

## **The Circulation of Ideas in Firms and Markets**

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**September 2006**



### **RICAFE2 - Regional Comparative Advantage and Knowledge Based Entrepreneurship**

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**A project financed by the European Commission, DG Research  
under the 'Citizens and governance in a knowledge-based society' (FP6) programme  
Contract No : grant CIT5-CT-2006-028942.**

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# The Circulation of Ideas in Firms and Markets

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## Abstract

Innovative but incomplete ideas require feedback and elaboration by other agents with complementary skills, yet when shared they may be stolen. The paper compares how different contractual environments support invention and implementation. 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, Firm Organization, Start-Ups

JEL Classification: D83, L22, M13, O31

The second author acknowledges financial support from the European Commission grant CIT5-CT-2006-028942.

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‡We would like to thank Daron Acemoglu, Amar Bhidé, Oliver Hart, Josh Lerner, Scott Stern, and seminar participants at the AEA-AFE session on Financing Innovation in Philadelphia, London School of Economics, London Business School, NBER Entrepreneurship Group, NBER Organizational Economics Group, Stanford GSB, University College London, University of Amsterdam, and the University of British Columbia, for their valuable comments. Financial support from the EU grant CIT5-CT-2006-028942 (Ricafe 2) is kindly acknowledged. All errors are ours.

## Non-Technical Summary

This paper focus on the earliest stage in the innovation process, where ideas are still incomplete so they cannot yet be patented. The model shows that they 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 it is remarkable how 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 young firms spin-offs generated or modified ideas encountered in previous employment. Gompers, Lerner and Scharfstein (2005) show how a large number of new entrepreneurs in high tech firms started their firm after leaving large firms. Klepper and Sleeper (2002) provide similar evidence from the laser industry. Clearly, large established firms play a major role as incubators for innovation.

Following Schumpeter (1926, 1942) we define an early stage idea as a novel combination of existing factors which is incompletely specified (see also Biais and Perotti, 2004, and Weitzman, 1998). The idea needs to be shared with agents who have expertise that is complementary to the inventor's. Yet as the idea is novel, it is not obvious in which direction it should be developed, and thus what may be the “missing” expertise. Truly 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), for example, emphasizes “cross-pollination” and open networking as a central aspect of Silicon Valley's innovative potential.

Yet there is a fundamental problem with the open circulation of ideas, namely that they can be easily stolen (Arrow, 1962). We focus on ideas that are incomplete, and thus too vague for an independent patent office to grant exclusive property rights. In practice, “non-disclosure agreements” (NDAs henceforth) are rarely used by those agents who are repeatedly involved in assessing new ideas, such as venture capitalists and Hollywood producers. Once agents are unwilling to sign such blind contracts, incomplete ideas must be shared without contractual protection.

We characterize the process of elaborating new but incomplete ideas as a search for some complementary expertise the inventor does not possess. Because of their novelty, it is not obvious how ideas should be matched, so necessarily the search is in part random. 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 concept. If the inventor meets a complementor, both parties have incentives to cooperate. However, often the inventor meets an agent whose skills essentially replicate his own. We call such an agent a “substitute.” A substitute understands the idea, but is unable to elaborate on it and thus cannot expect any gain from the interaction. He may thus 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 the elaboration of valuable ideas. Yet idea stealing may deny the inventor a sufficient reward for invention.

In this context, firms emerge as a solution to market failure. Agents who accept employment in a firm *de facto* 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 must be backed by its owner’s reputation. The threat of loss of corporate reputation ensures that agents are willing to contractually commit to sharing and not stealing ideas inside the firm, while they would refuse to sign an equivalent contract with another 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 agents who commit not to steal internal ideas via their employment contract.

The model implies an internal organization of the firm which “registers” employee ideas as internal projects and “credits” their inventors. This recording system creates a verifiable paper trail with 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 secret.

Firms, however, have important drawbacks. Controlling any outflow of ideas may require costly monitoring. More critically, 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 all internal projects creates a role for markets. Markets complement firms by completing ideas that could not be elaborated inside firms. This requires firms to become open, in the sense of allowing employees to spin-off those 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.

# 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 it is remarkable how 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 young firms spin-offs generated or modified ideas encountered in previous employment. Gompers, Lerner and Scharfstein (2005) show how a large number of new entrepreneurs in high tech firms started their firm after leaving large firms. Klepper and Sleeper (2002) provide similar evidence from the laser industry. Clearly, large established firms play a major role as incubators for innovation.<sup>1</sup>

Following Schumpeter (1926, 1942) we define an early stage idea as a novel combination of existing factors which is incompletely specified (see also Biais and Perotti, 2004, and Weitzman, 1998). The idea needs to be shared with agents who have expertise that is complementary to the inventor's. Yet as the idea is novel, it is not obvious in which direction it should be developed, and thus what may be the “missing” expertise. Truly 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), for example, emphasizes “cross-pollination” and open networking as a central aspect of Silicon Valley's innovative potential.

Yet there is a fundamental problem with the open circulation of ideas, namely that they can be easily stolen (Arrow, 1962). We focus on ideas that are incomplete, and thus too vague for an independent patent office to grant exclusive property rights.<sup>2</sup>

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<sup>1</sup>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.

<sup>2</sup>The well-known Yale survey found that patent protection is only one among many ways that

Similar to Anton and Yao (1994, 2002), we argue that 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 rarely used by those agents who are repeatedly involved in assessing new ideas, such as venture capitalists and Hollywood producers. Once agents are unwilling to sign such blind contracts, incomplete ideas must be shared without contractual protection.<sup>3</sup>

We characterize the process of elaborating new but incomplete ideas as a search for some complementary expertise the inventor does not possess. Because of their novelty, it is not obvious how ideas should be matched, so necessarily the search is in part random. 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 concept. If the inventor meets a complementor, both parties have incentives to cooperate. However, often the inventor meets an agent whose skills essentially replicate his own. We call such an agent a “substitute.” A substitute understands the idea, but is unable to elaborate on it and thus cannot expect any gain from the interaction. He may thus 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 the elaboration of valuable ideas. Yet idea stealing 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 *de facto* 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 must be backed by its owner’s 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 are willing to contractually commit to sharing and not stealing ideas inside the firm, while they would refuse to sign an equivalent contract with another 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 agents who commit not to steal internal ideas via their employment contract.

The model implies an internal organization of the firm which “registers” employee

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firms protect their intellectual property, and that patents only matter for a limited set of industries (Levin et. al., 1987).

<sup>3</sup>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.

ideas as internal projects and “credits” their inventors. This recording system creates a verifiable paper trail with 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 secret. This provides a justification for the bureaucracy associated with hierarchical firms (Novaes and Zingales, 2004).

Firms, however, have important drawbacks. Controlling any outflow of ideas may require costly monitoring. More critically, 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 all internal projects creates a role for markets. Markets complement firms by completing ideas that could not be elaborated inside firms. This requires firms to become open, in the sense of allowing employees to spin-off those 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.<sup>4</sup>

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.

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.

Finally, market agents have a comparative advantage in developing ideas requiring modest budgets and high potential returns, 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

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<sup>4</sup>Note that by firms we mean large established multi-project firms, rather than small entrepreneurial single-project start-ups (which we associate with markets).

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 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  $\delta$  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  $\psi$ , in which case they generate an idea with probability  $\gamma$ . 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  $\varepsilon$ . We focus on the case of  $\varepsilon \rightarrow 0$ . 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  $\phi$ , the listener is a “complementor”, who upon hearing the idea knows how to complete it. With probability  $\bar{\phi}(\equiv 1 - \phi)$ , the listener is a “substitute” who has the same skills as the talker, but does not know how to further elaborate the idea. Substitutes have nothing to contribute, but are able to steal 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).<sup>5</sup>

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<sup>5</sup>In Hellmann and Perotti (2005), we also consider the case where agents can hide their type. We

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

## 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. In the appendix we provide a model extension that fully rationalizes this assumption. The key intuition is that blindly signing a contract before seeing the content creates an adverse selection problem, where the signer exposes himself to a risk of extortion. 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 bargaining 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 is true even for off-the-equilibrium-path disagreements, since in Binmore, Rubinstein and Wolinsky's specification, players either continue bargain, or else exit the game. 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 value.<sup>6</sup>

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

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show how in this case substitutes may misrepresent their types, discourage talkers from pursuing their ideas, and then secretly steal the idea.

<sup>6</sup>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.

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  $\varepsilon \rightarrow 0$ ,  $D \rightarrow 1$ ).  $C$ 's outside option in case of a breakdown is  $o_C \equiv D(\bar{\phi}\bar{a}z + \phi\frac{1}{2}o_C)$ . To see this, note that  $C$  either finds a substitute to  $T$  with probability  $\bar{\phi}$  and gets a share  $\bar{a}$ ; or, with probability  $\phi$ , he finds another complementor, in which case they cannot implement the concept, and they toss a fair coin as to who continues. Solving the above we obtain  $o_C = \frac{D\bar{\phi}\bar{a}z}{1 - D\phi\frac{1}{2}}$ , which for  $D \rightarrow 1$  yields

$o_C = \frac{2 - 2\phi}{2 - \phi}\bar{a}z$ . Using similar reasoning,  $T$ 's outside option in case of breakdown is  $o_T \equiv D(\phi\frac{1}{2}o_T + \phi az)$ , so that for  $D \rightarrow 1$  we have  $o_T = \frac{2\phi}{1 + \phi}az$ . 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  $a$ :

$$a = \frac{1}{2} \frac{\phi + \phi^2}{1 - \phi + \phi^2}. \quad (1)$$

**Lemma 1:** The more common is the complementary skill  $\phi$ , the greater is the bargaining stake  $a$  gained by the talker, i.e.,  $\frac{da}{d\phi} > 0$ . If  $\phi = \frac{1}{2}$ , then  $a = \frac{1}{2}$ . For  $\phi \rightarrow 0$  we have  $a \rightarrow 0$ , and for  $\phi \rightarrow 1$  we have  $a \rightarrow 1$ .

Lemma 1 is easily verified by inspecting (1). The 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.

### 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  $\phi$ , a talker finds a complementor and bargains for a share  $az$ . With probability  $\bar{\phi}$ , 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  $u_T = \phi az + \bar{\phi}\frac{1}{2}Du_T$ . For  $D \rightarrow 1$  this implies  $u_T = \frac{2\phi}{1 + \phi}az$ ,

and using (1) we obtain

$$u_T = \frac{\phi^2}{1 - \phi + \phi^2} z. \quad (2)$$

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

The utility for a listener is given by  $u_L = \phi \bar{a}z + \bar{\phi} \frac{1}{2} D u_T$ , which for  $D \rightarrow 1$  yields  $u_L = \phi \bar{a}z + \frac{\phi(1 - \phi)}{1 + \phi} az$ . Using (1) we obtain after transformations<sup>7</sup>

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

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

$$u_M = -\psi + \gamma z. \quad (4)$$

This says that  $u_M$  exactly equals the expected value created by investing to produce one idea. This occurs because *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  $\phi$ , the chance of finding a complementor.

Markets are efficient at completing ideas, which circulate freely until someone finds a complementor. In equilibrium all ideas are completed. Yet idea stealing is an integral part of this equilibrium. 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.

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<sup>7</sup>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  $\phi$  on  $u_L$  is ambiguous is that the listener has a dual identity. He is not only a listener in the current talking round, but possibly also a talker in the next talking round.

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

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

Proposition 1 exposes the main weakness of the market as a governance system for idea exchange. Agents may not be able to appropriate enough value of their ideas to seek to invent. Condition (5) identifies the threshold cost of generating ideas ( $\psi_M$ ) beyond which markets fail to generate ideas.

The comparative statics of  $\psi_M$  with respect to  $\gamma$  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  $\phi$ . It is easy to verify that  $\text{sign}(\frac{d}{d\phi} \frac{\phi^2}{1 - \phi + \phi^2}) > 0$ . This suggests the following corollary.

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

When complementary skills are rare, the net payoff to generating an idea becomes negative. The intuition is that once it is very difficult to find a complementor, the idea generator faces a high risk 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

We now consider the firm as an alternative governance mechanism for idea circulation. In this section we focus on what we call 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. To begin with, we argue that it is impossible for anyone to establish a reputation among all market agents, since individual actions are not widely observable. However, an agent may make an investment into establishing a local reputation. We model this as a sunk cost that an agent occurs in order to establish a system by which his actions become visible to a subset of agents. Visibility of actions implies the possibility of a reputation mechanism, 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 his reputation to establish honest dealing among the entire subset of agents. Once he has the trust of all other agents, the reputed agent has an incentive to create a firm, which enables idea exchanges among its employees. Specifically, we argue that the employment contract naturally creates a legal boundary for the circulation of internal ideas. The employment contract can be interpreted as the sale of ideas to the firm owner, plus a collective NDA covering ideas registered inside the firm. Employees are subject to trade secret law, a standard feature of all labor contracts, which commits them contractually 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).

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.<sup>8</sup> The sunk investment  $K$  creates visibility, and thus potential reputation, among a fixed number of other agents that we call employees. Let  $E$  be the size of this set of agents. Note that the number of employees is fixed, an assumption that keeps the analysis tractable.<sup>9</sup> In addition to the sunk cost, in every period the owner has to incur some monitoring costs  $m$ . For simplicity, once an owner commits to managing a firm, he no longer has time to generate or complement ideas by himself.

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<sup>8</sup>For expositional convenience we assume in this section that all firms face the same  $K$ . Section 4 relaxes this condition.

<sup>9</sup>In Hellmann and Perotti (2005) we examine the case where the number of employees is endogenous due to convex monitoring costs, which offered no additional insight. Note that our analysis does not try to provide a theory of firm boundaries itself.

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. For the main model we assume that by incurring monitoring costs, firms can thus always prevent idea stealing. Section 5.1 explores how imperfections in monitoring or trade secret law affect the analysis.

Once a generator registers an idea with the firm, he seeks to implement it via internal matching. Since no employee can leak the idea outside the firm, the generator can count on cooperation from all internal listeners. In managerial terms, he becomes an “internal project champion” or an “intrapreneur.” The firm does not need to compensate listeners, since 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.

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  $\phi$ . We further discuss this assumption in section 5.2. The probability that an idea finds no match inside the firm is given by  $\bar{\phi}^E$ , and so the probability of internal completion is  $1 - \bar{\phi}^E$ . We contrast this with the probability of completion in the market, which is always 1.<sup>10</sup>

**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, the firm is costly to operate. Second, the firm allows only for a subset of possible matches to develop the idea. However, closed firms may emerge when markets fail to reward idea generation. With (5), the reward to operate in the market is zero, as the chance of listening to an idea is zero.<sup>11</sup> Thus the firm owner

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<sup>10</sup>In the first talking round, the probability of completion is  $\phi$ . With probability  $\bar{\phi}$ , the idea moves into a second talking round, where the probability of completion is  $\phi$ . With probability  $\bar{\phi}^n$ , the idea moves into a  $(n + 1)^{th}$  talking round. Thus the probability of completion is given by  $\phi + \phi\bar{\phi} + \phi\bar{\phi}^2 + \phi\bar{\phi}^3 + \dots = \frac{\phi}{1 - \bar{\phi}} = 1$ .

<sup>11</sup>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

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 ( $\psi$ ), adjusted for the probability of success ( $\gamma$ ), and the probability of completion ( $1 - \bar{\phi}^E$ ). The expected utility of generating an idea is given by  $u_E = (1 - \bar{\phi}^E)\gamma bz - \psi$ .

The firm's optimal compensation is thus given by

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

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  $(1 - \bar{\phi}^E)bz = \frac{\psi}{\gamma}$ . Without disclosure, the employee would have to leave the firm to obtain market returns  $\delta u_T$ , 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  $\pi = E(1 - \bar{\phi}^E)\gamma(1 - b)z - m$ . Using (6) we obtain

$$\pi = E((1 - \bar{\phi}^E)\gamma z - \psi) - m \quad (7)$$

The comparative statics are intuitive:  $\pi$  is increasing in  $\gamma$ ,  $z$  and  $\phi$ , and decreasing in  $\psi$  and  $m$ .

### 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.<sup>12</sup> 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:

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cannot afford the reputational investment  $K$ . This ensures that the outside option for the marginal employee is zero.

<sup>12</sup>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.



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

$$Ebz < \frac{\delta}{1-\delta}\pi. \quad (8)$$

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

### 3.4 Comparing closed firms and markets

In section 4 we examine the coexistence of markets and firms. As a preliminary step, however, it is useful to contrast some of the key properties of markets and firms when considered in isolation. For this, it is useful to identify the critical parameter ranges for which either of these institutions may occur. Note that if markets support idea generation, firms are a dominated form of idea exchange, since they need monitoring 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 the critical value  $\psi_F$  such that  $\frac{\pi(\psi_F)}{1-\delta} = K$ .  $\psi_F$  is the critical value above which firms do not generate ideas, i.e. are not viable. Using (7) we obtain

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

Figure 1 depicts  $\psi_M$  from (5) and  $\psi_F$  from (9). The value of ideas ( $z$ ) is on the horizontal and the cost of generating ideas ( $\psi$ ) is on the vertical axis.

**Proposition 2** *If markets fail, closed firms are feasible for  $\psi \in (\psi_M, \psi_F)$ . The range  $(\psi_M, \psi_F)$  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  $\psi$ ). The prediction about the relative competencies of firms and markets is that highly profitable areas of innovation can be well served by markets. Intermediate value innovations that require relatively large investment, however, naturally fall into the realm of established corporations.

Empirically we often observe that firms are good at incremental innovations, but that radical innovations are often created by market-based entrepreneurs (Christensen, 1997). Our analysis suggests that this division may be the natural result of the comparative advantages of firms and markets.

## 4 Idea exchange in open firms

### 4.1 Base assumptions

We are finally in a position to examine the full equilibrium model with firms and markets interacting. The previous section assumed that firms do not allow employees to leave to pursue an idea 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 now consider the opposite case where owners can monitor this process, and allow their employees to leave to develop their ideas externally. This allows the firm to extract some additional value from internal ideas. We assume that departing employees may develop the registered idea only in a start-up, but not within another established firm. We loosely justify this assumption arguing that firm owners do not wish to grant an advantage to any competitor.

Under (5) the reward to generating ideas in the market system is negative, so that all ideas are generated inside firms. The new aspect with open firms is that idea mobility allows market agents to hear ideas from departing employees. As before, all ideas circulating in the market are completed within one period. We assume that employees are committed 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 equilibrium where open firms and markets coexist.

**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 spun out into the market;
- (iii) all ideas that were not completed inside firms are completed in the market with a one period delay.

### 4.2 The payoff to be a market agent

In the model with open firms, there is a benefit for agents to remain in the market and 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  $\gamma$  ideas per period, but completes only a fraction  $1 - \bar{\phi}^E$ , so that the total number of spin-off ideas per period is  $n_S = n_E \gamma \bar{\phi}^E$ . 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  $\mu = \frac{n_S}{n_M}$ , where  $\mu$  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  $\phi$  will be resolved in the first talking round. In the second talking round there are  $n_S \bar{\phi}$  ideas, so that the expected number of ideas to listen to in that round is  $\frac{n_S \bar{\phi}}{n_M} = \mu \bar{\phi}$ . The total expected number of listening events per period is thus  $\mu(1 + \bar{\phi} + \bar{\phi}^2 \dots) = \frac{\mu}{\phi}$ .

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

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

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

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

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  $\phi$ , and increasing in  $\gamma$  and  $z$ .*

The proof is in the appendix. Figure 2 accompanies Proposition 3. Figure 2 has the density of firms ( $n_F$ ) on the horizontal and the utility of market agent ( $u_M$ ) on the vertical axis. Proposition 3 characterizes the  $\mathcal{M}$  curve, which shows how the utility of market agents depends on the density of firms. The figure shows that  $u_M$  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. Remember that market agents do not generate ideas by themselves, and therefore rely on the flow of new ideas from firms.

Proposition 3 also establishes some interesting comparative statics of  $u_M$ . Naturally,  $u_M$  is increasing in  $\gamma$  and  $z$ . The fact that it is also decreasing in  $\phi$  can be explained as follows. Using again  $u_M = \frac{\mu}{\phi} u_L$ , we note that there are three effects of  $\phi$ . First, from (10) we note that the fraction of ideas going to market agents, given by  $\mu$ , is decreasing in  $\phi$ . The intuition is that with higher  $\phi$ , more ideas are already resolved inside firms. Second, the term  $\frac{1}{\phi}$  is clearly decreasing in  $\phi$ , 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  $\phi$  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  $\phi$ . Figure 3 represents this as an outward shift of the  $\mathcal{M}$  curve.

### 4.3 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  $u_E = (1 - \bar{\phi}^E)bz + \bar{\phi}^E \delta u_T - \psi$ , where  $u_T$  is the utility gained by taking the idea out into the market, discounted by  $\delta$  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  $b = \frac{\psi + u_M - \bar{\phi}^E \delta u_T}{(1 - \bar{\phi}^E)\gamma z}$ . The firm's profits are given by  $\pi = E(1 - \bar{\phi}^E)(1 - b)z - m$ , or  $\pi = E[\gamma(1 - \bar{\phi}^E)z + \gamma \bar{\phi}^E \delta u_T - \psi - u_M] - m$ .

Again, we note that  $\pi$  equals the joint utility of the firm and all its employees. Using

our results for  $u_T$  and  $\mu$ , we can also rewrite this as

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

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  $n_F = \Omega(\hat{K})$  where  $\hat{K}$  is the fixed cost of the marginal entrant. We have  $\hat{K} = \frac{\pi}{1 - \delta} - \frac{u_M}{1 - \delta}$ , so that

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

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

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

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  $\phi$ ,  $\gamma$ ,  $z$ ,  $\delta$  and decreasing in  $\psi$  and  $m$ .*

Proposition 4 is again related to Figure 2, and characterizes properties of the  $\mathcal{F}$  curve. 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  $\gamma$ ,  $z$  and  $\psi$  are straightforward, all relating directly to the ex-ante value of an idea. A higher cost of monitoring  $m$  reduces firm profits and thus entry, whereas a higher discount factor  $\delta$  (corresponding to a lower discount rate) increases the life-time utility of starting a firm. The most interesting result concerns the fact that  $n_F$  is increasing in  $\phi$ . The key intuition is that with more complementors, firms are more likely to complete ideas internally. A higher value of  $\phi$  also increases the utility an employee receives from doing a spin-off. The comparative static result for  $\phi$  is represented in Figure 3, which shows that a higher value of  $\phi$  shifts the  $\mathcal{F}$  curve outwards.

## 4.4 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  $n_F = 0$ .

The most important comparative static concerns the equilibrium density of firms  $n_F$ . This is because in this model the number of firms is directly proportional to the number of agents that generate ideas, and thus to the degree of innovation in the economy. The following proposition therefore focuses only on the comparative statics for  $n_F$ . The accompanying Figures 3-5 also demonstrate the comparative static effects for  $u_M$ .

**Proposition 5** (i) *The effect of increasing the number of complementors (higher  $\phi$ ), is to shift out the  $\mathcal{F}$  curve and to shift down the  $\mathcal{M}$  curve, resulting in a higher density of firms (higher  $n_F$ ). See Figure 3.*

(ii) *The effect of increasing the value of ideas (higher  $z$ ), or the probability of generating ideas (higher  $\gamma$ ), is to shift out the  $\mathcal{F}$  curve and to shift 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) *The effect of increasing the cost of generating ideas (higher  $\psi$ ), the cost of monitoring (higher  $m$ ), or the cost of entry (shifting up the distribution  $\Omega(K)$ ), or decreasing the discount factor (lower  $\delta$ ), is to 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 provide a useful illustration of the main comparative statics of the coexistence 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 key intuition is that with more complementors, there is 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  $\Omega$  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 don't generate ideas in the coexistence equilibrium. However, they negatively affect firms, who have to bear this cost by compensating employees for their higher generation costs. As a result, there are fewer firms. The same result also holds for monitoring and entry costs, which are directly borne by firm owners. The effect of the discount factor is analogous.

## 4.5 Comparing open and closed firms

In this section we compare the model of closed and open firms. Market agents clearly prefer open firms, since this creates an opportunity of making profits. Employees similarly prefer open firms, since their compensation matches their outside option of becoming a market agent. The interesting question is whether firm owners also benefit from the move to open firms.

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  $\gamma \bar{\phi}^E \delta u_T$ , which the firm recoups by lowering its bonus payment  $b$ . The question remains whether firms benefit collectively from mobility. Mobility 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 ( $\pi$ ) 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 main insight from Proposition 6 is that 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. There is also a negative effect of mobility, coming 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 (and thus the distribution of fixed costs). Intuitively, if there are only a few firms, then open firms do better than closed ones, because of the better utilization effect matters, and the externality effect is small. For a high density of firms, however, the externality becomes much larger, and may thus 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 Further discussion

### 5.1 Imperfect prevention of idea stealing

The analysis so far assumes that the firm can always prevent employees from stealing other employees ideas. In reality, the firm's ability to prevent idea stealing is not absolute: monitoring may be incomplete, and the enforcement of trade secret laws may be imperfect. We briefly sketch how imperfect prevention of idea stealing affects the model. The appendix derives the formal model extension.

Consider a simple specification where employees face some probability  $\theta$  of being caught stealing ideas. If caught stealing, they forfeit the returns to the idea and may suffer a lower utility for one period, in terms of being disgraced. To preserve circulation of ideas inside the firm, the owner needs to provide appropriate incentives to ensure that no idea stealing occurs in equilibrium.

Which employees are most likely to steal ideas? We have already shown in conjunction with equation (6) that the generator always prefers to circulate the idea inside the firm, rather than taking it outside. Substitutes employees are not credible with idea stealing. In the appendix we explain that this is because once it is known that the generator is committed to the idea, they prefer not to compete. The real threat is therefore the complementor. Moreover, the most powerful deviation is that the complementor defects jointly with the generator. The reason that a joint deviation is more powerful than a single deviation is simply that the generator and complementor already know that they are a good match, and can thus avoid the risk of being inappropriately matched 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.

How does imperfect prevention affects firm profits? Paying the complementor is a cost for the firm, but the firm might be able to offset that cost by lowering its payments  $b$  to the generator. In the appendix we show that if prevention is sufficiently good ( $\theta$  sufficiently high), 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. For lower values of  $\theta$ , however, this incentive constraint becomes binding, so paying the complementor becomes a real cost. For  $\theta$  sufficiently low (and  $\delta$  sufficiently close to 1), it becomes impossible for the firm to break even. The reason is that if the firm cannot prevent idea stealing, then it has no means of capturing the value generated by the circulation of ideas.

Overall we find that the main insights of the model do not require perfect enforcement of trade secret laws, nor perfect monitoring. The main implication of relaxing the assumption of perfect prevention is that the firm needs to reward both idea generation and idea completion. The real cost of this depends on how imperfect prevention of idea stealing is. If prevention is close to perfect, then there are no real costs. However, if prevention is close to impossible, then firms are no longer viable, because in



this model they have no other advantages over markets.

## 5.2 Specialized firms

To provide a clean comparison of firms and markets, the formal model assumes that the probability of finding a complementor ( $\phi$ ) is constant throughout. While this goes beyond the scope of the formal analysis, it is also interesting to informally consider the possibility that different firms specialize in different types of ideas. If specialized firms attract employees with complementary capabilities, how might this affect our results? Specialization increases the probability of finding complementors inside the firm. From (7) we know that the firm's profits are increasing in  $\phi$ , suggesting a benefit of specialization. Part of this benefit comes from the fact that specialization lowers the cost of providing incentives to generators (see (6)). Another potential benefit of specialization could be lower monitoring costs ( $m$ ), because the firm has to monitor a smaller, more defined set of ideas. A potential cost of specialization is that the likelihood of generating ideas ( $\gamma$ ) might be lower, because the firm is only receptive to a smaller set of ideas.

What happens when employees generate ideas that do not fit well with the firm's specialization? The empirical literature (e.g., Klepper and Sleeper, 2005) notes that lack of fit as an important determinant for spin-offs activity. Without a good fit, employees are likely to leave the firm, possibly even without disclosing the idea at all. In our formal model employees always disclose their idea to the firm, and leave only after they have exhausted all internal matching possibilities. This seems to be an appropriate characterization for some spin-offs. Gene Amdahl, for example, pleaded for a long time with his colleagues at IBM to implement his ideas, before finally leaving IBM to start Amdahl Computers. However, there are also numerous examples where employees leave their employer without disclosing anything about their ideas or entrepreneurial ambitions. In an earlier version (Hellmann and Perotti, 2005) we discuss a simple 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.<sup>13</sup>

## 5.3 Rewards to entrepreneurship

At first, the result that markets produce poor incentives for idea generation, relative to firms, seems counter-intuitive. Typically it is believed that the returns for developing a new venture are greater for entrepreneurs (market agents) than intrapreneurs

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<sup>13</sup>It should also be mention that if we allow for heterogenous idea values, 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 compensate the generator (i.e., the reputation condition (8) may no longer hold).

(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  $\chi_M = \frac{2\phi}{1+\phi} < 1$ .<sup>14</sup> This contrasts with the probability of doing an internal venture, given by  $\chi_F = 1 - \bar{\phi}^E + \bar{\phi}^E \chi_M$ . 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  $\phi$ ).

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.<sup>15</sup>

## 5.4 Applying the model to 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, upon closer inspection, our model turns out to be well suited to theorize about innovative environments. As incubators of novel ideas, established firms appear to be a crucial feature of any highly innovative environment. Large firms are certainly an important component of 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. 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 employ-

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<sup>14</sup>To see this, note that in any one talking round the generator gets to develop the new venture if he is matched with a complement, which happens with probability  $\phi$ . If he is matched with a substitute, he continues to search with probability  $\frac{1}{2}$ . Thus, the probability of developing the new venture in the market ( $\chi_M$ ) is given by the following iterative formula  $\chi_M = \phi + \bar{\phi}\frac{1}{2}\chi_M \Leftrightarrow \chi_M = \frac{2\phi}{1+\phi}$ .

<sup>15</sup>Broadly consistent with these caveats is the recent evidence by Moskowitz and Vissing-Jorgensen (2002), which suggests that entrepreneurs fail to achieve an adequate return for the risks they run.

ment 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.

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## 8 Appendix

### 8.1 Proof of Proposition 2

To see that  $\psi_M$  and  $\psi_F$  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  $z \rightarrow 0$ , 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  $\gamma z$ , noting that  $(1 - \bar{\phi}^E) > \frac{\phi^2}{1 - \phi + \phi^2} \Leftrightarrow 1 > (1 - \phi\bar{\phi})\bar{\phi}^{E-1}$  since  $\bar{\phi}^{E-1} < 1$ .

### 8.2 Proof of Proposition 3

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

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

### 8.3 Proof of Proposition 4

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

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

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

## 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

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

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

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

Thus

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

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

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

which is equivalent to

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

Thus

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

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

## 8.5 Proof of Proposition 6

In the case of no mobility, the firm profits are  $\pi = E[(1 - \bar{\phi}^E)z - \psi] - m$  while with mobility, profits are  $\pi = E[(1 - \bar{\phi}^E)z - \psi - u_M + \bar{\phi}^E \delta u_T] - m$ . The net effect of mobility on firm profits is denoted by  $B$  and is thus given by  $B = \bar{\phi}^E \delta u_T - u_M$ .

Using (11) and (2), we have  $B = \frac{\bar{\phi}^E z}{1 - \phi + \phi^2} (\delta \phi^2 - \frac{\gamma n_F E (1 - \phi)}{1 - (1 + E)n_F})$ , so that  $B > 0$

$$\Leftrightarrow n_F < \frac{\delta \phi^2}{(1 + E)\delta \phi^2 + \gamma E(1 - \phi)}.$$

## 8.6 Model extension concerning absence of non-disclosure agreements in markets

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  $\sigma$  be the expected penalty that  $L$  has to transfer to  $T$ . For simplicity, we assume that  $\sigma$  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  $\tau$  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  $u_{T,n} = -\tau + \phi a_n z + \bar{\phi} D u_T$ , so that for  $D \rightarrow 1$  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  $a_n z = \frac{1}{2}z + \frac{1}{2}Du_{T,n}$ . For  $D \rightarrow 1$  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  $\sigma$  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  $(1 - s)(\tau + \phi \bar{a}_n z) - s\sigma$ , 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 are enough rent-seeking agents, the only equilibrium is that listeners always refuse to sign NDAs to avoid exposure to blackmail. The condition of enough rent-seekers is likely to be satisfied, because entry will persist as long as there are profits to be made from mimicking honest agents.

## 8.7 Model extension concerning imperfect prevention

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 the following three constraints. First,  $b$  and  $b_C$  have to satisfy the participation constraint, which is now given by  $u_E \geq u_M \Leftrightarrow [b(1 - \bar{\phi}^E)\gamma z + \bar{\phi}^E \delta u_T - \psi] + (E - 1)\gamma \phi b_C z \geq u_M$ . Second,  $b$  has to satisfy the incentive constraint for idea generation, given by  $b(1 - \bar{\phi}^E)\gamma z + \bar{\phi}^E \delta u_T \geq \psi$ . Third,  $b$  and  $b_C$  have to satisfy the incentive constraint for no joint defection, given by  $(b + b_C)z \geq \delta \bar{\theta} z + 2\delta \theta (\underline{u} - u_E)$ . Note that the right hand side is a decreasing function of  $\theta$ , implying that higher values of  $\theta$  make it easier to satisfy this constraint. For  $\theta \rightarrow 1$ , the right hand side converges to  $2\delta(\underline{u} - u_E) < 0$ , implying that the no defection constraint is never binding. This means that for  $\theta$  sufficiently large imperfect prevention does not impose any additional cost. To see this, note that it is always possible to choose  $b = \frac{\psi - \bar{\phi}^E \delta u_T}{(1 - \bar{\phi}^E)\gamma z}$  and  $b_C = \frac{u_M}{(E - 1)\gamma \phi z}$  so that  $u_E = u_M$ , i.e., the firm still pays each employee his reservation utility. For  $\theta \rightarrow 0$ , the right hand side converges to  $\delta z$ , so that

$(b + b_C)z \geq \delta z$ . For  $\delta$  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.

We also explain why substitute employees are not credible for stealing ideas. Under the assumption that it always takes one period to leave the firm, the only relevant situation concerns the case where the generator could not find an internal match and plans to pursue the venture in the market. A substitute employee might consider also pursuing the idea, but from section 2.2 we already know that having two agents pursuing the idea is never efficient. The efficient equilibria are the two 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 negotiate which one carries the idea forward. With employees leaving the firm, however, the firm owner can easily create a focal equilibrium. For this, we can think of the firm owner using the public signal of supporting the generator to pursue a spin-off, and discouraging substitute employees from stealing ideas. This public signal is further strengthened by the fact that the firm owner wants to reward the generator and will let him go cleanly, whereas the firm owner wants to discourage employee stealing, and can thus threaten to sue for violation of trade secrets. Given this public signal, the focal equilibrium becomes the one where the generator pursues the idea, and all substitute employees prefer not to compete.

# 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 ( $D \rightarrow 1$ )
$E$	Total number of employees within a firm
$K$	Fixed cost of starting a firm
$L$	Listener (also used as subscript)
$m$	Monitoring cost
$n_F, n_E, n_M, n_S$	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
$\psi$	Private idea generation costs
$\delta$	Discount factor across periods ( $\delta \rightarrow 1$ )
$\varepsilon$	Length of talking round ( $\varepsilon \rightarrow 0$ )
$\phi$	Probability that listener is complementor
$\gamma$	Probability of finding an idea
$\mu$	Fraction of employees leaving with ideas over market agents
$\pi$	Per-period firm profit
$\sigma$	Expected penalty in case of false accusation of NDA violation
$\tau$	Transfer payment for signing NDA
$\Omega$	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