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The Circulation of Ideas in Firms and Markets

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Abstract

The paper compares how different contractual environments support invention and implementation. Innovative but incomplete ideas require feedback and elaboration by other agents, yet when shared they may be stolen. Markets, as open exchange systems, are good for idea circulation and thus elaboration, but may fail to reward idea generation. Firms, as controlled idea exchange systems, can reward idea generation but restrict their circulation. A key finding is that an efficient environment requires a symbiotic relationship between markets and *open* firms, where ideas are allowed to cross firm boundaries. This interaction optimizes the basic trade-off between protecting rewards to invention and the best implementation of ideas.

Key Words: Ideas, Innovation, Entrepreneurship, Spawning, Firm Organization, Start-Ups
JEL Classification: D83, L22, M13, O31

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1 Introduction

The role of innovation in economic growth is well recognized (Romer, 1990), yet the process of generating innovative ideas is still a novel field of inquiry. The literature has focused on the role of intellectual property rights as incentive for invention (Nordhaus, 1969, Gallini and Scotchmer, 2001). We focus here on an earlier stage in the innovation process, where ideas are still half-baked so they cannot yet be patented, yet need to be shared in order to be further screened and elaborated. We study how different contracting environments promote the development of novel concepts, in the process exploring the notion that a free circulation of ideas may be as critical for innovation as their protection. Our main result is that the most innovative environment requires a symbiotic interaction between large firms and market-intermediated start ups. We show why established firms may specialize in incubating ideas, while markets (in the sense of open idea exchanges without a governance structure) are complementary, elaborating those ideas which do not fit firms.

The technological success of new ventures in Silicon Valley is often taken as evidence that innovation thrives in a free market environment. Yet any history of Silicon Valley essentially comprises a long list of talented people leaving large firms with novel ideas. According to Bhidé (2000), over 70 % of the founders of firms in the Inc. 500 list of fast growing high tech firms developed ideas encountered in previous employment. Gompers, Lerner and Scharfstein (2005) and Klepper and Sleeper (2002) provide evidence that established firms play a major role as incubators for innovative ideas which later are developed in new ventures by departing employees.[1]

Following Schumpeter (1926, 1942) we define an idea as a novel combination of existing factors (see also Biais and Perotti, 2004, and Weitzman, 1998). In this paper we study early stage ideas, defined as incompletely specified. An incomplete idea needs to be shared with agents who have expertise that is complementary to the inventor's. Yet in the case of a truly novel idea, it is not obvious in which direction it should be developed, and thus what may be the "missing" expertise. Innovative concepts cannot be planned as by definition their development cannot be well anticipated. As a result, a broad circulation of ideas is critical for innovation, as it allows maximum chance of elaboration. Saxenian (1994) emphasizes "cross-pollination" and open networking as a main cause of Silicon Valley's innovative success.

Yet there is a fundamental problem with the open circulation of ideas, namely that they can be easily stolen (Arrow, 1962). This is particularly true for ideas that are incomplete, and thus too vague for an independent patent office to grant exclusive property rights.[2] Similar to Anton and Yao (1994, 2002), we argue that

[1]Most R&D is still performed in established firms. The National Science Foundation estimates private industrial R&D spending at $180 billion in 2003 (latest available data). In comparison, the National Venture Capital Association reported investments in venture capital backed companies amounting to $18 billion.

[2]The well-known Yale survey found that patent protection is only one among many ways that firms protect their intellectual property, and that patents only matter for a limited set of industries

agents will not agree to sign a contract on an idea without knowing its content in advance. In practice, such "non-disclosure agreements" (NDAs henceforth) are never used by agents repeatedly involved in assessing new ideas, such as venture capitalists and Hollywood producers. Since agents are unwilling to sign such blind contracts, incomplete ideas must be shared without contractual protection.[3]

We characterize the process of elaborating incomplete ideas as a unguided search for some complementary expertise the inventor does not possess. This need to circulate ideas in an unstructured fashion, however, conflicts with the ability to prevent their appropriation, and thereby reward its generation. In our model, an inventor must find a partner with complementary skills (a "complementor") who is able to elaborate the initial concept. If the inventor meets a complementor, both parties have incentives to cooperate. Alternatively, the inventor may meet an agent whose skills essentially replicate his own, which we term a "substitute." A substitute understands the idea, but is unable to elaborate on it and thus cannot gain from the interaction. We show that he has an incentive to steal the idea and seek to complete it with other partners. In an open exchange environment such as a market, ideas will circulate through a sequence of agents, not necessarily their inventors, until matched to a complementor. From a social perspective, a free circulation of ideas is efficient in ensuring their elaboration, yet cause frequent idea stealing which may deny the inventor a sufficient reward for invention.

We argue that firms emerge as a solution to this market failure. Agents who accept employment in a firm agree, as part of their labor contract, to be bound by trade secret law. This effectively constitutes a broad non disclosure agreement on all ideas actively explored inside the firm. In exchange, the firm has to commit to reward inventors, a commitment which we argue is backed by its reputation. Reputation is modeled as the outcome of a sunk investment that large firms make in order to establish visibility among a limited set of agents (Kreps, 1986). The threat of loss of corporate reputation ensures that agents would contractually commit to sharing and not stealing ideas inside the firm, while they would refuse to sign an equivalent contract with an individual agent. An advantage of firms vis-à-vis market agents is that they provide a safe idea exchange not only with their owners, but also among the set of other employees.

The model implies an internal organization of the firm which "registers" employee ideas as internal projects and "credits" their inventors. A verifiable paper trail has a double purpose. First, it enables the firm to commit to reward idea generators. Second, it enables to lay a claim on the idea, ensuring that no employee may take an internally generated idea outside the firm, i.e., it helps to establish a firm's trade

(Levin et. al., 1987).

[3]We also develop a model extension that formally explains why not signing an NDA is a natural equilibrium outcome. If the agent receives the information first, then he longer benefits from signing the NDA. But if the agent hasn't seen the information, then the agent exposes him/herself to a risk of extortion.

secret. This provides a specific justification for the bureaucracy associated with large firms (Novaes and Zingales, 2004).

Firms, however, have important drawbacks. Reputation creation may be expensive, and monitoring the outflow of ideas may be costly. More fundamentally, containing ideas within firm boundaries limits the set of possible matching expertise. This leads to our main result: just as market failure creates a need for idea-incubating firms, firm failure to develop some internal projects creates a role for markets to complete those ideas not elaborated inside firms. This requires firms to become open, in the sense of allowing employees to spin-off their ideas that could not be used internally (Lewis and Yao, 2003). Thus, in our approach firms and markets truly complement one another, each compensating for the inefficiency of the other. Firms incubate ideas, while markets increase their chances of elaboration. This complementarity suggests a natural symbiosis of open firms and markets.[4]

An interesting finding is that while firms individually find it worthwhile to allow ideas to circulate beyond their boundaries, collectively they may be worse off with mobility. Idea mobility increases the returns for independent market agents to listen to ideas, and thus the cost to hiring employees. In our context, idea mobility is favorable to firms only as long as there are few other firms. As the density of firms increases, the increased cost of hiring employees outweighs the direct gain of allowing spin-offs.

Our analysis illustrates the importance of skill complementarity for innovation. The independent exchange of ideas in markets fails when there are too few complementors, because it is difficult for idea generators to capture enough value from their idea. Firms also rely on the presence of complementors, without whom too many ideas remain without an internal fit and have to be spun out into the market.

Finally, we show that market agents have a comparative advantage in developing valuable ideas requiring modest budgets, so they may account for a large fraction of radical innovations, whereas firms may focus on larger scale, complex ideas which require substantial investments. Interestingly, this result is not a consequence of financial constraints (as often assumed), but rather of the difficulty for inventors to secure a return on their ideas in the market.

Relationship to the literature

The modern theory of the firm shows that assets ownership is a residual right of control designed to resolve hold up problems (Williamson, 1975, Hart, 1995). Holmström and Roberts (1998) suggest that ideas and people should belong at the core of any theory of the firm. Our approach integrates these views by showing how individual choices are essential for the specification of corporate ownership rights on

[4]Note that by firms we mean large multi-project firms, rather than entrepreneurial single-project start-ups which we associate with markets.

intellectual assets. An employee's idea is in principle an intangible real asset owned by the firm, but cannot be claimed unless the employee chooses to report it.

In our model, firms emerge as legal boundaries around people and their ideas. As in Coase (1937), firms compensate for market failure, and specifically the inability to protect inventors against idea stealing. However, firms generate their own inefficiency, by limiting idea circulation inside their boundaries. Our results points to an important symbiotic relationship between firms and markets, with markets refining ideas that could not be elaborated within firms. Our model of coexistence is consistent with the empirical evidence on firms spawning innovative ventures (Gompers, Lerner and Scharfstein, 2005, Klepper and Sleeper 2005). Azoulay (2004) finds that pharmaceutical firms, while actively outsourcing in many other areas, maintain strong firm boundaries around knowledge intensive projects. Kremp and Mairesse (2004) find a positive relationship between firms' internal knowledge management systems and their innovative performance.

This paper contributes to the recent theory literature on innovation. The optimal allocation of control over observable innovative ideas is analyzed in Aghion and Tirole (1994). Critically, ideas are non excludable, and their origin is usually unverifiable. Anton and Yao (1994) show that inventors can secure some value from their idea by threatening to transmit it further, creating more competitors. Anton and Yao (2002, 2004) consider partial disclosure of ideas, as also Bhattacharya and Guriev (2006) and Cestone and White (2003). Baccara and Razin (2006a) examine a complex bargaining game where inventors consider whether to buy out all idea holders, or whether to allow some leakage of ideas, while Baccara and Razin (2006b) extend it by examining how a firm can provide incentive to prevent idea leakages. Rajan and Zingales (2001) examine how a hierarchy may prevent idea-stealing by granting access to its technology only to dedicated employees. Gromb and Scharfstein (2001) argue that firms have an advantage at knowing an employee's track record, which reduces the risk of innovative investment. Cassiman and Ueda (2006), Gambardella and Panico (2006), and Hellmann (2006) explain why firms may sometimes refuse to implement profitable employee innovations. Ueda (2004) and Chemmanur and Chen (2006) examines the trade-off of talking to uninformed investors who cannot steal an idea, versus venture capitalists who can. Biais and Perotti (2004) show that an unpatentable idea may be safely shared with experts in a partnership, only when their expertise is highly complementary. The current paper pursues this notion of complementarity one step further - or rather earlier - by allowing the complementary agent not just to screen, but to elaborate an initially incomplete idea.

A related literature has examined R&D spillovers across firms (d'Aspremont and Jacquemin, 1988, Kamien, Müller and Zhang, 1992). The literature on the open source movement also addresses the question of voluntary exchange of ideas (Lerner and Tirole, 2002; Johnson, 2002).

In section 2 we develop the basic model, focusing on idea exchanges in markets. In section 3 we develop a model of the firm, focusing on closed firms where ideas cannot escape. In section 4 we present a model where ideas may circulate across firm boundaries, and where firms and markets coexist. Section 5 provides an applied discussion, exploring several model predictions. We conclude with some thoughts for further research.

2 Idea exchange in markets

2.1 Ideas and agent types

The model has an infinite number of periods, with a discount factor of δ across periods. There is a mass of agents of unit size. At the beginning of each period, agents decide whether to create a firm (i.e., become an owner), join a firm (i.e., become an employee) or be active in the market (i.e., become what we call a market agent). Employees and market agents can attempt to generate a new idea, at a private cost ψ, in which case they generate an idea with probability γ. Idea generation is not verifiable per se. The idea is too incomplete and vague to be patentable, so idea generators need to find the complementary skills to further develop it. Complementarity is idea specific, so it is not obvious ex-ante which individual would be the right match. If a complementor is found, the idea is completed by the cooperative effort of both parties, in which case it produces a payoff z at the end of the period. For simplicity, if two parties attempt to implement the idea non-cooperatively, Bertrand competition ensures that all payoffs are zero.

Each period is divided in talking rounds, each of which takes an arbitrarily short time ε. We focus on the case of $\varepsilon \to 0$. In each talking round agents are matched at random and may talk about their ideas. Consider the process of finding a complementor. We call the agent with the idea the "talker," and his match the "listener." Because ideas are independent of each other, one agent can be a talker with respect to his idea, and also be a listener with respect to the other agent's idea.

A listener can have one of two unobservable types of idea-specific skills. With probability ϕ, the listener is a "complementor", who upon hearing the idea knows how to complete it. With probability $\overline{\phi}(\equiv 1 - \phi)$, the listener is a "substitute" who has the same skills as the talker, and thus does not know how to further elaborate the idea. We assume that the process of sharing an idea reveals the agent's type (e.g., the questions asked in the exchange reveal the listener's own understanding and interpretation).[5]

The remainder of this section examines the interaction among market agents in an environment without any governance structure. Section 3 and 4 examine open and closed firms as alternative governance mechanisms.

[5] In Hellmann and Perotti (2005), we also consider the case where agents can hide their type. We show how in this case substitutes may misrepresent their types, discourage talkers from pursuing their ideas, and then secretly steal the idea.

2.2 Bargaining

Market interaction offers idea generators unrestricted matching with an infinite set of free agents, not subject to any governance structure. We assume that listeners will not sign any contract before listening to an idea since blindly signing a contract before seeing the content of the commitment expose agents to a risk of extortion. (In the appendix we provide an extension that rationalizes this assumption). A talker must therefore reveal his idea to a listener without any contractual protection. If the listener is a complementor, it is efficient for the two agents to implement the concept together, after bargaining on how to share its value z. Let the fraction retained by the talker be denoted by a. If the listener is a substitute, it is efficient for the two agents to seek an efficient continuation game, in which only one agent pursues the concept further. Idea stealing is an overt threat whenever the talker meets a substitute, and becomes a reality whenever the substitute is the one to pursue the idea further.

Following Binmore, Rubinstein and Wolinsky (1986), the bargaining process is modeled as an alternating offer bargaining game, where after each offer rejection there is an infinitesimally small probability that a player exits the game. This specification has several advantages. First, its equilibrium coincides with the Nash bargaining solution. Second, this specification guarantees stationarity on and off the equilibrium path, which considerably simplifies the analysis. Specifically, while ideas may circulate via different agents, at any point in the game, only one player carries an idea further. This allows us to obtain a simple and intuitive bargaining outcome.

Consider first the case where a talker encounters a substitute. No joint implementation is possible and both are equally able to pursue the idea. Rather than competing, it is efficient to coordinate on who will continue to pursue the idea. This is easy to enforce, because once the idea is disclosed, parties can easily write contracts. We assume that in this case they simply split the continuation value.[6]

Consider next the case where a talker (denoted by T) encounters a complementor (denoted by C). T may be the idea generator, or a substitute that stole the idea. The efficient bargaining outcome is to cooperate immediately, since the best alternative is that only one of them finds a similarly complementary partner after some delay. To establish the equilibrium value of the talker's share, a, we compute each agent's outside options. Let $D = 1 - \varepsilon\delta$ be the discount factor for the delay of one talking round (so that as $\varepsilon \to 0$, $D \to 1$). C's outside option in case of a breakdown is $o_C \equiv D(\overline{\phi}\overline{a}z + \phi\frac{1}{2}o_C)$. To see this, note that C either finds a substitute to T with probability $\overline{\phi}$ and gets a share $\overline{a}$; or, with probability ϕ, he finds another complementor, in which case they cannot implement the concept, and they toss a fair coin as to who

[6] They may either toss a fair coin to determine who continues, or each may take an equal stake in the venture. Either process is a metaphor for a random process by which the idea is sometimes stolen, sometimes not. What matters is that only one agent pursues the idea further.

continues. Solving the above we obtain $o_C = \dfrac{D\overline{\phi}\overline{a}z}{1 - D\phi\frac{1}{2}}$, which for $D \to 1$ yields $o_C = \dfrac{2-2\phi}{2-\phi}\overline{a}z$. Using similar reasoning, T's outside option in case of breakdown is $o_T \equiv D(\overline{\phi}\frac{1}{2}o_T + \phi az)$, so that for $D \to 1$ we have $o_T = \dfrac{2\phi}{1+\phi}az$. We derive the Nash bargaining outcome, given by $az = \frac{1}{2}z + \frac{1}{2}(o_T - o_C)$. Substituting the values for $o_i, i \in (T, L)$, solves for the bargaining share a:

$$a = \frac{1}{2}\frac{\phi + \phi^2}{1 - \phi + \phi^2}. \tag{1}$$

Lemma 1: The more common is the complementary skill ϕ, the greater is the bargaining stake a gained by the talker, i.e., $\dfrac{da}{d\phi} > 0$.

Lemma 1 is easily verified by inspecting (1). They key intuition is that the talker is in a stronger bargaining position if the complementor's skills are easier to replace. The stake gained by either agent increases in the relative scarcity of its skill. Lemma 1 also confirms that our choice of bargaining model leads to a reasonable and intuitive outcome. If the skills were equally frequent, i.e. $\phi = \frac{1}{2}$, then the surplus is split, as $a = \frac{1}{2}$. For $\phi \to 0$ we have $a \to 0$, and for $\phi \to 1$ we have $a \to 1$.

2.3 Market rewards to invention

The ex-ante payoff for a talker sharing his idea in the market may now be determined. With probability ϕ, a talker finds a complementor and bargains for a share az. With probability $\overline{\phi}$, he finds a substitute, in which case they toss a fair coin. If he wins the coin toss, he moves into the next talking round, otherwise he exists. The utility of a talker is therefore given by $u_T = \phi az + \overline{\phi}\frac{1}{2}Du_T$. For $D \to 1$ this implies $u_T = \dfrac{2\phi}{1+\phi}az$, and using (1) we obtain

$$u_T = \frac{\phi^2}{1 - \phi + \phi^2}z. \tag{2}$$

It is easy to verify that $\dfrac{du_T}{d\phi} > 0$, so that a greater availability of complementors increases the talker's utility.

The utility for a listener is given by $u_L = \phi \bar{a} z + \overline{\phi} \frac{1}{2} D u_T$, which for $D \to 1$ yields $u_L = \phi \bar{a} z + \frac{\phi(1-\phi)}{1+\phi} a z$. Using (1) we obtain after transformations[7]

$$u_L = \frac{\phi - \phi^2}{1 - \phi + \phi^2} z. \tag{3}$$

We first assume that all agents attempt to generate ideas. In the first talking round, there is a mass γ of agents with ideas, who are matched with γ listeners. Of those ideas, $\phi\gamma$ are resolved, but $\overline{\phi}\gamma$ ideas remain unresolved. Whether stolen or not, all unresolved ideas go into the second talking round. More generally, in the n$^{\text{th}}$ round $\overline{\phi}^{n-1}\gamma$ ideas remain in circulation. In the first round any agent has a probability γ of becoming a listener. In the second round the number of incomplete ideas becomes $\overline{\phi}\gamma$. The total expected number of listening events is thus $\gamma(1 + \overline{\phi} + \overline{\phi}^2 + ...)$, or $\frac{\gamma}{\phi}$.

Let u_M be the expected utility of operating in the market, the sum of the expected gain from generating an idea, plus the gain of listening to others' ideas. Formally, we have $u_M = -\psi + \gamma u_T + \frac{\gamma}{\phi} u_L$. Using (2) and (3) we obtain after transformations

$$u_M = -\psi + \gamma z. \tag{4}$$

This says that u_M exactly equals the expected value created by investing to produce one idea. This occurs because, as long as all market participants contribute to idea creation, *the expected loss from stolen ideas is matched on average by the expected gain from stealing other agent's ideas.* Accordingly, the utility of operating in the market is independent of ϕ, the chance of finding a complementor.

Markets are efficient at completing ideas, which circulate freely until someone finds a complementor, so in equilibrium all ideas are completed. Yet so far we assumed have that market agents are willing to generate ideas, rather than just listening to others' ideas. The necessary condition for a positive return to generating ideas is $\gamma u_T > \psi$. Using (1), we obtain the following result.

Proposition 1 *There are no ideas developed in the market, and thus no ideas to listen to, whenever*

$$\psi > \psi_M \equiv \frac{\phi^2}{1 - \phi + \phi^2} \gamma z \tag{5}$$

[7] It is easy to verify that $\frac{du_L}{d\phi} = \frac{1-2\phi}{(1-\phi+\phi^2)^2} z$, so that $\frac{du_L}{d\phi} > 0$ for $\phi < \frac{1}{2}$, but $\frac{du_L}{d\phi} < 0$ for $\phi > \frac{1}{2}$. The intuitive reason why the effect of ϕ on u_L is ambiguous is that the listener has a dual identify. He is not only a listener in the current talking round, but possibly also a talker in the next talking round.

Proposition 1 exposes the main weakness of the market as a governance system for idea exchange. Inventors may not appropriate enough value from their ideas to reward their efforts. Condition (5) identifies the threshold cost of generating ideas (ψ_M) beyond which markets fail to generate ideas.

The comparative statics of ψ_M with respect to γ and z are obvious: idea generation is more attractive if ideas are less risky and more valuable. Less obvious is the effect of the probability of meeting a complementor ϕ. It is easy to verify that $sign(\frac{d}{d\phi}\frac{\phi^2}{1-\phi+\phi^2}) > 0$. This suggests the following corollary.

Corollary to Proposition 1: Market agents will not generate any ideas if there are too few complementors, i.e., ϕ to low.

When complementary skills are rare, the net payoff to generating an idea becomes negative, since the idea generator faces a high chance of expropriation from substitute agents. Moreover, Lemma 1 states that even if the generator finds a complementor, he has a weak bargaining position (low a), precisely because the complementor's skills are rare.

In conclusion, a market exchange for ideas (i.e. an open exchange system without any commitment) is ex-post efficient in ensuring that ideas can circulate in an unconstrained set of agents, and all ideas are completed. Yet this form of exchange may fail to reward invention adequately. We now turn to firms as alternative governance solutions.

3 Idea exchange in closed firms

Consider now the firm as an alternative governance mechanism for idea circulation. This section focus on closed firms, meaning firms that operate in isolation, without interacting with the market. The analysis of closed firms is of interest by itself, and also provides a necessary building block for the analysis of section 4, concerning the interaction of markets and (open) firms.

3.1 Firm reputation and employment contracts

We now introduce the firm as a possible solution to the case of market failure, when the expected reward of sharing an idea in the market is too low to justify their generation cost, as under (5). Our notion of a firm relies on two classical characteristics: reputation and authority. While individual actions are not widely observable, an agent may make a sunk investment into establishing a local reputation, by creating some arrangement by which his actions become visible to a subset of agents. Visibility of actions implies the possibility of a reputation equilibrium, where the observers believe the reputed agent until proven wrong (Kreps, 1986).

If an agent is able to establish such a local reputation, he may use it not only to be the recipient of ideas, but he can also use it to establish honest dealing among the subset of agents. In other words, the reputed agent is able to create a firm with a reputation for fair dealing with its employees. Moreover, the employment contract defines a legal boundary for the circulation of internal ideas. In our context it can be interpreted as the sale of future ideas to the firm owner, plus a collective NDA covering ideas registered inside the firm. Trade secret law, a standard feature of all labor contracts, commits employees not to appropriate any internal firm project. As a result, once the idea is recorded as a firm initiative, employees can exchange their ideas without the risk of theft. Naturally, this requires that the firm monitors its boundaries, which may imply a cost (Liebeskind, 1997). We will show later that firms can protect internal ideas even when trade secret law is enforced imperfectly.

For a firm to function as a reliable place of exchange of ideas, four incentive compatibility constraints have to be satisfied. First, agents must be willing to sign a collective NDA agreement in the form of an employment contract. Second, employees must be willing to report their own ideas, thus effectively relinquishing any ownership claim, in exchange for a promised reward. Third, the reputational value must be such that the firm owner prefers to pay the reward rather than stealing reported ideas. Finally, the firm has to be willing to monitor its boundaries, and pursue any idea theft by employees. In section 3.3 we derive the formal reputation condition.

3.2 Rewards to invention in a closed firm

We assume that any agent can make a sunk investment K to create a firm.[8] The sunk investment K creates visibility, and thus potential reputation, among a fixed number E of employees. We will assume that the number of employees is fixed to keep the analysis tractable.[9] For simplicity, once an owner commits to managing a firm, he no longer has time to generate or complement ideas by himself.

The firm can claim ownership over ideas once employees choose to disclose them; or more precisely, it can establish a claim which excludes all employees, but not external agents, at least until the idea is developed enough to be patentable.

When markets do not reward idea generation enough to justify invention, agents prefer to develop and disclose ideas inside firms, where they are promised a fraction b of their value z. Upon disclosure, ideas are "recorded" as internal projects in a verifiable form. Thus "bureaucratic procedures" and a "paper trail" are essential for the internal reward system, and for internal ideas to be covered by trade secret laws. In the main model we assume that firms can always prevent idea stealing. Section

[8] For expositional convenience we assume in this section that all firms face the same K. Section 4 relaxes this condition.

[9] Our analysis does not seek to provide a theory of the size of firm boundaries. In Hellmann and Perotti (2005) we examine the case where E is endogenous due to convex monitoring costs, which offered no additional insight.

5.1 explores how imperfections in enforcing trade secret law affect the analysis.

Once a generator registers an idea within the firm, he is assigned the task to implement it via internal matching. In managerial terms, he becomes an "internal project champion" or an "intrapreneur." Since no employee can leak the idea outside the firm, the generator can count on cooperation from all internal listeners. Thus the firm does not need to compensate listeners, as they cannot take ideas elsewhere. The utility of listening to ideas inside the firm is therefore zero, i.e., giving feedback to colleagues' ideas is part of the job.[10]

To provide a symmetric treatment of markets and firms, we assume that the chance of finding a complementor inside the firm and in the market is the same, given by ϕ. We further discuss this assumption in section 5.2. The probability that an idea finds no match inside the firm is given by $\overline{\phi}^E$, and so the probability of internal completion is $1 - \overline{\phi}^E$. Note that the probability of completion in the market is 1.[11]

Remark: The probability of idea completion inside the firm is always lower than in the market. A closed firm fails to complete all its internal ideas, whereas the market completes all ideas.

The circulation of ideas in closed firm is less efficient than in a market for two reasons. First, it is costly to set up a firm. Second, the firm allows only for a subset of possible matches. However, closed firms may succeed when markets fail to reward idea generation. Under (5), the reward to operate in the market is zero, as the chance of listening to an idea is zero.[12] Thus the firm owner simply rewards employees based on the value of the completed ideas they generate. Let the reward be a fraction b of its value, contingent on completion. The reward bz must be sufficient to compensate for the idea generation cost (ψ), adjusted for the probability of success (γ), and the probability of completion ($1-\overline{\phi}^E$). The expected utility of generating an idea is given by $u_E = (1 - \overline{\phi}^E)\gamma bz - \psi$.

[10] This is a specific result which vanishes once we allow for imperfect enforcement of trade secret laws.

[11] In the first talking round, the probability of completion is ϕ. With probability $\overline{\phi}$, the idea moves into a second talking round, where the probability of completion is ϕ. With probability $\overline{\phi}^n$, the idea moves into a $(n+1)^{th}$ talking round. Thus the probability of completion is given by $\phi + \phi\overline{\phi} + \phi\overline{\phi}^2 + \phi\overline{\phi}^3 + ... = \dfrac{\phi}{1-\overline{\phi}} = 1.$

[12] An agent may also consider starting an own firm (we treat this case in Section 4). For this section we assume that there are enough agents who cannot start their own firm, e.g. because they cannot afford the reputational investment K. This ensures that the outside option for the marginal employee is zero.

The firm's optimal compensation is thus given by

$$b = \frac{\psi}{(1-\overline{\phi}^E)\gamma z}. \tag{6}$$

Note that this optimal level of b also ensures disclosure. To see this more formally, note that (6) implies that the employee's return from disclosure is $(1-\overline{\phi}^E)bz = \frac{\psi}{\gamma}$. Without disclosure, the employee would have to leave the firm to obtain market returns δu_T, which from (5) is always less than $\frac{\psi}{\gamma}$.

The expected profit per period of a firm (gross of any reputational investment costs) is given by $\pi = E(1-\overline{\phi}^E)\gamma(1-b)z - \psi$. Substituting for b we obtain

$$\pi = E((1-\overline{\phi}^E)\gamma z - \psi) \tag{7}$$

The comparative statics are intuitive: π is increasing in γ, z and ϕ, and decreasing in ψ.

3.3 Credible Reputation

This subsection solves for the reputation constraint, i.e. the condition that ensures that firm owners choose to maintain their reputation. In principle, a firm owner could renege by failing to reward employees for their ideas, or he could misattribute ideas to other employees, etc.. From a model perspective, we only need to concern ourselves with the *maximal* deviation. It is easy to see that the most profitable deviation for the owner is to let the employees do all the work, and then not pay them, i.e., refuse to pay the bonus bz for completed ideas.[13] The maximal deviation for a firm owner would be to simultaneously refuse to pay all employees, in the rare event that they all had a completed idea at the same time. The value of this maximal deviation is Ebz. With this we can state the reputation condition as follows:

Reputation condition: A firm owner can credibly commit to maintain the firm's reputation if

$$Ebz < \frac{\delta}{1-\delta}\pi. \tag{8}$$

This condition is always satisfied for δ sufficiently close to 1, and we assume it satisfied for the remainder of the analysis.

[13] Based on section 2.4, one may also worry that the firm owner could falsely sue all his employees for appropriating ideas, with the intent to blackmail them. However,employees have already given away their rights to all of their ideas. As long as they remain with the firm, the firm owner cannot sue them for stealing ideas.

3.4 Comparing closed firms and markets

In section 4 we examine the coexistence of markets and firms. As a preliminary step, we contrast the key properties of markets and firms taken in isolation. In particular, we identify the critical parameter ranges for which either of these forms of exchange succeed in supporting idea generation. Note that if markets can support idea generation, firms are a dominated form of idea exchange, since they require fixed costs and limit the rate of idea completion.

A potential firm owner enters the market whenever the life-time value of the firm $\frac{\pi}{1-\delta}$ outweighs the required investment cost K. We define a critical value ψ_F such that $\frac{\pi(\psi_F)}{1-\delta} = K$. Since $\pi(\psi_F)$ decreases in ψ, ψ_F is the critical value above which firms do not generate ideas, i.e. are not viable. Using (7) we obtain

$$\psi_F = (1 - \overline{\phi}^E)\gamma z - \frac{m + (1-\delta)K}{E} \tag{9}$$

Figure 1 depicts ψ_M from (5) and ψ_F from (9). The value of ideas (z) is on the horizontal and the cost of generating ideas (ψ) is on the vertical axis.

Proposition 2 *If markets fail, closed firms are feasible for $\psi \in (\psi_M, \psi_F)$. The range (ψ_M, ψ_F) exist whenever the return to ideas (z) is not too low.*

Figure 1 reveals that markets work well for ideas which are valuable if successful and not too expensive to develop (high z, low ψ). Thus highly profitable innovations can be well provided by independent agents, while established corporations have a competitive advantage in intermediate value innovations that require relatively large investment. Empirically, established firms are good at incremental innovations, while radical innovations are often created by market-based entrepreneurs (Christensen, 1997). Our analysis suggests that this may be a natural result of the comparative advantages of firms and markets.

4 Coexistence of open firms and markets

We now examine the full equilibrium model where firms and markets interact. The previous section assumed that firms do not allow employees to leave to pursue ideas not resolved internally. This assumption is reasonable under some circumstances, such as if it is difficult for the owner to ensure that a departing employee is only taking his own ideas, and not any other trade secrets. We consider here the case where owners can monitor this process, and allow their employees to leave to develop specific internal ideas externally, in order to extract some additional value. We assume that departing employees are allowed to develop registered ideas in a start-up, but not within another established firm. We loosely justify this assumption arguing that firms do not wish to grant advantages to large competitors.

Under (5) the reward to generating ideas in the market system is negative, so all ideas are generated inside firms. Open firms create idea mobility, which allows market agents to hear ideas leaving firms. As before, an idea may be shared with all firms employees in one period, and ideas circulating in the market are completed within one period. We assume that employees commit to stay with their firm for at least one period, so that ideas not completed in a firm can move to the market after one period delay.

Agents may be of three types: firm owners, employees and market agents, with densities n_F, n_E and n_M respectively. Note that $n_E = En_F$ and $n_M = 1 - n_E - n_F = 1 - (1 + E)n_F$. Section 4.3 uses a free entry condition to determine the equilibrium density of firms n_F. In this section we assume that K varies across individuals, reflecting for instance different initial endowments of individual reputation. Specifically, let K be distributed according to some cumulative distribution $\Omega(K)$. For simplicity we assume that there is never a shortage of potential employees, so that $(1 + E)n_F < 1$. This assumption is satisfied by assuming that $K = +\infty$ for at least n_E agents.

Let us briefly highlight some important characteristics of the coexistence equilibrium between open firms and markets.

Remark: The equilibrium where open firms and market coexist has the following properties:

(i) all ideas are created inside firms;

(ii) some ideas are completed within firms, all others are taken by the inventor into the market for completion;

(iii) all ideas that were not completed inside firms are completed in the market with a one period delay.

4.1 The payoff to be a market agent

In the model with open firms, market agents get to listen to ideas, even though under (5) market agents do not generate ideas. Their utility u_M consists solely of the expected value of listening to others' ideas. This value depends on the frequency of ideas circulating in the market, which in turn depends on the density of firms, as well as their efficiency at completing ideas.

Each firm generates a stock of γ ideas per period, but completes only a fraction $1 - \overline{\phi}^E$, so that the total number of spin-off ideas per period is $n_S = n_E \gamma \overline{\phi}^E$. Note that as n_S employees leave firms at the end of the period to become market agents, they are replaced by n_S market agents that become employees, thus preserving the steady state proportions. The probability for an agent to listen to an idea in the first talking round is $\mu = \dfrac{n_S}{n_M}$, where μ represents the fraction of people with ideas in the market, over the total number of people in the market. Of all the ideas, a fraction ϕ

will be resolved in the first talking round. In the second talking round there are $n_S\overline{\phi}$ ideas, so that the expected number of ideas to listen to in that round is $\frac{n_S}{n_M}\overline{\phi} = \mu\overline{\phi}$. The total expected number of listening events per period is thus $\mu(1+\overline{\phi}+\overline{\phi}^2..) = \frac{\mu}{\phi}$.

Using $\mu = \frac{n_E\gamma\overline{\phi}^E}{n_M}$, $n_E = En_F$ and $n_M = 1 - n_F - En_F$, we note that

$$\mu = \frac{\gamma n_F E\overline{\phi}^E}{1-(1+E)n_F} \tag{10}$$

This generates the following useful Lemma.

Lemma 2: The frequency with which free agents hear new ideas, $\frac{\mu}{\phi}$, is increasing in the density of firms n_F.

A greater density of firms increases the reward for market agents, because more firms means more ideas that escape into the market. This identifies an important symbiotic relationship between firms and markets.

The expected reward to listening is given by u_L as determined by equation (3). Thus $u_M = \frac{\mu}{\phi}u_L$. Using (10) we obtain

$$u_M = \frac{\gamma n_F E\overline{\phi}^E}{1-(1+E)n_F}\frac{1-\phi}{1-\phi+\phi^2}z \tag{11}$$

This allows us to state the following Proposition.

Proposition 3 *(i) An agent's utility in the market u_M is increasing in the density of firms n_F.*

(ii) For a given density of firms n_F, u_M is decreasing in ϕ, and increasing in γ and z.

The proof is in the appendix. Proposition 3 describes the reservation utility for employees. This is characterized by the $\mathcal{M}$ curve in Figure 2, which presents demand and supply of labor. Clearly, u_M is increasing in n_F. The intuition for this is that if there are more firms, then there are more spin-offs, and thus more ideas circulating in the market.

Proposition 3 establishes the comparative statics of u_M. Naturally, u_M is increasing in the value of the firm, thus in γ and z. The fact that it is also decreasing in ϕ is due to the cumulation of three effects. First, from (10) we note that the fraction of ideas going to market agents, given by μ, is decreasing in ϕ. The intuition is that with higher ϕ, more ideas are already resolved inside firms. Second, the term $\frac{1}{\phi}$ is clearly decreasing in ϕ, and represents the speed of completion of ideas entering the market. The faster ideas are resolved in the market, the fewer chances market agents get to hear ideas. Third, in section 2.3 we already noted that the effect of ϕ on u_L is ambiguous. The formal proof in the appendix shows that the second effect always dominates the third, so that u_M is unambiguously decreasing in ϕ. Figure 3 represents this as an outward shift of the $\mathcal{M}$ curve.

4.2 Firm entry

We now turn to the analysis of firm profits, and the related entry decision. In addition to the gain $(1-b)z$ from completed internal ideas, open firms can gain from incomplete ideas which leave the firm. An option is for the firm owner to take a stake in each departing employee's venture (often called a spin off). In this model, this has the same effect as reducing the bonus b, so we assume that the employee retains the full value of the idea after leaving. The employee's utility of generating an idea inside the firm is given by $u_E = (1-\overline{\phi}^E)bz+\overline{\phi}^E\delta u_T-\psi$, where u_T is the utility gained by taking the idea out into the market, discounted by δ because of the one period delay. In equilibrium, the per period reward to employees must match the payoff to operate in the market, namely u_M. The firm's optimal policy is to set rewards so that $u_E = u_M$. Thus the optimal value of b satisfies $b = \frac{\psi + u_M - \overline{\phi}^E\delta u_T}{(1-\overline{\phi}^E)\gamma z}$. The firm's profits are given by $\pi = E(1-\overline{\phi}^E)(1-b)z-m$, or $\pi = E[\gamma(1-\overline{\phi}^E)\gamma z+\gamma\overline{\phi}^E\delta u_T-\psi-u_M]-m$. Using our results for u_T and μ, we can also rewrite this as

$$\pi = E[\gamma(1-\overline{\phi}^E)z+\gamma\overline{\phi}^E\delta\frac{\phi^2}{1-\phi+\phi^2}z-\psi-u_M] \tag{12}$$

The equilibrium density of firms is determined from a free entry condition. Potential owners compare the investment cost K against the discounted expected value of firm profits, given by $\frac{\pi}{1-\delta}$, minus the opportunity cost of not starting a firm, given by the utility to operate in the market, namely $\frac{u_M}{1-\delta}$. The number of agents wanting to start firms is given by $n_F = \Omega(\widehat{K})$ where $\widehat{K}$ is the fixed cost of the marginal entrant. We have $\widehat{K} = \frac{\pi}{1-\delta} - \frac{u_M}{1-\delta}$, so that

$$n_F = \Omega(\frac{\pi - u_M}{1-\delta}). \tag{13}$$

It is easy to see that the reputation condition for the model with open firms is now given by

$$Ebz < \frac{\delta}{1-\delta}(\pi - u_M). \tag{14}$$

With this, we can state the following proposition about firm entry.

Proposition 4 *(i) The equilibrium density of firms n_F is decreasing in u_M.*
(ii) For a given value of u_M, n_F is increasing in ϕ, γ, z, δ and decreasing in ψ.

Proposition 4 characterizes the $\mathcal{F}$ curve in Figure 2. This curve represents the density of firms, as a function of the utility of market agents, which equals the employee's outside option, and thus the cost of hiring. Proposition 4 establishes that n_F is a decreasing function of u_M, implying that the $\mathcal{F}$ curve is downward sloping. The intuition is simply that a higher market utility increases the cost of hiring employees, and thus reduces the optimal density of firms.

Proposition 4 also establishes the comparative statics for n_F. The intuition for γ, z and ψ are straightforward, all relating directly to the ex-ante value of an idea. A higher discount factor δ (corresponding to a lower discount rate) increases the lifetime utility of starting a firm. The most interesting result concerns the fact that n_F is increasing in ϕ. The key intuition is that with more complementors, firms are more likely to complete ideas internally. A higher value of ϕ also increases the utility an employee receives from doing a spin-off. The comparative static result for ϕ is represented in Figure 3, which shows that a higher value of ϕ shifts the $\mathcal{F}$ curve outwards.

4.3 Coexistence equilibrium

We are now in a position to characterize the comparative statics of the equilibrium where firms and markets coexist, which is characterized by the two equilibrium conditions (11) and (13). Figure 2 provides a graphical representation of the equilibrium. Since the $\mathcal{M}$ is upward sloping and the $\mathcal{F}$ curve downward sloping, there exists a unique equilibrium. For expositional convenience we ignore all trivial cases where the $\mathcal{M}$ and $\mathcal{F}$ curve intersect at a corner, such as $n_F = 0$.

We focus on the comparative static results on the equilibrium density of firms n_F. In this model, the number of firms determines the number of agents that generate ideas, and thus the degree of innovation in the economy. Figures 3-5 demonstrate the comparative static effects for u_M.

Proposition 5 *(i) An increase in the number of complementors (higher ϕ), shifts out the $\mathcal{F}$ curve and shifts down the $\mathcal{M}$ curve, resulting in a higher density of firms (higher n_F). See Figure 3.*

(ii) An increase in the value of ideas (higher z), or the probability of generating ideas (higher γ), shifts out the $\mathcal{F}$ curve and shifts up the $\mathcal{M}$ curve, resulting in an ambiguous net effect on the density of firms. See Figure 4. If n_F is sufficiently small (large), the net effect is positive (negative).

(iii) A higher cost of generating ideas (higher ψ), a higher cost of entry (shifting up the distribution $\Omega(K)$), or a lower discount factor (lower δ) shift back the $\mathcal{F}$ curve

without affecting the $\mathcal{M}$ curve, resulting in a lower density of firms (lower n_F). See Figure 5.

Figures 3-5 illustrates the main comparative statics of the model. Figure 3 shows that the effect of increasing the number of complementors increases the density of firms, and thus the number of ideas generated in the economy. The intuition is that this leads to more internal idea completion, making firms more profitable. Moreover, with more complementors, the returns to market agents are lower, thus reducing the cost of hiring employees, further increasing firm profits.

The result of part (ii) (i.e., Figure 4) may seem surprising at first. Intuitively, a higher value of ideas should increase firm profits and thus increase the density of firms. Indeed, this corresponds to the outward shift of the $\mathcal{F}$ curve. However, our analysis identifies a second effect. A higher value of ideas also increases the utility of market agents, and thus the cost of hiring employees, as represented by the upward shift of the $\mathcal{M}$ curve. The net effect of these two effects is ambiguous. In the appendix we derive an analytical expression for this trade-off and show that for sufficiently low values of n_F (this occurs when the distribution Ω puts a lot of weight on higher values of K) the net effect is always positive, but for sufficiently high values of n_F, the net effect is always negative.

The result of part (iii) (i.e., Figure 5) is again very intuitive. Higher idea generation costs do not affect the utility of market agents, since they do not invest in generating ideas, but affect firms negatively, as they bear this cost. As a result, higher reward costs lead to fewer firms. The same result also holds for entry costs, which are directly borne by firm owners. The effect of the discount factor is analogous.

4.4 Comparing open and closed firms

In this section we compare closed and open firms. Market agents clearly prefer open firms, since this creates an outflow of ideas to the market. Employees similarly prefer open firms, since their compensation now must match the increased payoff of market agents. The interesting question is whether firm owners benefit from the move to openness.

From the perspective of the individual firm owner, it is always beneficial to have an open firm, as it gives its employees an additional utility of $\gamma\overline{\phi}^E\delta u_T$, which the firm recoups by lowering its bonus payment b. The question remains whether firms benefit collectively from mobility, as it produces a negative externality. If one firm allows its employees to do a spin-off, this increases the expected utility for all market agents, which in turn raises the cost of hiring for all firms. The following Proposition considers the equilibrium effect of mobility.

Proposition 6 *Mobility increases (decreases) firm profits (π) and the equilibrium density of firms (n_F) if the density of firms is sufficiently small (large).*

The formal proof is in the appendix. The equilibrium effect of mobility on firm profits depends on the relative strength of two effects. There is a positive effect of mobility, coming from the better utilization of internally generated ideas. With mobility, employees obtain a return in the market from those ideas that have no internal match. The negative effect of mobility comes from the externality that spin-offs have on the utility of market agents. Proposition 6 shows that the relative strength of these two effects depends on the density of firms itself (which reflects the distribution of entry costs). Intuitively, if there are only a few firms, then open firms do better than closed ones, because they use fully the ideas their employees generate, while the externality effect is small. For a high density of firms, however, the externality may overshadow the utilization effect. Put differently, the utilization effect does not really depend on the number of spin-offs, but the externality effect is directly related to the number of spin-offs, and thus the density of firms.

5 Extensions

5.1 Imperfect prevention of idea stealing

The analysis so far assumes that the firm can prevent employees from stealing internal ideas. In reality, the firm's monitoring may be incomplete, or the enforcement of trade secret laws may be imperfect. We here briefly sketch how imperfect prevention affects our results. The appendix derives the formal extension.

Consider a simple specification where employees face some probability θ of being caught stealing ideas, in which case they forfeit the value of the idea and may suffer a lower utility for one period. Intuitively, to preserve free circulation of ideas inside the firm, the owner now needs to provide more incentives to employees.

Which employees are most likely to steal ideas? Since firms exist only when equation (6) is satisfied, we deduce that a generator prefers to circulate the idea inside the firm, rather than taking it outside. It is also easy to show that substitutes would not in general steal an internal idea. Everyone needs to wait until the next period to take the idea outside. If the generator does not find an internal match, he can pursue the idea next period with no threat of being pursued. Knowing that he has a natural handicap, the substitute prefers not to compete, and hence never steals the idea. This does not apply to an individual deviation by a complementor, who may have a higher chance of completion. Indeed, we can focus on the most profitable deviation, which is when the generator defects jointly with a complementor. Since they already know that they are a good match, they can avoid the risk of expropriation from an unlucky match in the market. To prevent any such defection, the firm owner needs to reward not only the generator but also the complementor for any internal idea completion.

The following Proposition examines how imperfect prevention affects firm profits and viability, as well as the rewards to the complementor.

Proposition 7 *There exist critical values θ_0 and θ_1 with $0 < \theta_0 < \theta_1 < 1$, such that*
(i) for all $\theta < \theta_0$, the firm is not viable;
(ii) for $\theta_0 < \theta < \theta_1$, the firm's profits are increasing in θ, and the rewards given to the complementor are decreasing in θ;
(iii) for $\theta > \theta_1$ the firm's profits are unaffected by θ.
The critical value θ_0 is increasing in K and m.

A key intuition is that while paying the complementor is costly, the firm might be able to offset that cost by lowering its payments b to the generator. The proof shows that if prevention is sufficiently good ($\theta > \theta_1$), then the firm does not incur any costs at all, because it has some slack in reducing b without affecting the incentive to generate ideas. The optimal compensation consists of rewarding both the generator and the complementor. For this region we note that even if trade secret law is imperfect, this does not affect out equilibrium outcome. For intermediate values of θ ($\theta_0 < \theta < \theta_1$) there is no more slack: both the incentive constraint for the generator and the no-defection constraint for the complementor are binding. The optimal compensation again consists of rewarding both the generator and the complementor. In this region, however, imperfections in trade secret law are costly to the firm. For θ sufficiently low ($\theta < \theta_0$), satisfying the incentive constraints of both the generator and the complementor becomes too costly for the firm. Since it cannot capture enough of the value generated by the internal circulation of ideas, the firm ceases to be viable. Overall, the main insight is that while the firm requires some protection through trade secret laws, it does not require perfect enforcement, nor perfect monitoring.

5.2 Specialized firms

To offer a fair comparison of firms and markets, the model assumes that their probability of harbouring a complementor (ϕ) is the same. It is interesting to informally consider the possibility that firms specialize in different types of ideas. Specialized firms may attract employees with more complementary capabilities, and this may increases the chance of finding complementors inside the firm. In our context is is not obvious that firms can plan their composition to favor novel ideas, which represent innovative rather than predictable combinations of factors. Yet firms focusing on specific areas may be able to affect their internal rate of completion ϕ for related ideas.

From (7) we know that the firm's profits are increasing in ϕ. Part of this benefit comes from a lower cost of providing incentives to generators (see (6)). Another benefit of specialization could be a higher ability to challenge idea theft, because the firm can more easily lay a claim to a better defined set of ideas. A natural cost may be that the likelihood of generating ideas (γ) might be lower, because the firm is only receptive to a smaller set of ideas.

In an earlier version (Hellmann and Perotti, 2005) we discuss a model extension where some employees leave prior to disclosure. This happens when their ideas fit poorly with the firm's specialization, so that disclosing the idea would be a waste of time and effort.[14] The empirical literature (e.g., Klepper and Sleeper, 2005) suggest that lack of fit is an important determinant of spin-offs activity, and that firms often agree to let employees go. Gene Amdahl, for example, pleaded for a long time with his colleagues at IBM to implement his ideas, before finally starting Amdahl Computers. However, there are other examples where employees left their employer without disclosing anything about their ideas or entrepreneurial ambitions.

5.3 Rewards to entrepreneurship

It is sometimes believed that the returns for developing a new venture are greater for entrepreneurs (market agents) than intrapreneurs (employees). The model identifies some important caveats for this common perception.

First, there is a risk of idea expropriation, so that the successful entrepreneur may not be the original generator. In our model, the probability that an idea generator gets to develop the new venture is given by $\chi_M = \dfrac{2\phi}{1+\phi} < 1$. This contrasts with the probability of doing an internal venture, given by $\chi_F = 1 - \overline{\phi}^E + \overline{\phi}^E \chi_M$. It is easy to verify that $\chi_F > \chi_M$.

Second, the rewards in the market may go disproportionately to the complementor, as revealed by the equilibrium value of a in equation (1). Interestingly, both the first and second of these effects disadvantage entrepreneurs especially in the case of few complementors (low ϕ).

Rewards inside firms may thus look less generous when compared with the returns of successful entrepreneurs, but they may be more reliable, less risky. Indeed, one important finding of the model is that intrapreneurs have many opportunities to discuss their ideas inside the firm, without fear of appropriation, whereas entrepreneurs have to worry about appropriation every time they discuss their ideas.[15]

5.4 The case of Silicon Valley

Our argument that ideas are generated inside firms may seem at odds with the common perception that the most innovative regions, such as Silicon Valley, thrives on entrepreneurial activity. Yet, established firms appear to play a crucial role in the productive structure in Silicon Valley. According to Business Week, Silicon Valley accounted for a remarkable 20% of the *largest* high tech firms in the world in 1997.

[14] there exist other reasons why employees leave without disclosing their ideas, namely if their ideas are exceptionally valuable. One problem is that the firm may not be able to fully adjust its compensation to the value of the idea (see also Gambardella and Panico, 2006). Another problem is that when confronted with a highly profitable idea, the firm may want to renege on its promise to the generator.

[15] This is consistent with recent evidence by Moskowitz and Vissing-Jorgensen (2002), which suggests that entrepreneurs fail to achieve an adequate return for the risks they run.

Moreover, any in-depth study of Silicon Valley notes that many innovations (especially early stage ideas) are originally developed inside established firms, but that entrepreneurs are often more adept at developing them. Indeed, entrepreneurs are often not the original inventors, but rather the ones who develop others' promising ideas. The best-known example is probably Steve Jobs and Steven Wozniak, who took their inspiration for Apple Computers from research at Xerox Parc. More generally, any account of Silicon Valley's success includes a long list of novel ventures started by individuals who left employment with a larger firm. The semiconductor industry, for example, is famous for its genealogy of firms, where each generation of new firms was started by employees leaving their parent firms. Gompers, Lerner and Scharfstein (2005) provide broader cross-sectional evidence on the role that large corporations play in entrepreneurial spawning. Consistent with our mobility model, they find that more open firms tend to spawn more ventures.

Along similar lines, Aoki (2001) and Saxenian (1994) argue that firms with porous boundaries create a symbiotic relationship with free market entrepreneurs. In contrast, a secretive corporate culture which resists interaction with markets may suffocate the circulation and thus subsequent elaboration of internally generated ideas. The hierarchical approach to R&D in Japan and Europe, as well as in the large high tech companies on Route 128 in Massachusetts, has been unfavorably contrasted with the loosely organized open environment of Silicon Valley in California, whose success is attributed to a free movement of ideas and individuals creating innovative ventures via informal arrangements. The intense exchange of ideas in Silicon Valley may seem puzzling, since California actually has a fairly weak tradition of protecting intellectual property, so that is not clear how idea generation may be rewarded (see Gilson 1999, Hyde, 1998). Our model offers a clue, showing that entrepreneurial firm formation and large multi-product firms are actually symbiotic. Large firms are a natural source of innovative ideas, yet many of these ideas can only be realized if they are allowed to move to a free exchange system. In turn, a dynamic market will attract skilled, entrepreneurial individuals only if there are enough firms from which ideas may leave, seeking elaboration. The open environment in Silicon Valley may thus thrive thanks to the historical presence of large firms in the area, which have acted as incubators of new ideas, particularly those which are costly to develop.

6 Conclusions

We have proposed a novel trade-off between the necessity to protect idea generation and the need to share ideas, in order to screen and elaborate them. The free circulation of ideas is efficient for the elaboration of incomplete concepts, but fails to reward personal effort for generating novel concepts. Individuals may voluntarily join close exchange systems, such as firms, to ensure that their initiatives receive support and feedback without being stolen. Firm ownership represent a claim on the use of registered ideas vis-à-vis employees. This creates a legal firm boundary which discourages the escape of ideas. The internal structure of the firm is designed to ensure a controlled circulation of ideas, along with a credible reward system. Our model also suggests that there is a natural symbiosis between the ability of firms to sustain exploration in ambitious ideas and the comparative advantage of market in screening and elaborating ideas which leave firms.

There are several interesting directions for future research which we intend to pursue. An example is the issue of self-selection of agents in firms and markets, which is affected by differences in the reward to complementors inside and outside firms. For instance, agents with a greater predisposition to operate as complementors to incomplete ideas may be better off outside firms, since inside they have no bargaining power to take their skills somewhere else. Examples may be experienced serial entrepreneurs, venture capitalists, seasoned angel investors, and professional mentors (including lawyers and consultants) who specialize in working with inventors/entrepreneurs, helping them to turn their ideas into viable businesses (Lee et. al., 2000). Such specialized complementors often organize alternative organizational structures, such as partnership and networks.

Another compelling research question concerns the generation and circulation of ideas in academia (e.g. Aghion, Dewatripont and Stein, 2005). Although academic researchers rarely capture the value created by their discoveries, the academic publication system may ensure some alternative reward mechanism. More generally, it is important to understand what institutional arrangements support a free circulation of ideas, a valuable public good.

7 References

- Aghion, Philippe, Mathias Dewatripont and Jeremy C. Stein 2005, "Academic Freedom, Private-Sector Focus, and the Process of Innovation," Mimeo, Harvard University.
- Aghion, Philippe and Jean Tirole, 1994, "On the management of innovation," Quarterly Journal of Economics, 1185–207.
- Anton, James, and Dennis Yao, 1994, "Expropriation and Inventions," American Economic Review, 190–209.
- Anton, James, and Dennis Yao, 2002, "The sale of ideas: Strategic disclosure, property rights and contracting," Review of Economic Studies, 69, 513-531.
- Anton, James, and Dennis Yao, 2004, "Little Patents and Big Secrets: Managing Intellectual Property," Rand Journal of Economics 35(1), 1-22, Spring.
- Aoki, Masahiko, 2001, Towards a Comparative Institutional Analysis, MIT Press.
- Arrow, Kenneth, 1962, Economic Welfare and the Allocation of Resources for Inventions, in R. Nelson, Ed., The rate and direction of inventive activity: economic and social factors, Princeton University Press, Princeton.
- d'Aspremont, C. and A. Jacquemin, 1988, "Cooperative and noncooperative R&D in duopoly with spillovers," American Economic Review, 78(5), 1133-1137, December.
- Azoulay, Pierre, 2004, "Capturing Knowledge Across and Within Firm Boundaries: Evidence from Clinical Development," American Economic Review, 94, 5, 1591-1612, December.
- Baccara Mariagiovanna, and Ronny Razin, 2006a, "From thought to practice: Appropriation and endogenous market structure with imperfect intellectual property rights," Working paper, New York University.
- Baccara Mariagiovanna, and Ronny Razin, 2006b, "Curb your innovation: corporate conservatism in the presence of imperfect intellectual property rights," Working paper, New York University.
- Biais, Bruno and Enrico Perotti, 2004, "Entrepreneurs and New Ideas," CEPR Discussion Paper no 3864, London.
- Binmore Ken, Ariel Rubinstein and Asher Wolinsky, 1986, "The Nash bargaining solution in economic modelling," Rand Journal of Economics, Summer, 17(2), 176-188.

- Bhattacharya, Sudipto and Sergei Guriev, 2006, "Knowledge disclosure, patents and optimal organization of research and development," Journal of the European Economic Association, forthcoming.

- Bhidé, Amar V., 2000, "The Origin and Evolution of New Businesses," Oxford University Press.

- Cassiman, Bruno and Masako Ueda, 2006, "Optimal Project Rejection and New Firm Start-Ups," forthcoming, Management Science.

- Cestone, Giacinta, and Lucy White, 2003, "Anti-Competitive Financial Contracting: the Design of Financial Claims," Journal of Finance 58(5), 2109-2141.

- Chemmanur, Thomas and Zhaohui Chen, 2006, "Venture Capitalists versus Angels: The Dynamics of Private Firm Financing Contracts," Boston College Mimeo.

- Christensen, Clay, 1997, The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail, Harvard Business School Press, Boston, Massachusetts.

- Coase, Ronald, 1937, "The nature of the firm," Economica, 4, 386-405.

- Gambardella, Alfonso and Claudio Panico, "Optimal Contracts for Employees' Ideas," Bocconi University, Mimeo, 2006.

- Gallini Nancy, and Suzanne Scotchmer, 2001, "Intellectual property: when is it the best incentive system?," chapter 2 in "Innovation policy and the economy," Vol. 2., eds. A. Jaffee, J. Lerner and S. Stern, MIT Press, Cambridge, Massachusetts, 51-77.

- Gilson, Ronald, 1999, "The Legal Infrastructure of High Technology Industrial Districts: Silicon Valley, Route 128, and Covenants Not to Compete," New York University Law Review, June, Vol. 74(3), 575-629.

- Gompers, Paul, Joshua Lerner, and David Scharfstein, 2005, "Entrepreneurial Spawning: Public Corporations and the Genesis of New Ventures: 1986-1999," The Journal of Finance, 60(2), 577-614.

- Gromb, Denis, and David Scharfstein, 2001, "Entrepreneurial Activity in Equilibrium," Mimeo, Massachusetts Institute of Technology.

- Hart, Oliver, Firms, Contracts and Financial Structure, Clarendon Press, Oxford, 1995.

- Hellmann, Thomas, 2006, "When do Employees Become Entrepreneurs," forthcoming, Management Science

- Hellmann, Thomas, and Enrico Perotti, 2005, "The Circulation of Ideas: Firms versus Markets," Preliminary Version, Mimeo, University of British Columbia.
- Holmström Bengt, and John Roberts, 1998, "The boundaries of the firm revisited," Journal of Economic Perspectives, 12(4), 73-94, Fall.
- Hyde, Alan, 1988, "Silicon Valley's High-Velocity Labor Market," Journal of Applied Corporate Finance, Vol. 11(2), Summer, 28-37.
- Johnson, Justin, 2002, "Open Source Software: Private Provision of a Public Good," Journal of Economics and Management Strategy, Winter, 11(4), 637-663.
- Kamien, M., E. Müller and I. Zhang, 1992, "Research joint ventures and R&D cartels," American Economic Review, 82(5), 1293-1306, December.
- Klepper, Steven, and Sally Sleeper, 2005, "Entry by Spin-offs," Management Science 51(8), 1291–1306.
- Kremp, Elisabeth and Jacques Mairesse, 2004, "Knowledge management, innovation and productivity: a firm level exploration based on French manufacturing CIS3 data," NBER Working paper 10237, January.
- Kreps, David, 1986, "Corporate Culture and Economic Theory," in Alt and Shepsle, editors, Rational Perspectives on Political Science.
- Lee, Chong-Moon, William F. Miller, Marguerite Gong Hancock and Henry S. Rowen, 2000, The Silicon Valley Edge, Stanford University Press, Stanford, California.
- Lerner, Joshua, and Jean Tirole, 2002, "Some simple economics of open source," Journal of Industrial Economics, 52, 197-234.
- Levin, Richard, Alvin K. Kelvorick, Richard R. Nelson and Sidney G. Winter, 1987, "Appropriating the Returns from Industrial R&D," Brooking Papers on Economic Activity, 3, 785-832.
- Lewis, Tracy and Dennis Yao, 2003, "Innovation, Knowledge Flow, and Worker Mobility," Mimeo, University of Pennsylvania, Philadelphia.
- Liebeskind, Julia, 1997, "Keeping Organizational Secrets: Protective Mechanisms and their Costs," Industrial and Corporate Change, 6(3), 623-663.
- Moskowitz, Paul and Annette Vissing-Jorgensen, 2002, "The Return to Entrepreneurial Investment: A Private Equity Puzzle?," American Economic Review, Vol. 92 no. 4, 745-778.

- Nordhaus, William, 1969, "Invention, growth and welfare: a theoretical treatment of technological change," MIT Press, Cambridge.
- Novaes, Walter, and Luigi Zingales, 2004, "Bureaucracy as a Mechanism to Generate Information," Rand Journal of Economics, 35(2), 245-259.
- Rajan, Raghuram and Luigi Zingales, 2001, "The Firm as a Dedicated Hierarchy," Quarterly Journal of Economics, 116, 3, 805-851, August.
- Romer, Paul, 1990, "Endogenous Technological Change," Journal of Political Economy, 98, 5, 71-102.
- Saxenian, Anna Lee, 1994, Regional Advantage: Culture and Competition in Silicon Valley and Route 128, Harvard Business School Press.
- Schumpeter, Joseph, 1926, Theorie der wirtschaftlichen Entwicklung, Duncker and Humbolt, Berlin.
- Schumpeter, Joseph, 1942, Capitalism, Socialism and Democracy, George Allen and Unwin, London.
- Ueda, Masako, 2004, "Banks versus Venture Capital: Project Evaluation, Screening, and Expropriation," April, Journal of Finance.
- Weitzman, Martin, 1998, "Recombinant growth," Quarterly Journal of Economics, 331–360.
- Williamson, Oliver, 1975, "Markets and hierarchies: Analysis and Antitrust Implications" The Free Press, New York, New York.

8 Appendix

8.1 Proof of Proposition 2

To see that ψ_M and ψ_F curves intersect for a positive value of z, consider first z sufficiently small. We have $\psi_F < \psi_M$ which follows from the fact that as $z \to 0$, we have $\psi_M = 0$ but $\psi_F < 0$. For z sufficiently large, however, we have $\psi_F > \psi_M$. To see this, compare the slope coefficients of γz, noting that $(1-\overline{\phi}^E) > \dfrac{\phi^2}{1-\phi+\phi^2}$ $\Leftrightarrow 1 > (1-\phi\overline{\phi})\overline{\phi}^{E-1}$ since $\overline{\phi}^{E-1} < 1$.

8.2 Proof of Proposition 3

The proof is based on taking derivatives of u_M, using (11). We have

$$\begin{aligned}
\frac{du_M}{dn_F} &= \frac{\gamma E\overline{\phi}^E}{(1-(1+E)n_F)^2}\frac{1-\phi}{1-\phi+\phi^2}z > 0 \\
\frac{du_M}{d\gamma z} &= \frac{n_F E\overline{\phi}^E}{1-(1+E)n_F}\frac{1-\phi}{1-\phi+\phi^2} > 0 \\
\frac{du_M}{d\phi} &= -E\overline{\phi}^{E-1}\frac{\gamma n_F E\overline{\phi}^E}{1-(1+E)n_F}\frac{1-\phi}{1-\phi+\phi^2}z \\
&\quad -\frac{\gamma n_F E\overline{\phi}^E}{1-(1+E)n_F}\frac{2\phi-\phi^2}{(1-\phi+\phi^2)^2}z < 0
\end{aligned}$$

8.3 Proof of Proposition 4

The prof is based on taking derivatives of n_F, using (13) and (12). We have

$$\begin{aligned}
\frac{dn_F}{du_M} &= \frac{\omega}{1-\delta}(\frac{d\pi}{du_M}-1) = -\frac{\omega}{1-\delta}(1+E) < 0 \\
\frac{dn_F}{d\gamma z} &= \frac{\omega}{1-\delta}E(1-\overline{\phi}^E+\overline{\phi}^E\delta\frac{\phi^2}{1-\phi+\phi^2}) > 0 \\
\frac{dn_F}{d\psi} &= -\frac{\omega}{1-\delta}E < 0 \\
\frac{dn_F}{d\delta} &= \omega\frac{\pi-u_M}{(1-\delta)^2} + \frac{\omega}{1-\delta}E\gamma\overline{\phi}^E\frac{\phi^2}{1-\phi+\phi^2}z > 0 \\
\frac{dn_F}{d\phi} &= \frac{\omega}{1-\delta}E\gamma z\frac{d}{d\phi}[1-\overline{\phi}^E+\overline{\phi}^E\delta\frac{\phi^2}{1-\phi+\phi^2}] \\
&= \frac{\omega}{1-\delta}E\gamma z[\overline{\phi}^E\delta\frac{2\phi-\phi^2}{(1-\phi+\phi^2)^2} + (\delta\frac{\phi^2}{1-\phi+\phi^2}-1)\frac{d\overline{\phi}^E}{d\phi}] > 0
\end{aligned}$$

where the last inequality follows from $\delta\dfrac{\phi^2}{1-\phi+\phi^2} < 1$ and $\dfrac{d\overline{\phi}^E}{d\phi} = -E\overline{\phi}^{E-1} < 0$.

8.4 Proof of Proposition 5

The only part that needs a formal proof concerns the ambiguity in part (ii). For this, we consider the net effect of increasing z on n_F. We totally differentiate (11) w.r.t. z to obtain

$$\frac{du_M}{dz} = \frac{\gamma n_F E\overline{\phi}^E}{1-(1+E)n_F}\frac{1-\phi}{1-\phi+\phi^2} + \frac{1-\phi}{1-\phi+\phi^2}z\frac{\gamma E\overline{\phi}^E}{(1-(1+E)n_F)^2}\frac{dn_F}{dz}.$$

We totally differentiate (13) w.r.t. z to obtain $\frac{dn_F}{dz} = \frac{\omega}{1-\delta}(\frac{d\pi}{dz} - \frac{du_M}{dz})$, where from (12) we have

$$\frac{d\pi}{dz} = E\gamma(1-\overline{\phi}^E) + E\gamma\overline{\phi}^E\delta\frac{\phi^2}{1-\phi+\phi^2} - E\frac{du_M}{dz}.$$

Thus

$$\frac{dn_F}{dz} = \frac{\omega}{1-\delta}E\gamma(1-\overline{\phi}^E) + \frac{\omega}{1-\delta}E\gamma\overline{\phi}^E\delta\frac{\phi^2}{1-\phi+\phi^2} - \frac{\omega}{1-\delta}(1+E)\frac{du_M}{dz}.$$

and replacing for $\frac{du_M}{dz}$ we obtain

$$\begin{aligned}\frac{dn_F}{dz} = \; & \frac{\omega}{1-\delta}E\gamma(1-\overline{\phi}^E)+ \\ & \frac{\omega}{1-\delta}E\gamma\overline{\phi}^E\delta\frac{\phi^2}{1-\phi+\phi^2} - \frac{\omega}{1-\delta}(1+E)\frac{\gamma n_F E\overline{\phi}^E}{1-(1+E)n_F}\frac{1-\phi}{1-\phi+\phi^2} \\ & -\frac{\omega}{1-\delta}(1+E)\frac{1-\phi}{1-\phi+\phi^2}z\frac{\gamma E\overline{\phi}^E}{(1-(1+E)n_F)^2}\frac{dn_F}{dz}\end{aligned}$$

which is equivalent to

$$\begin{aligned}&\frac{dn_F}{dz}[1+\frac{\omega}{1-\delta}(1+E)\frac{1-\phi}{1-\phi+\phi^2}z\frac{\gamma E\overline{\phi}^E}{(1-(1+E)n_F)^2}\frac{dn_F}{dz}] \\ &= \frac{\omega}{1-\delta}E\gamma(1-\overline{\phi}^E) + \frac{\omega}{1-\delta}\frac{E\gamma\overline{\phi}^E\delta\phi^2}{1-\phi+\phi^2} - \frac{\omega}{1-\delta}\frac{(1+E)\gamma n_F E\overline{\phi}^E}{1-(1+E)n_F}\frac{1-\phi}{1-\phi+\phi^2}\end{aligned}$$

Thus

$$sign(\frac{dn_F}{dz}) = (1-\overline{\phi}^E) + \frac{\overline{\phi}^E\delta\phi^2}{1-\phi+\phi^2} - \frac{(1+E)n_F\overline{\phi}^E}{1-(1+E)n_F}\frac{1-\phi}{1-\phi+\phi^2}.$$

For $n_F \to 0$ we have $sign(\frac{dn_F}{dz}) > 0$ and for $(1+E)n_F \to 1$ we have $sign(\frac{dn_F}{dz}) < 0$.

8.5 Proof of Proposition 6

In the case of no mobility, the firm profits are $\pi = E[(1-\overline{\phi}^E)z - \psi] - m$ while with mobility, profits are $\pi = E[(1-\overline{\phi}^E)z - \psi - u_M + \overline{\phi}^E \delta u_T] - m$. The net effect of mobility on firm profits is denoted by B and is thus given by $B = \overline{\phi}^E \delta u_T - u_M$. Using (11) and (2), we have $B = \frac{\overline{\phi}^E z}{1-\phi+\phi^2}(\delta\phi^2 - \frac{\gamma n_F E(1-\phi)}{1-(1+E)n_F})$, so that $B > 0$ $\Leftrightarrow n_F < \frac{\delta\phi^2}{(1+E)\delta\phi^2 + \gamma E(1-\phi)}$.

8.6 Proof of Proposition 7

Let $\underline{u}$ (with $\underline{u} < u_M$) be the one-period utility of a disgraced idea stealer. For simplicity we retain the assumption that leaving the firm always takes one period. We denote the payment to the complementor by $b_C z$. The firm's payments b and b_C have to satisfy three constraints.

First, b and b_C have to satisfy the participation constraint, which is now given by $u_E \geq u_M \Leftrightarrow [b(1-\overline{\phi}^E)\gamma z + \overline{\phi}^E \delta u_T - \psi] + (E-1)\gamma\phi b_C z \geq u_M$.

Second, b has to satisfy the incentive constraint for idea generation, given by $b(1-\overline{\phi}^E)\gamma z + \overline{\phi}^E \delta u_T \geq \psi$.

Third, b and b_C have to satisfy the incentive constraint for no joint defection, given by

$(b + b_C)z \geq \delta\overline{\theta}z + 2\delta\theta(\underline{u} - u_E)$.

Setting $b = \frac{\psi - \overline{\phi}^E \delta u_T}{(1-\overline{\phi}^E)\gamma z}$, this reduces to the following two conditions:

$$b_C z \geq \frac{u_M}{(E-1)\gamma\phi} \text{ and } b_C z \geq \delta\overline{\theta}z + 2\delta\theta(\underline{u} - u_E) - \frac{\psi - \overline{\phi}^E \delta u_T}{(1-\overline{\phi}^E)\gamma} \equiv \vartheta(\theta).$$

Note that $\vartheta(\theta)$ is a decreasing function of θ. At $\theta = 1$ we have $\vartheta(\theta) < 0$ so that the second constraint is not binding at all, i.e., the no defection constraint is never binding. This means that for θ sufficiently large, imperfect prevention does to impose any additional cost. For $\theta \to 0$, we can rewrite the no defection constraint as $(b + b_C)z \geq \delta z$. Assuming that δ is close to 1, the firm has to pay out almost all of its revenues to the generator and complementor. This means that the firm would not be able to recover its fixed costs. To find the critical value, below which the cannot recover its fixed costs, we consider $\pi(\theta) = E(1-\overline{\phi}^E)(1-b-b_C(\theta))z - m$, where $b = \frac{\psi - \overline{\phi}^E \delta u_T}{(1-\overline{\phi}^E)\gamma z}$ as above and where we assume that the no defection constraint is binding, so that $b_C(\theta) = \frac{\vartheta(\theta)}{z}$. In this case, we note that $b_C(\theta)$ is a decreasing function of θ, as noted in the Proposition. Moreover, $\pi(\theta)$ is an increasing function of θ. A firm remains viable as long as $\frac{\pi}{1-\delta} - \frac{u_M}{1-\delta} - K \geq 0 \Leftrightarrow \pi \geq u_M + (1-\delta)K$. We thus define θ_0 implicitly from $\pi(\theta_0) = u_M + (1-\delta)K$. It is easy to verify that θ_0 is increasing in K and m. So far we have assumed that the no defection constraint is binding. Comparing the two conditions $b_C z \geq \frac{u_M}{(E-1)\gamma\phi}$ and $b_C z \geq \vartheta(\theta)$ we implicitly define the critical value θ_1 such that $\vartheta(\theta_1) = \frac{u_M}{(E-1)\gamma\phi}$. It is immediate that for $\theta > \theta_1$ the condition $b_C z \geq \vartheta(\theta)$ is no longer binding. In this case, the firm can set b and b_C so as to satisfy the first two constraints as in section 3. For $\theta > \theta_1$ the firm's profits thus no longer depend on θ, since θ affects a non-binding constraint.

It is easy to see that substitute employees will not steal ideas, since it takes one period to leave the firm. Even when the generator does not find an internal match, a substitute employee will not pursue a competing venture. Having two agents pursuing the idea is never efficient, unlike the asymmetric equilibria where either the generator or the substitute employee pursue the idea. In section 2.2., the two markets agents are perfectly symmetric and thus need to negotiate which one carries the idea forward. When one of them is supported by the firm, however, a competing venture by a substitute employees is discouraged, as it faces the threat to be sued by the firm for violation of trade secrets. Thus the focal equilibrium becomes the one where only the original generator pursues the idea, and all substitute employees prefer not to compete.

8.7 Extension: Refusal of NDA in market exchange

Is it possible to protect an incomplete idea by writing an ex-ante contract? Any idea which may be explained verbally may be written down in words, so it should in principle be contractible. In practice, contracts that protect against idea stealing, e.g. non-disclosure agreements (NDAs) are rarely used. We sketch here a simple rationale for refusing to sign NDAs, namely that they expose the signer to the risk of being falsely accused of stealing ideas.

Let T be a talker who requests a NDA before disclosing an idea, and L the listener whom is asked to sign it. Suppose the NDA can indeed protect the contracted idea, but it may be so generic so as to enable T to sue L for infringement, even when L is only using his own ideas (for instance, because the NDA is very generic, or it is tailored to cover ideas L already has). In case of such an opportunistic lawsuit, let σ be the expected penalty that L has to transfer to T. For simplicity, we assume that σ is exogenous, and that there are no additional legal costs. Of course, the risk of expropriation may be compensated by an ex-ante payment by the agent requesting a NDA (assuming no wealth constraints).

Suppose there are two types of talkers. The first type, a legitimate talker, truly has an idea, and does not have the ability to pursue a rent-seeking lawsuit. The second type is an opportunistic talker who has no ideas, but is skilled at pursuing a legal claim of contract breach to blackmail L. Let s be the proportion of opportunistic talkers in the population.

If a legitimate talker does not request a NDA contract, he can obtain a utility as in (2). If he does, his utility is as follows. Let τ be the payment that T pays for every NDA. The expected number of talking rounds is $\frac{1}{\phi}$, so that a legitimate talker seeking a match faces expected NDA costs of $\frac{\tau}{\phi}$. The NDA contract ensures no idea stealing, so that T always obtains his contracted share of the value of the idea, which we denote by a_n. Using the same reasoning as before, T's utility with a NDA contract is given by $u_{T,n} = -\tau + \phi a_n z + \overline{\phi} D u_T$, so that for $D \to 1$ we have $u_{T,n} = a_n z - \frac{\tau}{\phi}$. Note that, while T has $Du_{T,n}$ as outside option, L has no outside option since he is contractually committed not to steal the idea. From the Nash bargaining solution, we have $a_n z = \frac{1}{2} z + \frac{1}{2} D u_{T,n}$. For $D \to 1$ we have $a_n = 1 - \frac{\tau}{\phi z}$. After transformations, the utility that T obtains by asking for a NDA is given by $u_{T,n} = z - 2\frac{\tau}{\phi}$. Higher NDA payments thus weaken a legitimate talker's bargaining power, as they increase the cost of seeking other listeners.

A legitimate talker is willing to offer a transfer for a NDA as long as $u_{T,n} \geq u_T$ $\Leftrightarrow z - 2\frac{\tau}{\phi} \geq \frac{\phi^2}{1-\phi+\phi^2} z \Leftrightarrow \tau \leq \tau^* = \frac{\phi - \phi^2}{1-\phi+\phi^2}\frac{z}{2}$. Opportunistic talkers, however, are willing to offer any amount up to σ for a NDA. We focus on the case $\sigma > \tau^*$, when rent-seeking lawsuits are a non-trivial threat for L. For any payment $\tau > \tau^*$, L realizes that only an opportunist could have made the offer, and thus refuses to sign the NDA. For any $\tau < \tau^*$, L's expected return from signing a NDA is $(1-s)(\tau + \phi \overline{a_n} z) - s\sigma$, which simplifies to $(1-s)2\tau - s\sigma$. Thus we can conclude that L is never willing to sign an NDA agreement as long as $s > s^* = \frac{2\tau^*}{2\tau^* + \sigma}$.

This simple model extension shows that as long there may be rent-seeking agents, the only equilibrium is that listeners always refuse to sign NDAs to avoid exposure to blackmail. The condition is likely to be satisfied, because entry by rent seekers will persist as long as there are profits to be made from mimicking honest agents. This is consistent with our assumption that limited observability impedes individual reputation, whether positive or negative.

Table 1: Key notation

a	Talker's share in market returns
b	Generator's share in firm returns
C	Complementor (also used as subscript)
D	Discount factor across talking rounds ($D \to 1$)
E	Total number of employees within a firm
K	Fixed cost of starting a firm
L	Listener (also used as subscript)
n_F,n_E,n_M,n_S	Number (density) of firms, employees, market agents, spin-offs
s	Fraction of opportunistic talkers
T	Talker (also used as subscript)
u_L, u_T	Per-period utility of listener and talker
u_E, u_M	Per-period utility of employee and market agent
z	Value of completed idea
ψ	Private idea generation costs
δ	Discount factor across periods ($\delta \nrightarrow 1$)
ε	Length of talking round ($\varepsilon \to 0$)
ϕ	Probability that listener is complementor
γ	Probability of finding an idea
μ	Fraction of employees leaving with ideas over market agents
π	Per-period firm profit
σ	Expected penalty in case of false accusation of NDA violation
τ	Transfer payment for signing NDA
Ω	Distribution of fixed costs

Common subscripts

E	Subscript for employees
F	Subscript for firms
L	Subscript for listener
M	Subscript for markets
S	Subscript for spin-off
T	Subscript for talker

Figure 1: Feasible regions for idea generation

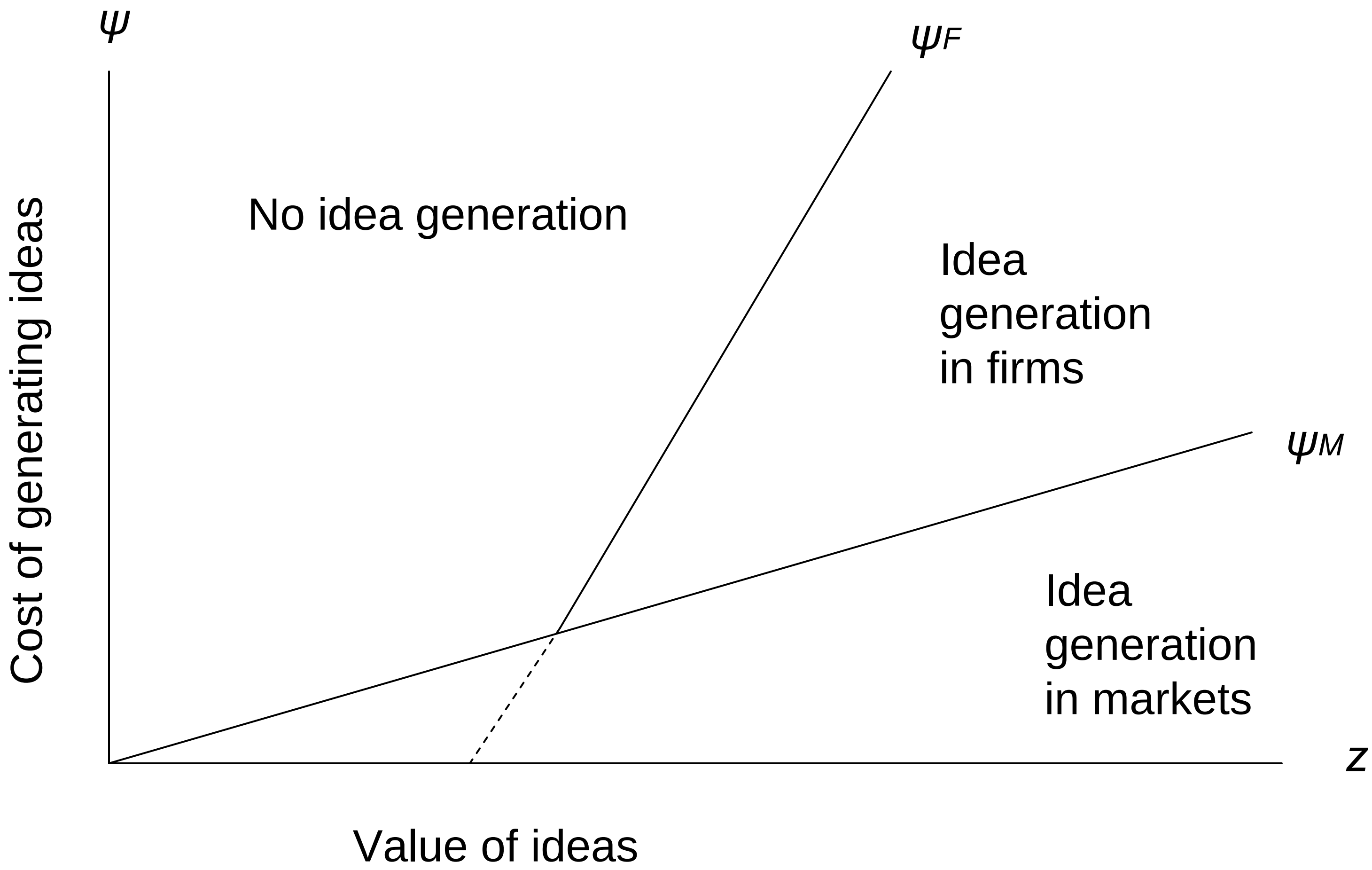


Figure 2: Coexistence equilibrium

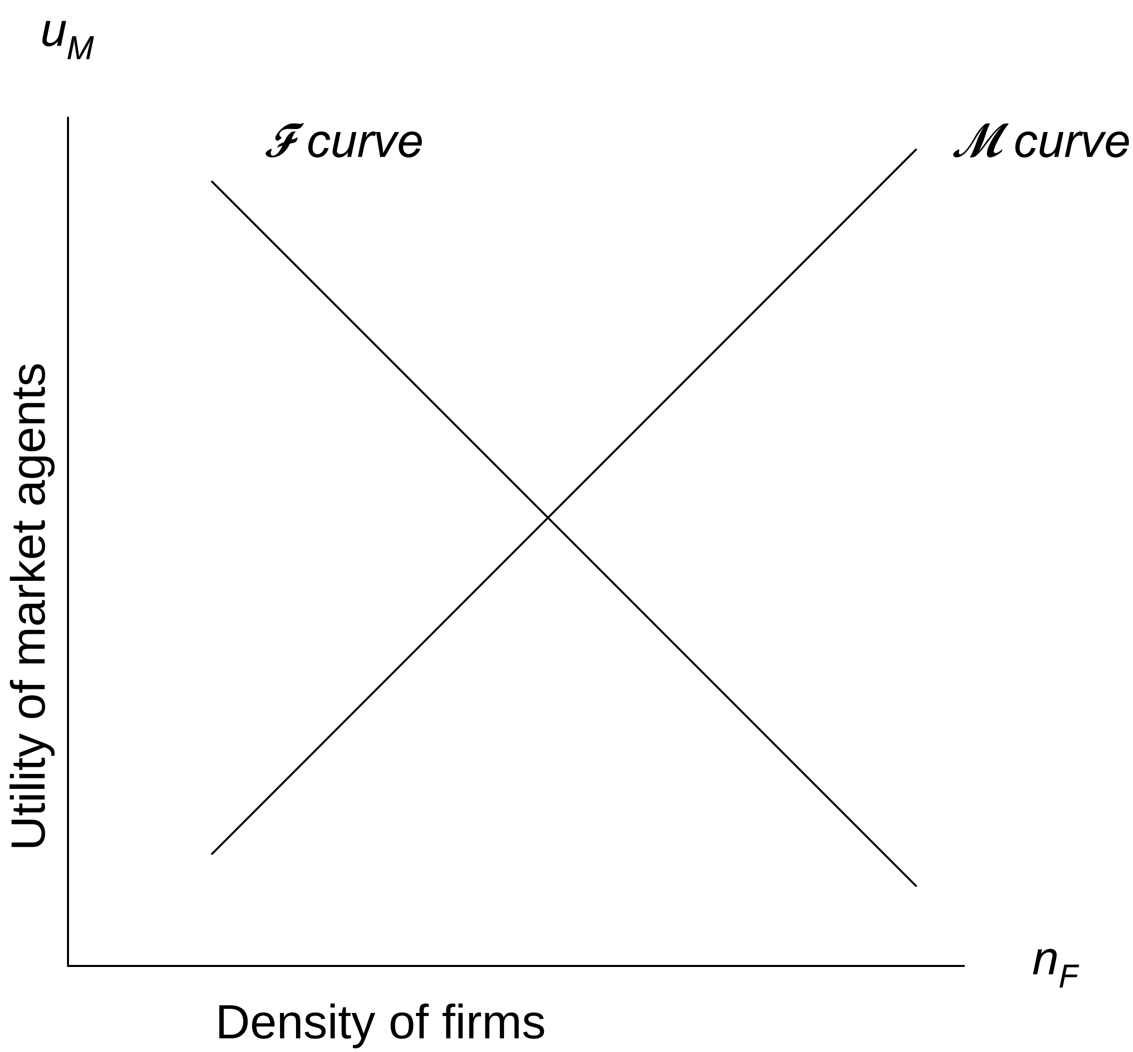
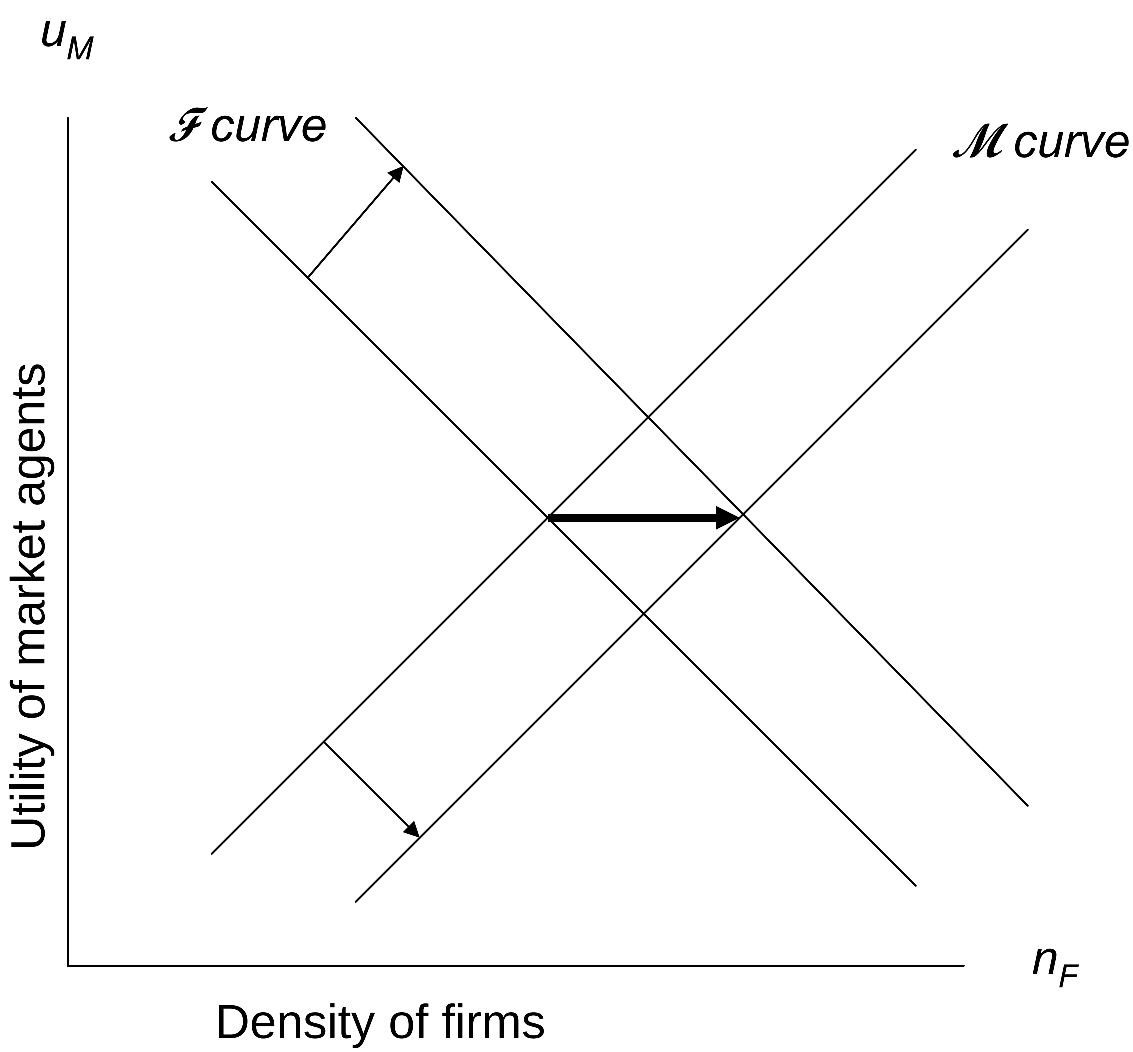
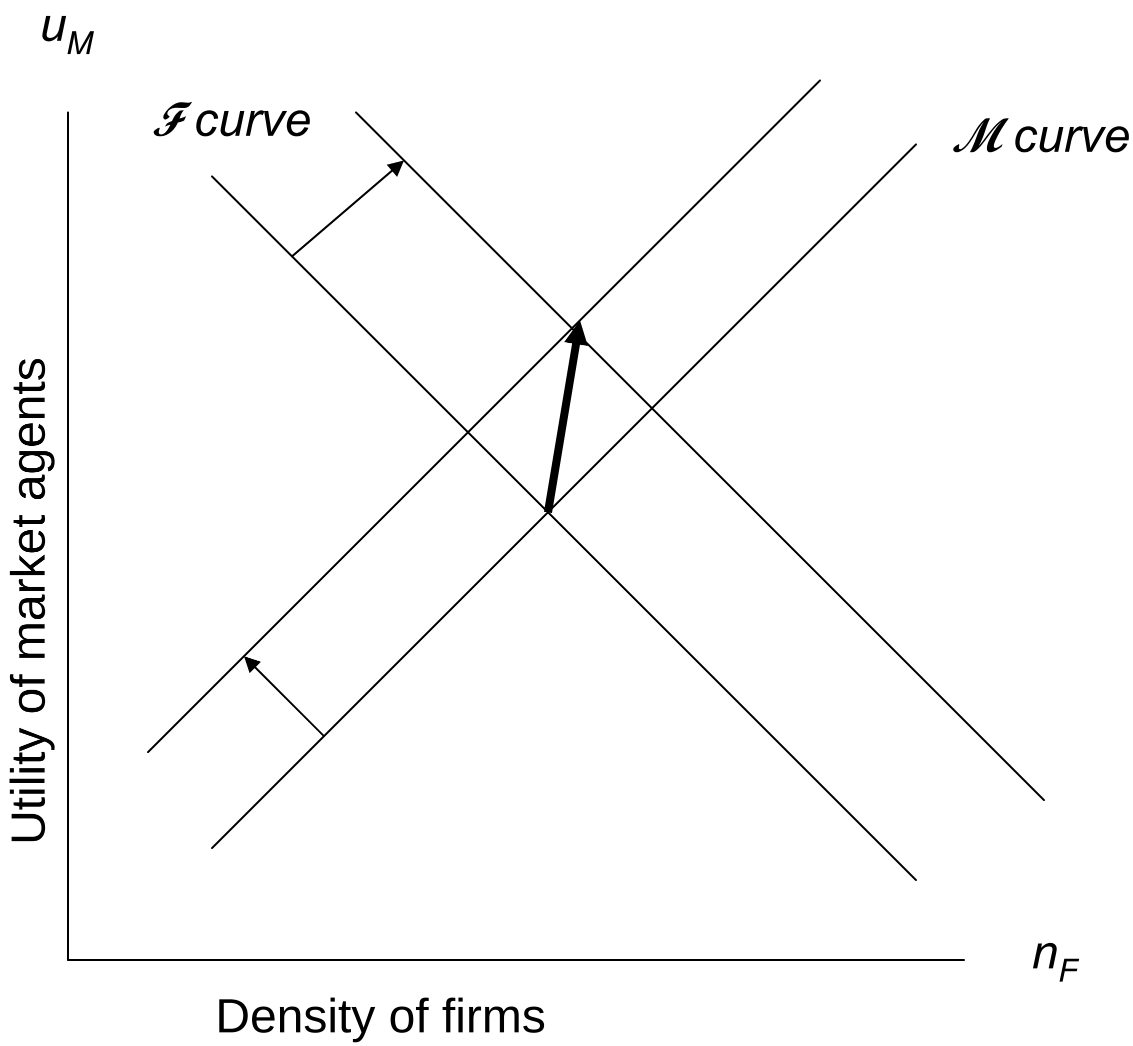


Figure 3: The effect of more complementors (Φ)



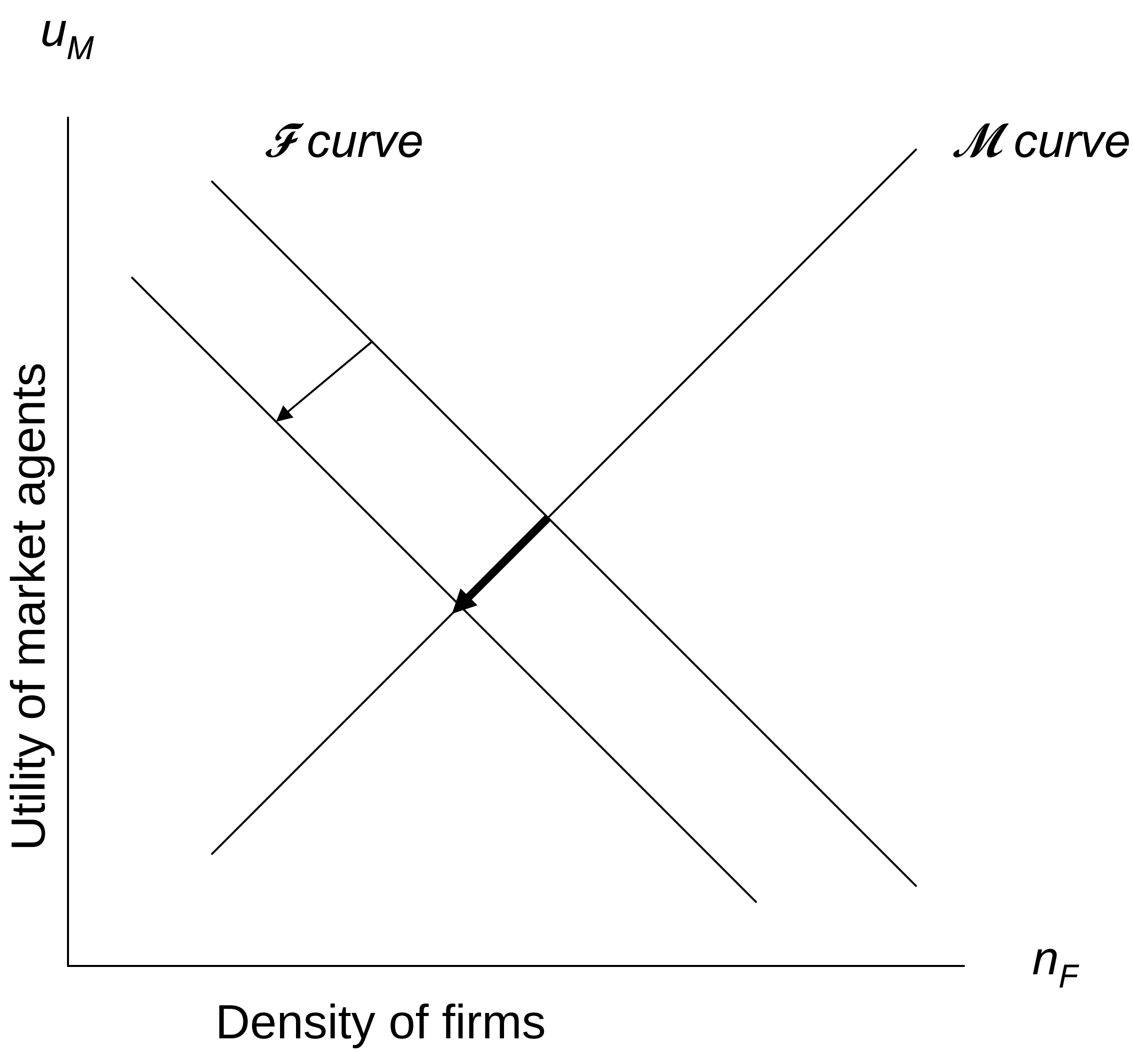
More complementors increase firm density

Figure 4: The effect of higher idea values (z, γ)



Higher idea values increase utility of market agents

Figure 5: The effect of higher costs (*ψ, m, K*)



Higher costs decrease firm density and the utility of market agents