\hat{\zeta}^1, \hat{\zeta}^2); \rho) < U^I(q^I(\zeta^1, \zeta^2); \rho)$. Further, $U^E(q^E(\bar{a}^{ij}); \rho) > U^{Ez}(z^1, z^2; \rho)$ for all professionals i and j who found a non-marginal entrepreneurial firm implying that $a^{pt} \geqq z^t$, with $p = i, j$ and $t = 1, 2$, with strict inequality for one of the two tasks t. Hence, all industry professionals realize higher expected utility in the equilibrium characterized by (ζ^1, ζ^2) than given the equilibrium with selection criteria $(\hat{\zeta}^1, \hat{\zeta}^2)$. Consequently, an efficient equilibrium must satisfy (19).[19]

Part (b) of the proof of Proposition 3 also implies that $U^{Ez}(z^1, z^2; \rho) > U^I(q^I(z^1, z^2); \rho)$ for all combinations (z^1, z^2) which yield $z^1 z^2 \in (\bar{Q}^*, 1]$, where $\bar{Q}^* \equiv \zeta^1 \zeta^2$. As shown above,

[19] Clearly, the same argument can be made if there are more than two competitive equilibria in which industrial and entrepreneurial firms coexist.

all possible competitive equilibria with $z^1 z^2 \in [(a_L)^2, \bar{Q}^*)$ are not efficient. Hence, $\bar{Q}^*$ is uniquely determined in efficient competitive equilibrium. ■

Again, efficiency requires to implement a second-best trade-off between risk-shifting in industrial firms and economizing on the productive advantage of allocating tasks according to comparative advantages. However, the efficient "incubator"-equilibrium clearly implies a different mix of professionals remaining in the pool for industrial employment compared to the efficient "spin-off"-equilibrium.

5 Comparing "spin-off" and "incubator"-equilibria

5.1 General industry structure effects

The possibility of multiple equilibria generally precludes drawing general positive conclusions concerning the impacts of fostering entrepreneurial activity through spin-offs or formal incubator organizations. However, it is possible to compare the respective efficient equilibria with respect to the degree of entrepreneurial activity generated in the industry. As illustrated by Figures 2 and 3, the two institutional regimes induce qualtitatively different separations of professional-types even with identical cut-off criterion.

Proposition 5 *The entrepreneurial sector of the industry is smaller in efficient "spin-off"-equilibrium than in efficient "incubator"-equilibrium:* $\bar{Q}^* < \bar{q}^*$.

Proof. Take any (z_1^*, z_2^*)-combination that satisfies $z_1^* z_2^* = \bar{q}^*$. Comparing (8) with $\bar{q} = \bar{q}^*$ and (18) with $(z_1, z_2) = (z_1^*, z_2^*)$, it is immediately clear that $q^I_{(8)}(\bar{q}^*) > q^I_{(18)}(z_1^*, z_2^*)$. It follows that

$$\begin{aligned} U^I(q^I_{(8)}(\bar{q}^*); \rho) &= U^E(\bar{q}^*; \rho) \\ &= U^{Ez}(z_1^*, z_2^*; \rho) > U^I(q^I_{(18)}(z_1^*, z_2^*); \rho) \ . \end{aligned} \tag{20}$$

Focussing on efficient equilibria only, Propositions 2 and 4 therefore imply $\zeta^1 \zeta^2 = \overline{Q}^* < \bar{q}^*$. ■

Ceteris paribus - i. e. holding the team quality of the marginal entrepreneurial firm constant - consider two professionals with high abilities in the same one of the two tasks and very low abilities in the other task. If such individuals happen to be matched in "spin-off"-equilibrium, they would decide not to become entrepreneurs and rather enter the industrial workforce. However, these professionals would become entrepreneurs in "incubator"-equilibrium because they could search for and then team up with individuals characterized by a compensating ability profile.

Hence, moving from "spin-off" to "incubator"-equilibrium more high ability specialists leave the labor pool of industrial firms. Consequently, the expected team quality in such firms decreases. Since efficient equilibria are unique and in both cases maximize this expected team quality, the team quality of the marginal entrepreneurial firm must also be lower in efficient "incubator"-equilibrium. Clearly, this conclusion implies that more individuals found entrepreneurial partnerships.

5.2 Evaluating industry structure and welfare effects

5.2.1 The assumptions for simulating the model

The general analysis above cannot address the size of the structural effect reported in Proposition 5 above. Obviously, the increase in entrepreneurial activity by moving from a "spin-off" to an "incubator"-equilibrium depends on risk-preferences and the properties of the ability profile distribution. Moreover, the corresponding welfare effects are generally ambiguous. On the one hand, the certain utility of professionals employed in industrial firms is lower in efficient "incubator"-equilibrium. On the other hand, high ability professionals do not face the risk of an "unlucky" match.

Simple simulations of the model framework may, however, provide some insights into the relative importance of risk-aversion and the cost of capital for the size of the structural effects and the welfare dominance of the two regimes. Reasonably, such simulations compare only the efficient equilibrium outcomes under both regimes. For parsimony, the analysis above has already assumed a simple Cobb-Douglas-type production function for complete production processes. For our simulations the capital intensity is set to $\gamma = 0.3$ to match current estimates of the share of labor income in GDP.[20]

Positive initial wealth Y has actually only been introduced to the model to ensure positive optimal investments of entrepreneurs. In our simulations, $Y = 0.5$ then. This value has proved to induce well-scalable effects of varying the degree of risk aversion and the interest rate over broad ranges. Risk-preferences are expressed by a CRRA utility function. Hence, $u(y) = \frac{y^{1-c}}{(1-c)}$, for $c \neq 1$, and $u(y) = ln(y)$, for $c = 1$.[21] According to Kaplow (2003), the

[20] Gollin (2002)

[21] Since $Y > 0$, risk preferences can also be seen to reflect HARA rather than CRRA-utility.

degree of relative risk-aversion c can plausibly take on even very high values - i.e. greater than 10.

Analytic approaches found in the literature typically assume that individual task abilities are identically and independently distributed. In the remaining, let therefore $f(a^1, a^2) = g(a^1)g(a^2)$. Further, we specify g as the uniform density[22] on $[a_L, 1]$ with a_L itself set to 0.1. However, the qualitative results reported below still hold for general joint ability densities with non-negative correlation between the two task abilities and identical marginal densities.

5.2.2 Changes in industry structure and capital usage

Given the assumptions above, the simulations reported in Tables 1 a) and b) confirm Proposition 5. The entrepreneurial sector is always larger in the "incubator"-equilibrium.

INSERT TABLES 1 a) -b) ABOUT HERE!

Interestingly, lower interest rates decrease the size of the entrepreneurial sector in both scenarios. This somewhat counter-intuitive effect can be explained by recalling the occupational options depicted graphically in Figure 1. An increase in the interest rate "harms" successful as well as unsuccessful entrepreneurs. *Ex-ante* entrepreneurial partnerships respond by reducing the optimal capital input. Obviously, the same adjustment is carried out in industrial firms. Yet, entrepreneurs effectively shift payoff from the success to the failure state. Thus, entrepreneurial partnerships also increase their self-insurance.

In contrast, more industrial employment implies better risk-shifting. Hence, higher degrees of risk-aversion decrease the size of the entrepreneurial sector. However, the respective effect on industry-wide capital-usage - i. e. calculated by taking the average over industrial and entrepreneurial firms - is generally ambiguous:

- Higher risk-aversion induces an increase in the number of high-ability individuals employed in the industrial sector. Thus, it raises the average team quality in this sector. Consequently, outside investors invest more into their production teams - inducing an increase of the average capital input in the industrial sector.
- Some low quality teams, that, with lower risk-aversion, would have become entrepreneurs, now opt for industrial employment. Hence, the average team quality in the

[22] Compare Lazear (2004) once more.

entrepreneurial sector increases as well. Yet, although capital-usage is an increasing function of team quality, this effect is only of second-order. It is more than offset by the direct negative effect of an increase of risk-aversion on the choice of the capital-input by entrepreneurial partnerships.

- Finally, there is an effect of relative sector sizes. For low degrees of risk-aversion the average capital input in industrial firms is small compared to that in entrepreneurial firms. Thus, the increased size of the industrial sector tends to lower industry-wide investments. For high degrees of risk aversion the average capital input is higher in industrial firms. Hence, a larger industrial sector results in a higher overall capital input.

In all our simulations, this third effect implies that the capital usage in the industry constitutes a non-monotonic function of the degree of risk-aversion: it decreases with higher risk-aversion at low degrees of risk-aversion, then reaches a minimum, and increases for higher degrees of risk-aversion. Further, minimum investment levels are always realized at lower degrees of risk-aversion in the efficient "spin-off"-equilibrium.

INSERT FIGURES 4 a) - c) ABOUT HERE!

Clearly, higher interest rates decrease the capital usage in all firms - industrial as well as entrepreneurial firms. Moreover, since they imply that the entrepreneurial sector increases, lower-quality teams of professionals found entrepreneurial partnerships. Comparing "spin-off" and "incubator"-equilibria again, the marginal entrepreneurial firm therefore always uses less capital in the latter case.

Figures 4 a) - c) illustrate these structural effects. The light and the dark columns display the average capital input of entrepreneurial firms and the capital input of industrial firms, respectively. The line then indicates the average capital input in the industry taken over all firms. Qualitatively, all figures depict the same functional relationship between risk-aversion and capital inputs as regimes are compared. Only the levels of these capital inputs decrease with higher interest rates.

5.2.3 Welfare effects

Our welfare criterion compares the expected utilities and certainty equivalent incomes of individuals who do not yet know the realization of their ability profiles. Thus, welfare effects emerge from the *ex-ante* risk-type uncertainty as well as the realized *ex-post* project success risk. This welfare criterion naturally corresponds to the idea that governments should not deliberately discriminate among individual-types.

Recall that in both the "spin-off" and the "incubator"-setting, each professional possesses an initial wealth of Y. Hence, teams with initial joint wealth of $2Y$ face the payoff alternatives illustrated in Figure 1 when making occupational choices. If risk aversion c approaches 0 - i.e. if we assume risk-neutrality - no team will have an incentive to seek, respectively stay in industrial employment since $q^E \geq q^I$. In this case, the expected team quality is therefore given by $E(q) = E(\tilde{a}^1) \cdot E(\tilde{a}^2)$ under the "spin-off"-setting and $E(q) = E((\tilde{a}^1)^2)$ in the "incubator"-regime. The latter expression always exceeds the former then.[23] In contrast, for extremely risk averse professionals - hence, if c approaches infinity - the welfare difference between the two regimes approaches zero. Both regimes converge to the same all-employee borderline case.

If individuals are moderately risk averse, a trade-off emerges. On the one hand entrepreneurs in the "incubator"-setting enjoy the advantage of being able to pick their partner and therefore - on average - realize a higher team quality than in the "spin-off"-case. On the other hand, compared to the "spin-off" case employees under the "incubator"-setting receive a lower wage in industrial firms due to the induced lower average employee team-quality in such firms. An increase in risk aversion increases the proportion of individuals becoming employees under both settings. This effect tends to favor the "spin-off"-setting.

INSERT TABLE 2 ABOUT HERE!

These conclusions are confirmed by the simulations reported in Table 2. For low degrees of risk aversion, the "incubator"-equilibrium is welfare dominant. As c increases, the "spin-off"-regime *ceteris paribus* becomes dominant. Moreover, for very high degrees of risk aversion the welfare differences expressed in certainty equivalents or in terms of relative difference in expected utilities decreases.

As noted above, increasing the interest rate yields more entrepreneurial activity under both regimes due to enhanced self-insurance in the entrepreneurial partnerships. Thus, higher interest rates should also tend to support the welfare-dominance of the "incubator"-equilibrium. The results reported in Tables 3 a) - b) confirm this conclusion. Yet, given

[23] This general difference in calculating expected team qualities between the two regimes also implies that the conclusions derived below can be transferred to the case of positively correlated task abilities.

our specific simulation model and realistic movements of interest rates, the capital-cost effect appears to be weak: comparing welfare differentials between the two regimes, the effect of increasing the interest rate by 4% can (on average) be offset by lowering the degree of risk aversion by only one unit.[24]

INSERT TABLES 3 a) – b) ABOUT HERE!

6 Concluding discussion

Competitive equilibria in which industrial firms and entrepreneurial partnerships coexist are supported by institutions to match complementary individual task abilities prior to making occupational choices. Two such institutions have been analyzed in detail: corporate spin-offs of initially randomly matched production teams whose members can observe each others' ability profiles and incubator organizations in which each member can observe all other members' profiles and rationally choose a partner. While there generally exist multiple equilibria, each institutional regime entails a unique efficient competitive equilibrium that separates an industrial from an entrepreneurial sector.

Comparing these efficient equilibria the "incubator"-case entails more entrepreneurial activity. However, the marginal entrepreneurial firms founded in "incubator"-equilibrium operate with rather low capital inputs. Moreover, from an *ex-ante* welfare point of view this equilibrium also implies less industry-wide risk-sharing. Consequently, higher degrees of risk aversion tend to render the efficient "spin-off"-equilibrium dominant. In contrast, higher interest rates induce a tendency towards a dominating "incubator"-equilibrium. The resulting decrease in the optimal capital input yields better self-insurance in entrepreneurial partnerships. Hence, more such firms are founded which economize on comparative advantages in organizing their production.

Also recall that industry-wide capital usage follows a u-shape function of risk-aversion given both institutional regimes. The respective minima of the two functions generally occur at different degrees of risk-aversion. Hence, moving an industry from the "spin-off" towards the "incubator"-equilibrium by public support for incubator organizations can increase as well as decrease industry-wide investments. Moreover, even if investments increase, welfare

[24] Hence, suppose a situation in which the efficient "spin-off"-equilibrium welfare dominates. Starting from this situation, a 4% increase in the interest rate would then (on average) render the "incubator"-equilibrium dominant. However, assuming an increase of the risk-aversion parameter c by one would again restore the original dominance of the "spin-off"-equilibrium.

may still decrease. Further, the interest rate effect appears relatively weak in our simulation model and empirical estimates of the degree of risk-aversion vary greatly. Hence, educational entrepreneurship programs that increase the participant's propensity to bear project risk may show less measurable direct impact. Yet, they are more likely to actually generate a sustainable, welfare-enhancing increase of entrepreneurial activities than investment programs to subsidize the cost of capital.

Finally, there currently exists an understanding that US households are willing to bear considerable more risk than their continental-European counterparts.[25] Following North (1981), our analysis would suggest that this difference in risk-taking attitudes explains why incubator organizations, such as the *Silicon Valley* network, have emerged naturally in the US while elsewhere they require persistent public support for their existence. Generally, industrial and regional development politics should be aware of the possibility of welfare losses associated with subsidizing incubator organizations. Our analysis has shown that performance evaluations cannot merely appreciate the frequency of induced firm foundations. Rather, they must account for the crowding-out effects on the industrial sector.

[25] Allen and Santonomero (1999) are among the first to report this conclusion.

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Appendix: The partnership of equals as the dominant organizational form for entrepreneurial firms

Generally, define the expected utilities of two professionals i and j, founding a new firm as

$$\begin{aligned} U^{ij} = T(\bar{a}^{ij}) & \left[a^{1i}a^{2j}u(Y - \phi(\bar{a}^{ij}) + (1-\beta(\bar{a}^{ij}))[(K(\bar{a}^{ij}))^{\gamma} - \rho K(\bar{a}^{ij})])\right. \\ & \left. +(1-a^{1i}a^{2})u(Y - \phi(\bar{a}^{ij}) - (1-\beta(\bar{a}^{ij}))\rho K(\tilde{a}^{i}))\right] \\ + \left(1 - T(\bar{a}^{ij})\right) & \left[a^{1j}a^{2i}u(Y - \phi(\bar{a}^{ij}) + (1-\beta(\bar{a}^{ij}))\left[(K(\bar{a}^{ij}))^{\gamma} - \rho K(\bar{a}^{ij})\right])\right. \\ & \left. +(1-a^{1j}a^{2i})u(Y - \phi(\bar{a}^{ij}) - (1-\beta(\bar{a}^{ij}))\rho K(\bar{a}^{ij}))\right] \end{aligned} \tag{21}$$

and

$$\begin{aligned} U^{ji} = T(\bar{a}^{ij}) & \left[a^{1i}a^{2j}u(Y + \phi(\bar{a}^{ij}) + \beta(\bar{a}^{ij})[(K(\bar{a}^{ij}))^{\gamma} - \rho K(\bar{a}^{ij})])\right. \\ & \left. +(1-a^{1i}a^{2})u(Y + \phi(\bar{a}^{ij}) - \beta(\bar{a}^{ij})\rho K(\bar{a}^{ij}))\right] \\ + \left(1 - T(\bar{a}^{ij})\right) & \left[a^{1j}a^{2i}u(Y + \phi(\bar{a}^{ij}) + \beta(\bar{a}^{ij})\left[(K(\bar{a}^{ij}))^{\gamma} - \rho K(\bar{a}^{ij})\right])\right. \\ & \left. +(1-a^{1j}a^{2i})u(Y + \phi(\bar{a}^{ij}) - \beta(\bar{a}^{ij})\rho K(\bar{a}^{ij}))\right] \ , \end{aligned} \tag{22}$$

where $T(\bar{a}^{ij}) = \{0, 1\}$ indicates the two possible task allocations within the team.

In (21) and (22) $\phi(\bar{a}^{ij})$ constitutes a transfer of fixed income between the two partners. Partner j additionally receives the share $\beta(\bar{a}^{ij})$ in the firm. Thus, if $\beta(\bar{a}^{ij}) = 0$ ($\beta(\bar{a}^{ij}) = 1$) professional i (professional j) becomes a single entrepreneur paying the wage $\phi(\bar{a}^{ij})$ to her employee j (employee i). It is assumed that the ownership structure, the capital input, and the task allocation within this new entrepreneurial firm are simultaneously determined as the solution of the symmetric Nash-bargaining problem

$$\max_{K(\bar{a}^{ij}),T(\bar{a}^{ij}),\phi(\bar{a}^{ij}),\beta(\bar{a}^{ij})} \left[U^{ij} - v^{i}\right]^{\frac{1}{2}} \left[U^{ji} - v^{j}\right]^{\frac{1}{2}} \tag{23}$$

subject to

$$T(\bar{a}^{ij}) \in \{0, 1\} \ , \tag{24}$$

$$0 \leqq \beta(\bar{a}^{ij}) \leqq 1 \ , \tag{25}$$

$$K(\bar{a}^{ij}) \geqq 0, \tag{26}$$

$$U^{ij} - v^{i} \geqq 0 \text{ and } U^{ji} - v^{j} \geqq 0 \tag{27}$$

where v^i and v^j denote reservation utility levels for the two professionals. Let the superscript "E" denote the bargaining outcomes.

Lemma 3 *Within the current model framework, the symmetric Nash-bargaining solution implies $\phi^E(\bar{a}^{ij}) = 0$ and $\beta^E(\bar{a}^{ij}) = \frac{1}{2}$. The capital input $K^E = K^E(q^E(\bar{a}^{ij}); \rho)$ in such entrepreneurial firms satisfies (2)*

Proof. Consider the optimization problem (23) to (27). Obviously, for every $K(\bar{a}^{ij})$, $\phi(\bar{a}^{ij})$, and $\beta(\bar{a}^{ij})$ (23) is always maximized by choosing the task allocation according to the rule of comparative advantage. Hence, the optimal task allocation implies $T^E(\tilde{a}^i) = 1$ (0) if $a^{1i}a^{2j} \geqq (<) \; a^{1j}a^{2i}$ which yields the definition of $q^E(\bar{a}^{ij}) = \max \{a^{1i}a^{2j}, \, a^{1j}a^{2i}\}$ in the lemma. Further, let

$$\begin{aligned} y_s^{ij} &\equiv Y - \phi(\bar{a}^{ij}) \; + (1 - \beta(\bar{a}^{ij}))[(K(\bar{a}^{ij}))^\gamma - \rho K(\bar{a}^{ij})] && (28) \\ y_{ns}^{ij} &\equiv Y - \phi(\bar{a}^{ij}) \; - (1 - \beta(\bar{a}^{ij}))\rho K(\bar{a}^{ij}) && (29) \\ y_s^{ji} &\equiv Y + \phi(\bar{a}^{ij}) \; + \beta(\bar{a}^{ij})[(K(\bar{a}^{ij}))^\gamma - \rho K(\bar{a}^{ij})] && (30) \\ y_{ns}^{ji} &\equiv Y + \phi(\bar{a}^{ij}) \; - \beta(\bar{a}^{ij})\rho K(\bar{a}^{ij}) && (31) \end{aligned}$$

For interior solutions, the first-order conditions with respect to $\beta(\bar{a}^{ij})$, $K(\bar{a}^{ij})$, and $\phi(\bar{a}^{ij})$, can then be rearranged to yield

$$\begin{aligned} &\left[q^E(\bar{a}^{ij})u'(y_s^{ij})[(K(\bar{a}^{ij}))^\gamma - \rho K(\bar{a}^{ij})] - (1 - q^E(\bar{a}^{ij}))u'(y_{ns}^{ij})\rho K(\bar{a}^{ij})\right] \left[U^{ij} - v^i\right]^{-\frac{1}{2}} \qquad (32) \\ &\left\{\begin{matrix} \geqq \\ = \\ \leqq \end{matrix}\right\} \left[q^E(\bar{a}^{ij})u'(y_s^{ji})[(K(\bar{a}^{ij}))^\gamma - \rho K(\bar{a}^{ij})] - (1 - q^E(\bar{a}^{ij}))u'(y_{ns}^{ji})\rho K(\bar{a}^{ij})\right] \left[U^{ji} - v^j\right]^{-\frac{1}{2}} \\ &\qquad\qquad \text{if } \beta(\bar{a}^{ij}) \begin{cases} = 0 \\ \in (0,1) \\ = 1 \end{cases} , \end{aligned}$$

$$\begin{aligned} &\left[q^E(\bar{a}^{ij})u'(y_s^{ij})[\gamma(K(\bar{a}^{ij}))^{\gamma-1} - \rho] - (1 - q^E(\bar{a}^{ij}))u'(y_{ns}^{ij})\rho\right] \left[U^{ij} - v^i\right]^{-\frac{1}{2}} (1 - \beta(\bar{a}^{ij})) \qquad (33) \\ &= - \left[q^E(\bar{a}^{ij})u'(y_s^{ji})[\gamma(K(\bar{a}^{ij}))^{\gamma-1} - \rho] - (1 - q^E(\bar{a}^{ij}))u'(y_{ns}^{ji})\rho\right] \left[U^{ji} - v^j\right]^{-\frac{1}{2}} \beta(\bar{a}^{ij}) , \end{aligned}$$

and

$$\begin{aligned} &\left[q^E(\bar{a}^{ij})u'(y_s^{ij}) + (1 - q^E(\bar{a}^{ij}))u'(y_{ns}^{ij})\right] \left[U^{ij} - v^i\right]^{-\frac{1}{2}} \qquad (34) \\ = \; &\left[q^E(\bar{a}^{ij})u'(y_s^{ji}) + (1 - q^E(\bar{a}^{ij}))u'(y_{ns}^{ji})\right] \left[U^{ji} - v^j\right]^{-\frac{1}{2}} , \end{aligned}$$

respectively. In the following, assume that $U^{ij} - v^i > 0$ and $U^{ji} - v^j > 0$.

(i) Suppose that $\beta(\bar{a}^{ij}) = 0$ in the optimum. Then, (34) implies

$$\begin{aligned} &q^E(\bar{a}^{ij}) + (1 - q^E(\bar{a}^{ij}))\frac{u'/Y + F(\bar{a}^{ij}) \;)}{u'(Y - F(\bar{a}^{ij}) \; - \rho K(\bar{a}^{ij}))} \qquad (35) \\ = \; &\frac{\left[U^{ji} - v^j\right]^{-\frac{1}{2}}}{\left[U^{ij} - v^i\right]^{-\frac{1}{2}}} \frac{u'(Y + F(\bar{a}^{ij}) \;)}{u'(Y - F(\bar{a}^{ij}) \; + (K(\bar{a}^{ij}))^\gamma - \rho K(\bar{a}^{ij}))} . \end{aligned}$$

The expected surplus $q^E(\bar{a}^{ij})(K(\bar{a}^{ij}))^\gamma - \rho K(\bar{a}^{ij})$ must be positive if $K(\bar{a}^{ij}) > 0$ and, hence, production will take place. Then, (35) contradicts that the LHS of (32) can be greater or equal than the RHS.

(ii) Assuming that $\beta(\bar{a}^{ij}) = 1$ yields a very similar argument as in (i) above. Hence, this case can also be excluded.

(iii) Consequently, let $0 < \beta(\bar{a}^{ij}) < 1$. Conditions (34) and (32) then imply

$$\begin{aligned} & \left[q^E(\bar{a}^{ij})(K(\bar{a}^{ij}))^\gamma - \rho K(\bar{a}^{ij}) \frac{(1 - q^E(\bar{a}^{ij}))u'(y_{ns}^{ij})}{u'(y_s^{ij})} \right] \times \\ & \left[q^E(\bar{a}^{ij}) + \frac{(1 - q^E(\bar{a}^{ij}))u'(y_{ns}^{ji})}{u'(y_s^{ji})} \right] \\ = & \left[q^E(\bar{a}^{ij})(K(\bar{a}^{ij}))^\gamma - \rho K(\bar{a}^{ij}) \frac{(1 - q^E(\bar{a}^{ij}))u'(y_{ns}^{ji})}{u'(y_s^{ji})} \right] \times \\ & \left[q^E(\bar{a}^{ij}) + \frac{(1 - q^E(\bar{a}^{ij}))u'(y_{ns}^{ij})}{u'(y_s^{ij})} \right] . \end{aligned} \tag{36}$$

The second terms on each side of (36) are clearly positive. Thus, suppose the two terms in the first quantities on both sides of the equation are also positive. In this case, (36) is easily verified to imply

$$\frac{u'(y_s^{ij})}{u'(y_{ns}^{ij})} = \frac{u'(y_s^{ji})}{u'(y_{ns}^{ji})} . \tag{37}$$

This conclusion may not hold if, and only if, both first terms on each side of (36) are negative. Yet, in this case (36) and (33) contradict. Hence, (37) must hold true in the optimum.

Either (34) or (32) then further yield

$$\frac{\left[U^{ji} - v^j\right]^{-\frac{1}{2}}}{\left[U^{ij} - v^i\right]^{-\frac{1}{2}}} \frac{u'(y_s^{ij})}{u'(y_s^{jj})} = 1 . \tag{38}$$

Notice that, for both institutional regimes, $v^i = v^j = \bar{v}$ since each partner's alternative is to seek industrial employment and, thus, to receive the same wage-income. Further, $U^{ij} = U^{ji} \geq \bar{v}$ with equality only for the marginal entrepreneurial firm. Hence, (38) and (37) then necessarily imply $\phi(\bar{a}^{ij}) = 0$ and $\beta(\bar{a}^{ij}) = \frac{1}{2}$. Insertion into (33) finally yields the capital input rule (2). ■

Also, the above assumption that each partner can observe her colleague's ability profile before production commences can now be supported. The expected utility of each partner of an entrepreneurial firm only depends on team quality. This team quality is maximized by choosing an optimal task allocation. Thus, potential partners possess effective incentives to communicate their abilities in both tasks truthfully.

Tables 1

a) Cut-off team qualities in the spin-off case ($\bar{q}^*$)

and in the incubator case ($\overline{Q}^*$)

risk aversion c		3	4	5		3	4	5
$\rho = 1\%$	$\bar{\mathbf{Q}}^*$	0.19	0.62	0.79	$\bar{\mathbf{q}}^*$	0.65	0.78	0.86
$\rho = 2\%$		0.05	0.28	0.61		0.53	0.68	0.78
$\rho = 3\%$		0.03	0.08	0.43		0.44	0.61	0.72
$\rho = 4\%$		0.02	0.05	0.21		0.38	0.56	0.68
$\rho = 5\%$		0.02	0.04	0.1		0.32	0.51	0.64
$\rho = 6\%$		0.02	0.03	0.06		0.28	0.47	0.61
$\rho = 7\%$		0.02	0.03	0.05		0.25	0.44	0.58
$\rho = 8\%$		0.02	0.03	0.04		0.22	0.4	0.55
$\rho = 9\%$		0.02	0.02	0.04		0.19	0.38	0.52
$\rho = 10\%$		0.02	0.02	0.03		0.19	0.35	0.50

b) Percentage of Entrepreneurs in the Economy

risk aversion c		3	4	5		3	4	5
$\rho = 1\%$	**In**	86	42	23	**Spin**	9	3	1
$\rho = 2\%$	**cu**	98	77	43	**off**	17	7	3
$\rho = 3\%$	**ba**	99	96	62		25	11	5
$\rho = 4\%$	**tor**	> 99	98	84		31	14	7
$\rho = 5\%$		> 99	99	94		39	18	9
$\rho = 6\%$		> 99	99	97		45	22	11
$\rho = 7\%$		> 99	99	98		50	25	13
$\rho = 8\%$		> 99	> 99	99		55	29	15
$\rho = 9\%$		> 99	> 99	99		61	31	17
$\rho = 10\%$		> 99	> 99	99		61	35	19

Table 2:

Welfare Dominance of Institutional Regimes

under Varying degrees of Risk-Aversion

risk aversion c	1	2	3	4	5	6	7	8	9	10
$E(u\|incubator)$	-0.28	-1.47	-1.25	-1.53	-2.12	-2.62	-3.20	-4.04	-5.19	-6.82
$E(u\|spin-off)$	-0.50	-1.73	-1.43	-1.45	-1.61	-1.91	-2.38	-3.07	-4.07	-5.47
$CE(incubator)$	0.76	0.68	0.63	0.60	0.59	0.60	0.61	0.62	0.63	0.63
$CE(spin-off)$	0.61	0.58	0.59	0.61	0.63	0.64	0.64	0.65	0.65	0.65

Definitions: $E(u|incubator)$ $[E(u|spin-off)]$ and $CE(incubator)$ $[CE(spin-off)]$ denote the *ex-ante* expected utility and the certainty equivalent income, respectively, associated with the efficient incubator [spin-off] equilibrium. $\bar{q}|\, incubator$ $[\bar{q}|\, spin-off]$ denote the cut-off team quality associated with the efficient incubator [spin-off] equilibrium. All teams with quality higher than $\bar{q}$ found an enterprize.

Note: The interest rate ρ has been set to 4% in this simulation.

Tables 3:

Welfare effects of varying interest rates and relative risk aversion

a) Expected utilities [$E(u|incubator)$, respectively $E(u|spin-off)$]:

risk aversion c		3	4	5		3	4	5
$\rho = 1\%$	**In**	-1.137	-1.013	-0.935	**Spin**	-0.951	-0.787	-0.737
$\rho = 2\%$	**cu**	-1.199	-1.409	-1.498	**off**	-1.195	-1.099	-1.126
$\rho = 3\%$	**ba**	-1.229	-1.499	-1.878		-1.343	-1.305	-1.404
$\rho = 4\%$	**tor**	-1.252	-1.527	-2.124		-1.433	-1.450	-1.611
$\rho = 5\%$		-1.270	-1.546	-2.189		-1.504	-1.572	-1.788
$\rho = 6\%$		-1.286	-1.564	-2.220		-1.549	-1.667	-1.928
$\rho = 7\%$		-1.299	-1.579	-2.235		-1.580	-1.739	-2.055
$\rho = 8\%$		-1.310	-1.593	-2.253		-1.606	-1.813	-2.169
$\rho = 9\%$		-1.322	-1.605	-2.269		-1.628	-1.859	-2.275
$\rho = 10\%$		-1.332	-1.617	-2.284		-1.636	-1.910	-2.356

b) Certainty equivalent incomes [$CE(incubator)$, resepctively $CE(spin-off)$]:

risk aversion c		3	4	5		3	4	5
$\rho = 1\%$	**In**	0.663	0.690	0.719	**Spin**	0.725	0.751	0.763
$\rho = 2\%$	**cu**	0.646	0.618	0.639	**off**	0.647	0.672	0.686
$\rho = 3\%$	**ba**	0.638	0.606	0.604		0.610	0.634	0.650
$\rho = 4\%$	**tor**	0.632	0.602	0.586		0.591	0.613	0.628
$\rho = 5\%$		0.627	0.600	0.581		0.577	0.596	0.612
$\rho = 6\%$		0.624	0.597	0.579		0.568	0.585	0.600
$\rho = 7\%$		0.620	0.595	0.578		0.563	0.577	0.591
$\rho = 8\%$		0.618	0.594	0.577		0.558	0.569	0.583
$\rho = 9\%$		0.615	0.592	0.576		0.554	0.564	0.576
$\rho = 10\%$		0.613	0.591	0.575		0.553	0.559	0.571

Figure 1:

The Payoff (Lottery) Associated with Occupational Choices

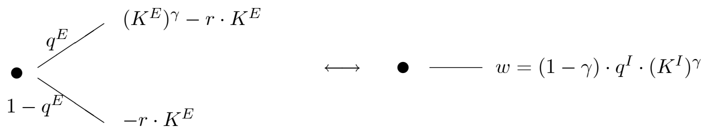


Figure 2:

Production Teams opting for industrial labor in spin-off setting

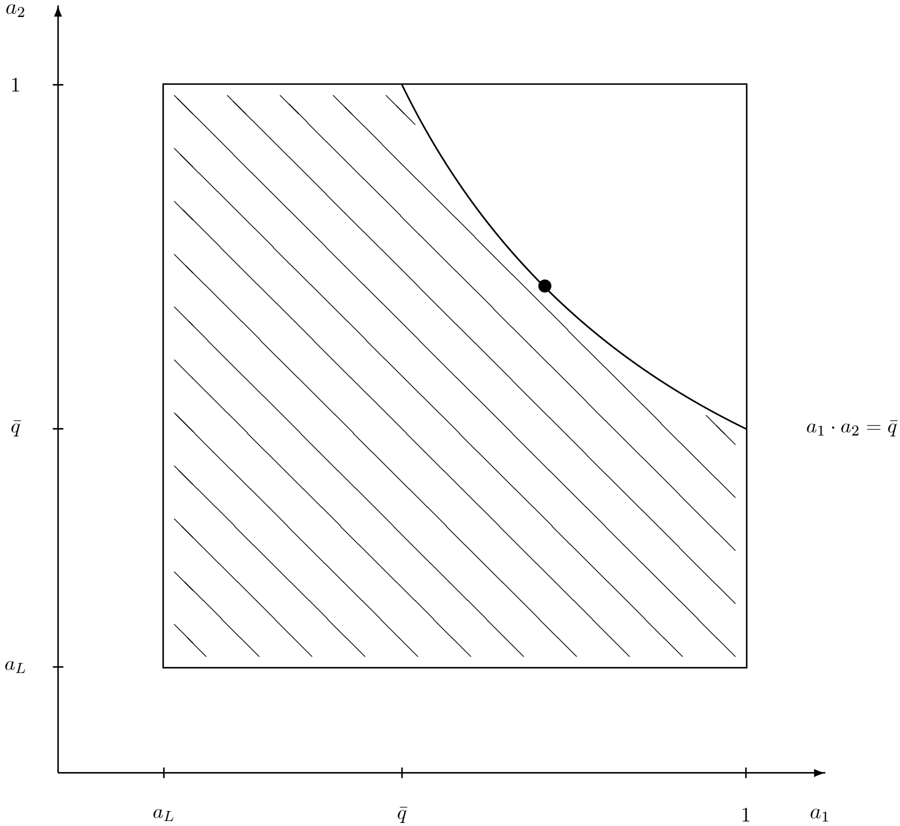


Figure 3:

Professionals opting for industrial labor in incubator setting

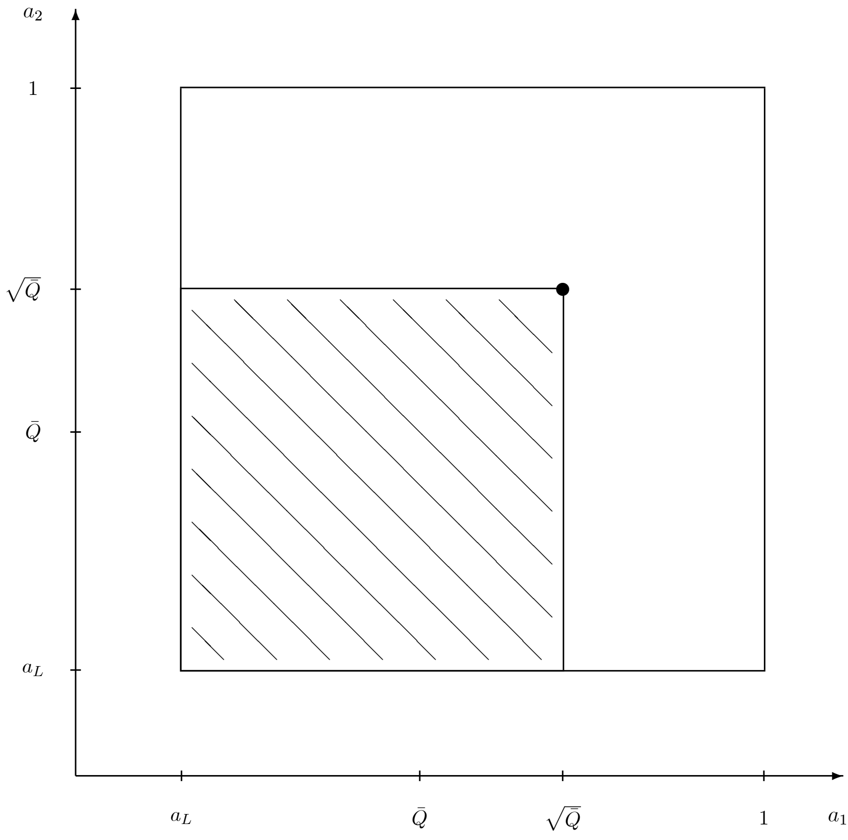
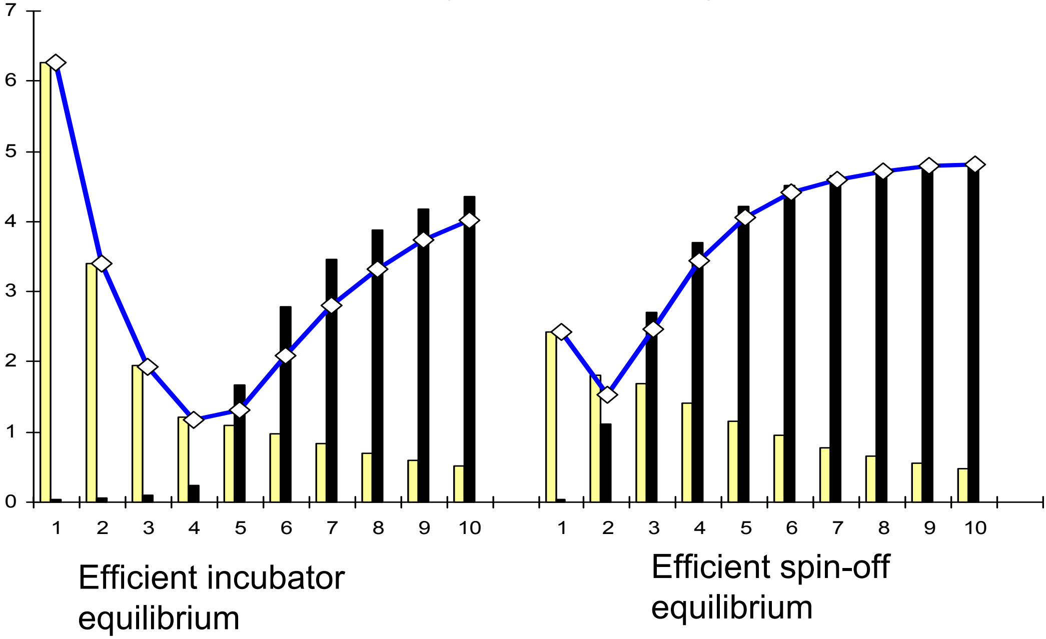


Figure 4 a): Capital input as a function of risk-aversion

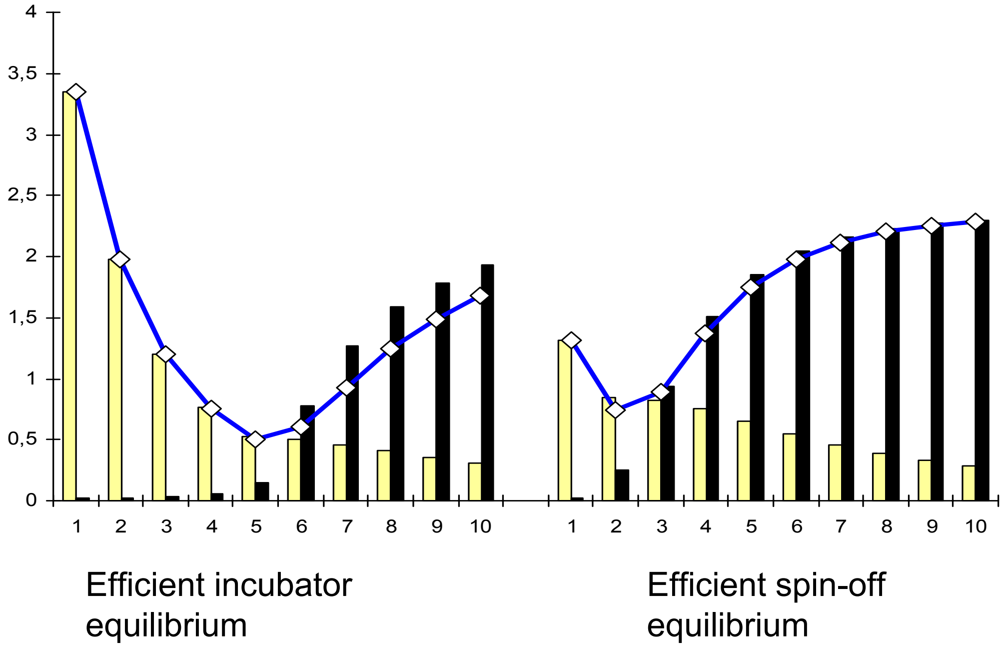
(interest rate: 3 %)



Remarks: dark columns: capital input of the industrial firm; light columns: average capital input of entrepreneurial firms; line with diamonds: average capital input in the industry.

Figure 4 b): Capital input as a function of risk-aversion

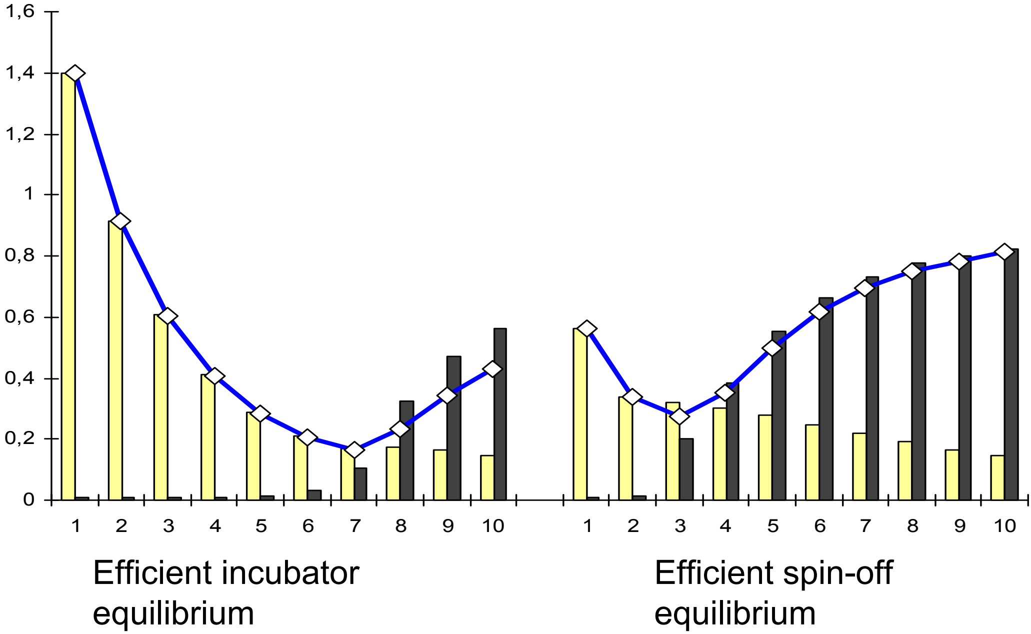
(interest rate: 5 %)



Remarks: dark columns: capital input of the industrial firm; light columns: average capital input of entrepreneurial firms; line with diamonds: average capital input in the industry.

Figure 4 c): Capital input as a function of risk-aversion

(interest rate: 10 %)



Remarks: dark columns: capital input of the industrial firm; light columns: average capital input of entrepreneurial firms; line with diamonds: average capital input in the industry.

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