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ABSTRACT

Novel early stage ideas face uncertainty on the expertise needed to elaborate them, which creates a need to circulate them widely to find a match. Yet as information is not excludable, shared ideas may be stolen, reducing incentives to innovate. Still, in idea-rich environments inventors may share them without contractual protection. Idea density is enhanced by firms ensuring rewards to inventors, while their legal boundaries limit idea leakage. As firms limit idea circulation, the innovative environment involves a symbiotic interaction: firms incubate ideas and allow employees leave if they cannot find an internal fit; markets allow for wide ideas circulation of ideas until matched and completed; under certain circumstances ideas may be even developed in both firms and markets.

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1 Introduction

The role of innovation in economic growth is well recognized (Romer, 1990), yet the process of generating innovative ideas is still a novel field. The literature has focused on intellectual property rights as incentive for invention (Nordhaus, 1969, Gallini and Scotchmer, 2001). We focus here on an earlier stage in the innovation process, when novel but incomplete ideas are too vague to be granted patent rights, since they are still half-baked and in need of further elaboration. While the development of standard ideas can be planned, for truly novel concepts the next step for their development is unclear, and the missing expertise cannot be identified ex ante. So new ideas need to circulate widely to find the right match. This exposes inventors to the risk of idea theft as information is not excludable.

To understand this trade-off, we study an environment when all agents choose whether to produce ideas or to seek to elaborate ideas of others. Our fundamental assumptions are that early stage ideas are half-baked and valueless until elaborated further by another individual with the right complementary expertise (which we term a complementor). When an agent with an idea is matched with a complementor, it is optimal for them to cooperate to develop the concept.[1] The problem of idea theft arises when the matched individual lacks the complementary fit, but acquires the idea.

The common assumption in the literature is that agents cannot commit not to steal an idea before hearing it. According to Arrow (1962), a listener to an idea would not know how to price it, yet afterwards it is no longer optimal to pay the disclosing party. Indeed, agents frequently involved in assessing new ideas, such as venture capitalists, academic researchers and Hollywood producers, routinely refuse to sign non-disclosure agreements (NDAs).

We seek to answer two basic questions. Why, if asking for an NDA is always beneficial for the issuer, would the other party not agree to sign it? Prior literature points to contractual imperfections and the possibility of extortion (Anton and Yao, 2002, 2003, 2004).[2] Second, if indeed most ideas are shared without contractual protection, how can inventors protect their claim? Previous work has analyzed the

[1]Cooperation is possible as ideas are in principle contractible: if they are shared verbally, they may also be written down.

[2]NDAs are sometimes employed at late stages of idea elaboration, to formalize commitments to a well defined project (Bagley and Dauchy, 2008).

problem of sharing a single idea between two agents (Anton and Yao 1994, 2004), while we examine the creation and circulation of many ideas among a large set of agents.

In the model, at each date agents choose whether to invent, or to be matched with agents who may either have ideas or be free-riding as well. If a good fit is found for an idea, both parties have incentives to cooperate. However, if the idea is shared with someone unable to elaborate it, there can be no gain from cooperating. So in an open market exchange, ideas circulate through a sequence of agents, not necessarily their inventors, until matched to a complementor. From an ex-post perspective, a free circulation of ideas is most efficient in ensuring their elaboration. However, frequent idea stealing may deny the inventor a sufficient reward for the initial concept.

We first derive the conditions under which idea protection fails endogenously. Agents have limited memory so they can recall at most one idea. We show that there always exists an equilibrium where no one signs NDAs, even for an arbitrarily small drafting cost. In addition, when ideas are sufficiently frequent, there may be no equilibria where all agents sign NDAs.[3] In general, ideas will circulate unprotected when the threat not to disclose without a NDA is not credible.

Next we seek to understand what context creates high idea density to compensate for idea stealing. We argue that next to independent agents, firms are a source of ideas because they can create an internal environment where ideas can be shared and idea generation can be rewarded. We argue that such an environment requires that firms to develop a local reputation for transparency among its employees. In addition, firms use their legal boundary to control the leaking of internal idea, ensuring a safe internal idea exchange.

Yet some ideas will not be resolved within firms when no matching skill is found. Open knowledge strategies allow unresolved ideas to leave the firm to spawn new ventures. So markets benefits from idea incubators such as firms (or academic institutions) to increase the rate of idea generation. As a conclusion, coexistence of open firms and markets produces an optimal environment for idea generation and their completion by wider circulation.

In this approach, firms can emerge as a solution to a market failure where agents

[3]This reflects a similar paradox as in Grossman and Stiglitz (1983), who show that financial prices cannot be fully informative as there would be no gain to collect information. In our context, if there is no risk of idea theft there are no opportunists, so at the margin the NDAs are superfluous.

who accept employment are bound by trade secret law, which can be thought of as a collective non-disclosure agreement. In exchange, the firm has to commit to reward creative employees, a commitment which we argue need to be backed by reputation. We assume that a firm owner can make a costly investment in building a local reputation by creating visibility of her actions among the firm's employees (Kreps, 1986). The threat of loss of corporate reputation for fair dealing ensures that employees agree to contractually commit to sharing and not stealing ideas inside the firm, even though they may refuse to sign an equivalent contract with an individual agent who has more limited visibility and thus a limited punishment in case of breach. As the employment contract implies respect for firm trade secrets, the firm can provide a safe idea exchange, and a safer return to idea generators.

Firms incur costs for reputation creation and monitoring the flow of ideas, so the density of firms depends on their return relative to independent activity. But the fundamental cost of a firm here is that it contains idea circulation within firm boundaries, thus limiting the set of possible matching expertise. This leads to our second main result: just as market failure creates a need for idea-incubating firms, firm failure to develop some internal projects creates a role for markets to complete those ideas, increasing the density of firms in the market. This requires firms to pursue an open knowledge approach, allowing employees to spin-off their ideas that could not be used internally (Lewis and Yao, 2003; Sevilir, 2009). Thus, in our approach firms and markets complement one another, each compensating for some 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, as it is the case in innovative environments such as Silicon Valley.[4]

Relationship to the theoretical literature

Following Schumpeter (1926, 1942), this paper treats a new idea as a novel combination of existing factors (see also Biais and Perotti, 2008, and Weitzman, 1998). In the case of a truly novel idea, unlike conventional team production, the process of discovery by matching skills cannot be planned. As a result, a broad circulation of

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

ideas is critical for innovation, as it allows maximum chance of elaboration. Saxenian (1994) emphasizes "cross-pollination" and open networking as a main cause of Silicon Valley's innovative success. We can rationalize such an environment thanks to the explicit dynamic game where idea density sustains their free circulation. Haessler et al. (2009) show that idea sharing may occur in a dynamic model with repeated interaction, and provide some supporting evidence. For a fascinating review of historical periods of high idea density and free circulation, see Meyer (2003).

The literature on innovation has long recognized the non-excludability of information as a key obstacle for innovation. Aghion and Tirole (1994) studied the optimal allocation of control over innovative ideas. Anton and Yao (1994) show that inventors can ex-post secure some value by threatening to transmit the idea more broadly, creating more competitors. Anton and Yao (2002, 2004) show how partial or sequential disclosure of ideas helps inventors secure a larger payoff (see also Bhattacharya and Guriev, 2006, and Cestone and White, 2003)). The basic mechanism is the threat to disseminate an idea if stolen. Some papers considers instead limiting the circulation of ideas. Baccara and Razin (2006, 2008) examine whether inventors may buy out all idea holders, or allow some leakage. Rajan and Zingales (2001) examine how a hierarchy may prevent idea-stealing by granting access to its technology only to dedicated employees. Ueda (2004) and Chemmanur and Chen (2006) examines the trade-off of talking to uninformed investors versus venture capitalists who may steal the idea. Silveira and Wright (2007) examine a matching model where non-rival ideas can be traded. Idea diffusion models where the number of agents with the same idea increases over time are quite complex, so our focus is on the simpler case of (ex post efficient) idea circulation without diffusion.

Biais and Perotti (2008) show that an unpatentable idea may be safely shared with agents known to be highly complementary experts, and implemented by a contingent partnership. This paper pursues the effect of complementarity one step further - or rather earlier - by allowing the complementary agent not just to screen, but to elaborate the idea. In a related approach, Stein (2008) studies the complementarity of information shared sequentially in the elaboration of a project. Bolton and Dewatripont (1994), and Novaes and Zingales (2004) examine idea generation and communication within firms. Johnson (2002) and Lerner and Tirole (2002) examine idea exchanges in an open-source context.

In our model, firms emerge to compensate for opportunism in market interaction, as in Coase (1937). Holmström and Roberts (1998) suggest that ideas, and the people who generate them, belong at the core of any theory of the firm. An employee's idea is an intangible real asset in principle owned by the firm, but which cannot be claimed unless the employee reports it. Loss of firm reputation to reward invention (Kreps, 1986) is costlier than the breach of an individual promise observed by few other agents.

In section 2 we develop the basic model, focusing on idea sharing in markets and the use of precontracting with NDAs. Section 3 studies idea circulation within firms and across firm boundaries, where firms and markets coexist. Section 4 presents simple extensions and discusses the empirical evidence, in particular on open firm environments and firm spawning. We conclude with some thoughts for further research.

2 Idea circulation in a pure market setting

2.1 Basic assumptions

We first examine the interaction among market agents in an environment without any firms. The base model has an infinite number of periods, with a discount factor of δ. All agents are risk-neutral and infinitely-lived.

We assume that ideas are too preliminary to be patentable. However, we assume that it is possible to write down ideas, and therefore to contract on ideas. Non Disclosure Agreements (NDAs henceforth) can be used to contractually protect idea. Whether agents choose to contract or not is endogenous. In sections 2.1 - 2.6 we simplify the exposition by assuming that agents do not use any NDAs; Section 2.7 examines the model with NDAs; Section 2.8 derives the conditions under which agent do or don't use NDAs.

At the beginning of each period, agents decide whether to generate an idea, or interact with others to elaborate ideas (later we let agents also start firms). Each activity lasts one period. Generating an idea requires a private cost ψ, and we denote idea generators by G. For simplicity we assume that each agent always succeeds to generating an idea, which he will seek to complete with someone else the following period.[5] All active agents (i.e., not busy generating ideas) are matched at random.

[5] An earlier version of the paper allowed for a more general specification where the probability of success was a parameter $\gamma \in (0, 1]$. The comparative statics of γ were straightforward, so we simplify the model by setting $\gamma = 1$.

We denoted by I "idea-bearing" agents have ideas to elaborate (whether their own creation or stolen in previous periods). Agents without any idea, denoted by O (or "opportunists"), seek a match to elaborate others' ideas without contributing an idea themselves. Ideas can be carried across periods, although due to limited memory each agent can remember one idea at most. Whether an active agent carries a valid idea can only be ascertained when the agents interact after being matched. Matched agents cannot observe each other's prior history. Since there is an infinite number of agents active in the market, the chance that two agents are matched repeatedly is negligible.

Successful elaboration of an idea requires an idea-specific fit between individual skills, which cannot be identified ex-ante. Thus to find out whether an idea fits the skills of two agents, it needs to be shared.[6] Denote the probability of an idea-specific fit by ϕ, the chance that the idea-bearer finds a "complementor" by a random match. With probability $\overline{\phi}$ there is no fit, and the two agents are "substitutes".[7] Two matched agents share their ideas, so every match shares zero, one or two ideas. When an idea finds the matched skill to complete it, it can get implemented by a cooperative effort, generating a net payoff z.

If two well-matched agents fail to cooperate and seek to implement the idea with someone else in a later period, competition is such that the sum of their expected individual returns z_0 is less than the cooperative return, i.e., $z > 2z_0$. Moreover, the delay reduces the discounted value of the payoff. This ensures that once two agents have an idea that fits, cooperation is the efficient strategy. If instead there is no fit, the agents optimally agree on who should continue to pursue the idea further to avoid competition.[8]

Each period of interaction has three stages. First, the two agents share their own ideas to find out whether there is a fit. If there is a fit, the two agents negotiate the sharing of profit, sign an agreement and implement the developed project. Two agents can implement two projects at the same time.

In any given period there are three types of agents: Agents working on their own,

[6] In Hellmann and Perotti (2005), we consider the case where agents know but can hide their type. In this case, substitutes may misrepresent their types, discouraging idea-bearers from pursuing their idea, and then secretly steal it.

[7] Throughout the paper a bar above a probability denotes its complement, so that $\overline{\phi} \equiv 1 - \phi$. .

[8] Since the idea is contractible, a feasible implementation of the ex post efficient noncompetitive arrangement is that the winner of a coin toss is the owner of the idea.

termed "generators", attempt to generate new ideas and are not matched for the period. Matched agents may be either "idea-bearers" or "opportunists" with no own idea to share. We denote the relative fraction of these three types by n_G, n_I and n_O, where $n_G + n_I + n_O = 1$.

A critical variable which the model endogenizes is the density of ideas in circulation, measured by the fraction θ of matched agents carrying an idea:

$$\theta = \frac{n_I}{n_I + n_O}$$

This fraction θ of agents who carry ideas reflect individual choices to either spend time developing an idea or to act opportunistically. The model endogenizes this natural metric for the degree of innovation in the economy under different forms of idea exchange. We start with pure market exchange.

2.2 Bargaining

We assume that all bargaining follows the Nash solution.[9] As we will see below, most bargaining situations in this model are perfectly symmetric, so other bargaining solutions, such as Rubinstein's (1982) alternating offer game, yield the same results. We first examine the bargaining game in the absence of any NDAs. Section 2.7 will address bargaining with NDAs.

The bargaining situation naturally differs according to how many ideas are present, and how many ideas fit. Consider first the case where there is only one idea, and it doesn't fit - this happens with $2\overline{\theta}\theta\overline{\phi}$. Because ideas can be stolen, both parties have the same outside option, irrespective of which partner had idea. However, since $z > 2z_0$, it is optimal to avoid competition. The two agents agree that only one of them should take the idea into the next period. It is therefore optimal to flip an even coin, i.e., to let either agent take the idea further with probability $\frac{1}{2}$. Idea stealing thus occurs in equilibrium, and it is overt, in the sense that both parties are fully aware of it.[10]

[9] Binmore, Rubinstein and Wolinsky (1986) provide a foundation for the use of the Nash bargaining solution, as the outcome of an alternating offer bargaining game with an infinitesimal probability that a player exits the game.

[10] We may ask how to enforce this efficient continuation. The two agents can write a contract that guarantees one of them the right to continue. Such a contract can be thought of as an ex-post nondisclosure agreement. This is fundamentally different from an ex-ante nondisclosure agreement, since at the ex-post stage, both agents know the idea and want to ensure that only one of the carries

Consider next the case where there is only one idea, and it fits - this happens with $2\theta\overline{\theta}\phi$. Since $z > 2z_0$, it is always efficient to implement the project, generating a joint value of z. The outside options of both agents are again symmetric, because of idea stealing. That is, in case of disagreement the situation is similar to the above, i.e., each partner takes the idea with probability $\frac{1}{2}$. The equilibrium bargaining outcome is therefore an equal split, where each agent gets $\frac{z}{2}$.

Consider now the case where there are two ideas. If neither idea fits (which happens with $\theta^2\overline{\phi}^2$), each partner simply continues with his idea. If both ideas fit (which happens with $\theta^2\phi^2$), the joint value is $2z$, and the outside option is that each partner continues with his idea. The equilibrium bargaining outcome is therefore that the two agents split the total surplus equally, each receiving a value of z. If only one idea fits (which happens with $2\theta^2\phi\overline{\phi}$), then the joint value of cooperation is z, and the outside option is that each partner continues with his idea. Each partner receives a value $\frac{z}{2}$, and a probability $\frac{1}{2}$ of taking the idea that did not fit into the next period.

We note that because ideas can be stolen, all the bargaining outcomes are perfectly symmetric. There is an interesting difference between the case of one versus two ideas. If there is only one idea, then the two partners enter the bargaining game asymmetrically, but leave symmetrically. Intuitively, the opportunist (O type) benefits but the idea-bearer (I type) loses out. However, if there are two ideas, then both partners enter and exit the bargaining game symmetrically. Put differently, if two idea-bearers meet, there are no winners and losers. This insight plays an important role in the analysis of section 2.8, as it suggests that protecting ideas is only worthwhile when an idea-bearer worries about being matched with an opportunist.

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it forward.

Writing an ex-post contract is not even necessary if the agreement is self-enforcing. Suppose the first agent won the coin flip and caries the idea into the next period. Consider a deviation by the second agent to also pursue the idea. For simplicity, let us focus on a one-period deviation. It is easy to see that if the one-period deviation is not profitable, neither will a multi-period deviation be. With probability ϕ^2, the two agents both find a fit in the next period and compete, generating returns z_0. With probability $\phi\overline{\phi}$, the deviant agent is the only one to find a fit, generating returns z_0. The second agents deviation is unprofitable whenever $\phi\overline{\phi}z + \phi^2 z_0 < 0 \Leftrightarrow z_0 < -\frac{\overline{\phi}}{\phi}z$. This condition thus requires that agents make sufficient losses in case of competition, i.e. that the cost of implementing the idea under competition outweighs the benefits under monopoly.

2.3 Dynamics of idea generation and circulation

To determine the equilibrium fractions of types and thus idea density, consider an arbitrary period t. The number of idea-bearers is composed of two types. There are $n_{G,t-1}$ generators with new ideas. Last period there were $n_{I,t-1}$ idea-bearers, of which a fraction ϕ found a fit and implemented the idea and $\overline{\phi} n_{I,t-1}$ old ideas continue circulating in period t. Thus the total number of undeveloped ideas is $n_{I,t} = n_{G,t-1} + \overline{\phi} n_{I,t-1}$. In the steady state, $n_I = \frac{1}{\phi} n_G$. Straightforward calculations (see appendix) reveal that

$$n_G = \frac{\theta\phi}{1+\theta\phi},\ n_I = \frac{\theta}{1+\theta\phi} \text{ and } n_O = \frac{\overline{\theta}}{1+\theta\phi}.$$

The value of θ is determined endogenously in each of the idea exchange equilibria derived below.

In the case of a market equilibrium, every idea is circulated until it finds a match, so the probability that an idea is implemented is 1.[11] However, many generators receive no economic reward. The appendix shows that the probability of a generator implementing his own idea is given by $\frac{2\phi}{2-\overline{\phi}(1+\theta\overline{\phi})} < 1$.[12]

2.4 The choice to generate and elaborate ideas

We now derive expected utilities of pursuing a G, I and O strategy. We denote lifetime utilities with U. Agents not carrying an idea from last period (I) will choose among a G and a O strategy. The utility of an opportunist is given by

$$U_O = \overline{\theta}\delta U_O + \theta\phi(\frac{z}{2} + \delta U_O) + \theta\overline{\phi}(\frac{1}{2}\delta U_O + \frac{1}{2}\delta U_I)$$

where θ is determined endogenously.

The first term reflects the case where the agent is matched with another opportunist, so the immediate return is zero and the agent gets the discounted utility of

[11] To see this, note that in each period, there is a probability of ϕ of implementing the idea, and with $\overline{\phi}$ the idea gets carried into the next period. Thus $Prob(implementation) = \phi + \overline{\phi}\phi + \overline{\phi}^2\phi + ... = \phi \sum_{j=0}^{j=\infty} \overline{\phi}^j = \frac{\phi}{1-\overline{\phi}} = 1$.

[12] The comparative statics are simple: this probability is strictly increasing in the ease of finding a match ϕ. Thus idea generation is most rewarding in an environment where there is a good chance of finding a complementor.

being an opportunist (or a generator) next period. The second term reflects the case where the O agent is matched with an idea-bearer and there is a fit, so that the agent gets $\frac{z}{2}$ and then comes back next period as an opportunist. The third term reflects the case where the agent is matched with an idea-bearer but there is no fit. The two flip an even coin, so that with probability one half the agent goes back without an idea, and with probability one half the agent steals the idea and becomes an idea-bearer next period.

The utility of an idea-bearer is independent of whether the idea has been self generated or stolen, and is given by

$$U_I = \overline{\theta}[\phi(\frac{z}{2}+\delta U_O)+\overline{\phi}(\frac{1}{2}\delta U_O+\frac{1}{2}\delta U_I)]+\theta[\phi^2(z+\delta U_O)+2\phi\overline{\phi}(\frac{z}{2}+\frac{1}{2}\delta U_O+\frac{1}{2}\delta U_I)+\overline{\phi}^2\delta U_I]$$

The first term reflects the case where the agent is matched with an opportunist. With probability ϕ there is a fit and the pair implement the agent's idea, after which the next expected period payoff equals δU_O. If there is no fit, with probability one half the agent retains the idea for the next period, while with probability one half the opportunist takes away the idea. The second bracket term reflects the case where two idea-bearers are matched. When both ideas fit, each agent gets z. When only one fits, the payoff is $\frac{z}{2}$ plus a half chance to take the idea further as before. If neither idea fits each agent carries his idea forward.

The utility of a generator is given by

$$U_G = \delta U_I \ - \psi$$

which equals its expected payoff of an idea-bearer next period, minus the cost of developing the idea. Note the obvious point that $U_G < U_I$, as it is more profitable to seek to develop a stolen idea than to incur some generation cost to produce it.

It is useful to define

$$\Delta = U_I - U_O$$

so that Δ measures the net benefit of having an idea. Δ will play an important role throughout the analysis, as it provides a natural metric for the value of being an idea-bearer.

2.5 Social efficiency

Before stating the main Proposition on the market equilibrium, we characterize the socially efficient benchmark, defined as the allocation that maximizes the sum of utilities of all agents. We denote it by the superscript S.

Proposition 1 ***(Social efficiency)***
Define $\Delta^S = \dfrac{\phi z + \psi}{1 + \delta\phi}$ *and* $\psi^S = \dfrac{\delta\phi z}{1 - \delta + \delta\phi}$.
The socially efficient equilibrium has the following characteristics:
(i) If $\psi \geq \psi^S$, *then it is socially efficient not to generate any ideas.*
(ii) If $\psi < \psi^S$, *then the optimal allocation has no opportunists, so that* $n_O = 0$ *and* $\theta = 1$. *Irrespective of how the idea value* z *is split, utilities are given by*

$$U_G^S = \frac{\delta\Delta^S - \psi}{1 - \delta} \text{ and } U_I^S = \frac{\Delta^S - \psi}{1 - \delta}.$$

Proposition 1 states that it is socially optimal not to have any opportunists. The intuition is simple. When an idea-bearer is matched with an opportunist, he gets the same expected feedback, but as the opportunist has no valid idea, he cannot provide any useful feedback. It is therefore always more efficient to match an idea-bearer with another idea-bearer. All agents without ideas should generate new ones.

2.6 Equilibrium rewards to invention and elaboration

Generators need to achieve a non-negative utility by creating an idea, i.e., $U_G \geq 0$. Any agent without an idea will choose between generating an idea versus listening to others', which implies $U_G(\theta) = U_O(\theta)$. This indifference condition drives the density of ideas, as measured by θ. We denote variables associated with the market equilibrium by the superscript M.

Proposition 2 ***(Market equilibrium)***
Define $\Delta = \dfrac{\phi z}{2 - \delta + \phi\delta}$ *and* $\psi^M \equiv \delta\Delta$.
The market equilibrium has the following characteristics:
(i) If $\psi \geq \psi^M$, *then no ideas are generated in the market.*
(ii) If $\psi < \psi^M$, *then the equilibrium fraction of idea-bearers is given*

$$\theta = \delta - \frac{\psi}{\Delta} < 1$$

and utilities are given by

$$U_G = U_O = \frac{\theta\Delta}{1-\delta} = \frac{\delta\Delta - \psi}{1-\delta} \text{ and } U_I = \frac{\Delta - \psi}{1-\delta}.$$

(iii) In comparison to the socially efficient outcome, the market equilibrium has a smaller feasible range (i.e., $\psi^M < \psi^S$), fewer generators ($n_G^M < n_G^S$), fewer idea-bearers ($n_I^M < n_I^S$), more opportunists ($n_O^M > n_O^S = 0$), a lower utility for generators ($U_G < U_G^S$), and a lower utility for idea-bearers ($U_I < U_I^S$).

Proposition 2 shows how in a pure market setting, idea generation occurs for lower generation costs than the socially optimal ψ^S, so for any $\psi \in [\psi^M, \psi^S)$, idea generation would be socially desirable, yet it cannot be achieved in a market exchange. Even if idea generation is feasible in the market, its equilibrium return is inefficient since agents can participate in elaborating ideas without contributing any. The market equilibrium always contains less idea-bearers than optimal, i.e., $\theta < 1$. To see that the utility of generating ideas is lower than the socially desirable level we then note from Propositions 1 and 2 that $\Delta < \Delta^S$, implying that the premium for having an idea in the market is too low relative to the social optimum.

The comparative statics are as follows.

Corollary to Proposition 2: Comparative statics of market equilibrium

Consider the market equilibrium with $\psi < \psi^M$.

(i) The equilibrium number of generators (n_G^M) is increasing in z and ϕ, and decreasing in ψ.

(ii) The equilibrium number of opportunists (n_O^M) is decreasing in z and ϕ, and increasing in ψ.

(iii) The equilibrium number of idea-bearers (n_I^M) is increasing in z, and decreasing in ψ. It is also increasing in ϕ for larger values of ψ, but decreasing in ϕ for smaller values of ψ.

(iv) The utilities U_G, U_I and U_O are all increasing in z and ϕ, and decreasing in ψ.

These results are quite intuitive, as the number of opportunists responds to economic variables in exactly the opposite way as the number of generators. The more attractive it is to generate ideas, the fewer agents seek to only listen to other agents' ideas. The more subtle result concerns ϕ, the probability of fit. A higher likelihood of fit encourages ideas generation, but also increases the expected speed at which ideas get implemented. Higher values of ϕ are thus associated with more 'new' but fewer 'old' ideas. The net effect can go either way. The appendix shows that there exists a critical value $\psi^{\phi} \in (0, \psi^{M})$ such that the 'new' idea effect dominates the 'old' idea effect if and only if $\psi > \psi^{\phi}$. Finally, note that in equilibrium the utility of opportunists - unlike the number of opportunists - remains equal to the utility of generators.

2.7 Equilibrium with perfect idea protection

The analysis so far rules out the protection of ideas via NDAs. We now examine NDAs in two steps. This subsection assumes that it is feasible to protect an idea by inducing a counterpart to sign an NDA. We thus derive the market equilibrium with NDAs. In section 2.8 we then derive under what circumstances NDAs are actually adopted in equilibrium.

An agent who seeks to protect his idea is termed the "issuer" of the NDA, and the agent who agrees not to steal the idea is the "signee" of the NDA. We assume that matched partners either agree to sign mutual NDAs, so that each agent becomes both an issuer and a signee, or neither does. If an agent turns out to be an opportunist, issuing a NDA is useless but is harmless. Each agent incurs an arbitrarily small transaction cost $c > 0$ every time he agrees to a mutual NDA. Our analysis does not rely on large transaction c, whose role is merely to break an indifference condition.

If NDAs are signed by all, any inventor keeps his idea until implementation. This increases his bargaining power in case of a fit. Interestingly, the NDA protects the inventor's claim on the idea, but does not grant him the full return to his idea. The complementor has some bargaining power, since his skills are required for implementation and seeking another one would imply a delay and thus a lower discounted value.

Let the superscript N denote variables associated with the NDA equilibrium. To derive the Nash bargaining solution, let s be the profit share of the idea-bearer. Consider the case where A has an idea that fits, and B is an opportunist without ideas (the appendix shows that all other cases follow a similar logic). The value of cooperation is z, with continuation utilities δU_O^N for A and B. A's outside option is to take the idea back into the market next period, which gives him a continuation value δU_I^N. B cannot steal the idea, so his outside option is δU_O^N. The Nash bargaining solution therefore implies that A's utility is given by

$$sz + \delta U_O^N = \frac{1}{2}[z + 2\delta U_O^N + \delta U_I^N - \delta U_O^N] \Leftrightarrow s = \frac{1}{2} + \frac{\delta \Delta^N}{2z}$$

The idea-bearer retains more than half of the idea value, which is an improvement over the no contract outcome. The exact value retained depends on (endogenous) difference in utilities $\Delta^N = U_I - U_O$. The appendix shows that $s < 1$, so that the idea-bearer still does not capture the entire value of the idea.[13]

The appendix derives the market equilibrium when all agents sign NDAs, summarized in the following Proposition.

Proposition 3 ***(NDA equilibrium)***
Define $\Delta^N = \dfrac{\phi z}{2 - 2\delta + \delta\phi}$, $\psi^N \equiv \delta\Delta^N$ *and* $\psi^O \equiv Max[0, c + (2\delta - 1)\Delta^N]$.
The NDA equilibrium has the following characteristics:
(i) If $\psi > \psi^N$, *then no ideas are generated in a market with NDAs.*
(ii) If $\psi^O < \psi \leq \psi^N$, *then the NDA equilibrium has a positive fraction of opportunists. The equilibrium fraction of idea-bearers is given by*

$$\theta^N = \frac{2}{\phi} \frac{\delta\Delta^N - (\psi - c)}{z - \delta\Delta^N} < 1$$

Agent's utilities are given by

$$U_G^N = U_O^N = \frac{\delta\Delta^N - \psi}{1 - \delta} \text{ and } U_I^N = \frac{\Delta^N - \psi}{1 - \delta}.$$

(iii) If $\psi \leq \psi^O$, *then the NDA equilibrium has no opportunists, so that the equilibrium fraction of idea-bearers is given by* $\theta = 1$. *The equilibrium is the same as the socially*

[13] Could an idea-bearer do even better by asking the counterpart to accept a contract even more onerous than an NDA, such as a contract that gives the idea bearer all of the surplus (i.e., $s = 1$)? The problem is that such contracts would not be renegotiation-proof. Before agreeing to cooperate, the complementor can always renegotiate terms. The renegotiation bargaining game is identical to the one described above - it is easy to see that the joint value and the outside options are identical - implying that the outcome after renegotiation is the same as above. Hence there is no loss of generality limiting our analysis to NDA contracts.

efficient equilibrium, except for the transaction costs, so that we replace Δ^S *with* $\Delta_c^S = \dfrac{\phi z + \psi - c}{1 + \delta\phi}$.

(iv) The range of the NDA equilibrium lies in between the simple market equilibrium and the socially efficient equilibrium, i.e., $\psi^M < \psi^N < \psi^S$.

(v) For $\psi^O < \psi \leq \psi^N$*, the are more generators than in the market equilibrium, but fewer than in the socially efficient equilibrium* ($n_G < n_G^N < n_G^S$)*. Same for idea-bearers* ($n_I^M < n_I^N < n_I^S$)*. There are fewer opportunists than in the market equilibrium, but more than in the socially efficient equilibrium* ($n_O^M > n_O^N > n_O^S = 0$)*. The utilities are higher than in the pure market equilibrium, but lower than in the socially efficient equilibrium* ($U_G < U_G^N < U_G^S$ *and* $U_I < U_I^N < U_I^S$)*.*

Proposition 3 shows that NDAs improve over the pure market outcome as they help idea generators to capture a larger fraction of the value they generate. This is reflected in the fact that $\Delta^N > \Delta$, which shows that the net benefit of having an idea is higher when ideas are protected. For intermediate values of ψ (i.e., $\psi \in (\psi^O, \psi^N)$) the equilibrium is more efficient than the market equilibrium, but still not socially optimal, as opportunistic incentives to to elaborate rather than generate ideas continue to exist. Only for sufficiently low values of ψ (i.e., $\psi < \psi^O$) we find that idea generation always dominates the opportunist strategy. In this case, the equilibrium is efficient, except for transaction costs.

2.8 Are NDAs used in equilibrium?

The analysis of section 2.7 assumes that NDAs are signed by all agents. This section examines under what conditions NDAs will actually be used in equilibrium. Our goal is to address a puzzle. Casual empirical observation suggests that NDAs are used very rarely by agents actively involved with new ideas. Even to the limited extent NDAs are employed, they are rarely used at the initial stages of exchanging ideas.

Why are NDAs used so rarely by agents who share innovative ideas? Asking for an NDA seems always beneficial for the issuer, the question is why the other party should sign it? Prior literature suggests that informational imperfections and the possibility of extortion limit the use of NDAs (see, in particular, Anton and Yao, 2002, 2004, 2005). We offer a parsimonious explanation for why agents may refuse to sign NDAs, namely that doing so may be suboptimal.

The NDA contracting game occurs when neither agent knows whether the other actually has an idea. We assume symmetric agents would sign an NDA only if the other also agrees to sign one - we return to this assumption at the end of the section. Whether two agents choose to sign a mutual NDA depends on expectations about subsequent behavior. To examine out-of-equilibrium beliefs of agents, we use the intuitive criterion of Cho-Kreps (1987).

The stage game proceeds as follows. Let agent A propose a mutual NDA, and agent B either accepts or reject. Agents then decide whether to disclose their ideas. If there is a fit, the two negotiate the terms of cooperation, else they negotiate who will take the idea further. The behavior at the contracting stage is influenced by expectations over whether or not disclosure occurs subsequent to a refusal to sign. There may be multiple equilibria supported by different beliefs about ex-post disclosure.

We first establish the existence of an equilibrium where nobody signs NDAs. The key insight is that agents can never credibly commit to refuse disclosing their idea without a NDA. Intuitively, agents still want to disclose their ideas, even if their match refused to sign an NDA. This is a self-fulling equilibrium, because everyone expect same situation next period.[14]

Consider, starting from an equilibrium where no one uses NDAs, whether introducing NDAs constitutes a profitable deviation. The appendix shows that disclosure happens even without an NDA. Signing an NDA therefore does not affect the actual exchange of ideas or value created. However, it affects the division of rents between the two agents. This insight implies that using NDAs is a zero-sum game. In fact, in the presence of transaction costs, using NDAs is a negative-sum game.[15] That is why introducing NDAs does not constitute a profitable deviation.

Proposition 4 ***(Existence of equilibrium without NDAs)***
There always exists an equilibrium in which agents never sign NDAs, and the equilibrium is the market equilibrium as described in Proposition 2.

[14]The appendix shows that an agent cannot commit not to disclose even when he knows that the other agent is an opportunist. The reason is that, in equilibrium, there are always enough opportunists (i.e., θ is sufficiently low), so that sharing an idea with a known opportunist in the current period is no worse than sharing an idea with an agent that is an opportunist with probability $\overline{\theta}$ in the next period. This result holds for all values of δ.

[15]Assuming a small transaction cost seems reasonable. However, the result continues to hold even for $c = 0$, except that idea-bearers are now indifferent about signing NDAs. The model with $c = 0$ thus has knife-edge properties. Hence our focus on the model with $c > 0$.

To sketch the proof, note that if agents disclose ideas with or without NDAs, then NDAs either do nothing (when both or neither has an idea), or they transfer utility from one agent to another. Specifically, if both agents are idea-bearers, then NDAs cancel out each other. Similarly, if both are opportunists, then NDAs are irrelevant. If, however, one agent is an idea-bearer and the other an opportunist, then an NDA has the effect of transferring utility from the opportunists to the idea-bearer. Having established that NDAs do not create value, consider now an equilibrium where nobody signs NDAs and examine whether a deviation where A proposes using mutual NDAs breaks the equilibrium. B uses the intuitive criterion to make an inference about A's type. Clearly A cannot be an opportunist, since an O type can never benefit from an NDA. B would thus believe that A is an idea-bearer. What is B's best response? If B is an opportunist, he would be worse off accepting the NDA. However, even if B is an idea-bearer, he would still refuse to sign the NDA, because the two NDAs cancel out each other. So it is never worthwhile to incur the transactions c to write up NDAs that have no economic benefit. It follows that, starting from an equilibrium without NDAs, the deviation of offering NDA is always met with a negative response. Moreover, the appendix shows that A cannot commit not to disclose the idea even after B refuses the NDA. Thus A's deviation to introduce an NDAs is not worthwhile.

Proposition 4 deals with a situation where no one uses NDAs, and shows that this is a stable equilibrium. This still leaves open to possibility that there is another equilibrium where NDAs are used. Intuitively, the equilibrium with NDAs is self-enforcing as long as agents refuse to disclose their ideas without an NDA. The key issue is thus whether refusing to disclose an idea without NDA is credible.

In the appendix we show that the refusal to disclose is not credible in many circumstances. Consider a deviation from the NDA equilibrium, where one agent, call him A, refuses to sign the NDA. We derive a condition of when B would still want to disclose his idea. Using the intuitive criterion, we show that B would not update his belief about A after an NDA rejection, because both idea-bearers and opportunists prefer not to sign NDAs. Whenever B's initial belief of having met an idea-bearer is sufficiently high (i.e., θ^N is sufficiently high), he still prefers to discloses the idea, even after an NDA rejection. This, however, makes A's deviation of refusing to sign the NDA profitable, implying that the equilibrium where all agents sign NDAs cannot be sustained. The key condition for an NDA equilibrium to be stable is thus that the fraction of idea-bearers is not too high. Proposition 3 showed that for any

$\psi < \psi^O$, the NDA equilibrium is efficient and has no opportunists, i.e., $\theta^N = 1$. We thus note that this equilibrium can never be sustained, because agents can never commit not to disclose their ideas. For the range $\psi^O < \psi < \psi^N$ we have $\theta^N < 1$. The appendix derives a simple condition for when the refusal to disclose is credible in this range. Formally we obtain the following result.

Proposition 5 ***(Existence of equilibrium with NDAs)***
The equilibrium where all agents sign NDAs described in Proposition 3 is not sustainable if $\theta^N > 3 - \dfrac{2}{\delta}$, or equivalently, if $\dfrac{2}{3} > \delta$ and $\psi < \widehat{\psi}$ where $\widehat{\psi} = c + \dfrac{2 - 5\delta + 4\delta^2}{\delta}\Delta^N > \psi^O$.

Proposition 5 is an important and perhaps surprising result. It says that NDA contracts can arise endogenously only under limited circumstances. For a large range of parameters, using NDA is simply not an equilibrium. This is in sharp contrast to Proposition 4 which showed that the equilibrium without NDAs is always stable.

The condition for when NDAs can be used in equilibrium can be expressed in two ways. The condition $\theta^N < 3 - \dfrac{2}{\delta}$ indicates that the rate of idea generation cannot be too high, or else there are too few opportunists in equilibrium to make the refusal to disclose an idea credible. Put differently, when ideas are plentiful the expected payoff to share an unprotected idea is high, so agents do not bother to demand costly NDAs. Since θ^N is endogenous, we restate the condition exogenously in terms of $\psi > \widehat{\psi}$, which also requires $\dfrac{2}{3} < \delta < 1$. So NDAs can be used only when there are fewer ideas in circulation and the cost of generating them is sufficiently high, so that agents become averse to disclose their ideas without an NDA.

The analysis so far is based on the adoption of a mutual NDA. Would anything change if we allow for unilateral NDAs? Mutual NDAs clearly require no transfer payments. In order to be willing to sign a unilateral NDA, it is conceivable that the NDA signee would require a payment from the NDA issuer. Such arrangements are hardly ever observed in practice. Reassuringly, our model also predicts that such arrangements would never be used in equilibrium. The proof is in the appendix, we briefly sketch the main intuition. Proposition 4 continues to hold, because of the central insight that, starting from a equilibrium without NDAs, introducing NDAs is a negative-sum game. While it is possible for one agent to design a unilateral NDA such that only idea-bearers would sign it, doing so is ultimately futile: the NDA doesn't increase the joint utility, and offering ends up costing the issuer more than he can benefit from it. For Proposition 5, unilateral NDAs with side payments are unnecessary whenever the NDA equilibrium exists, nor do they affect the logic of how a refusal to sign the NDA breaks the equilibrium.

Our analysis identifies one important reason why agents involved in frequent idea exchange do not sign NDAs: they become unnecessary when agents cannot commit not to disclose their ideas anyway, which occurs when ideas are sufficiently abundant.[16]

Next to contracts, agents can create a commitment to idea protection through reputation. The ability to create a reputation for not stealing ideas depends on the visibility of one's action. We consider next the possibility that an agent invests in creating a visible environment among multiple agents. In principle there may be multiple institutional arrangements that are supported by reputation mechanism. Individuals may acquire a reputation, possible within some network structure, and organizations may be the repositories of a collective reputation. We will not attempt to provide a comprehensive characterization of all reputation mechanisms, but instead focus on one important reputation mechanism, namely the firm (Kreps, 1986). This allows us to link our analysis to the larger economic debate about the relative roles of markets versus firms (Hart, 1995, Williamson, 1975).

3 Idea circulation with firms

3.1 The firm as a local reputation mechanism

The value of a reputation depends on the number of agents able to observe such an opportunistic action, and whether they would choose to punish the deviation. Clearly, a 'global' reputation could resolve idea stealing in our model, if it would imply exclusion from any future idea exchange with anyone. Realistically, most actions are visible only among a few agents directly or indirectly involved. Firms may be seen as governance mechanisms to overcome individual opportunism. We propose to think of firms as having 'local' transparency among a finite set of agents that we call employees, reflecting a natural information distinction between insiders and outsiders.

[16] Obviously there may be other reasons not modelled here for why NDAs are not used, such as the risk that an NDA could be used to extort rents even if no true violation of the NDA occurred.

Firms make use of a different legal arrangement than NDAs to protect against idea stealing, namely trade secret law. Whereas NDAs pertain to transactions among unrelated parties, and are relatively rarely used in practice, trade secret law automatically bind parties related through employment contracts. Agents accepting employment commit not to take ideas out of the firms, so that the firm defines a legal boundary for the circulation of internal ideas. 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 be costly (Liebeskind, 1997, Chou, 2007).

We model the firm as an enabler of idea circulation among a finite set of agents. The firm claims ownership on all internally generated ideas. Since employees' ideas are unobservable until reported, the firm needs to provide appropriate incentives for idea disclosure, and to protect them within its own boundaries, pursuing any idea theft. The reward is credible only if the firm owner would lose more from taking advantage by using ideas without adequately compensating their generators. Visibility enables to develop a local reputation, where insiders trust the reputed agent until proven wrong (Kreps, 1986). Thus a reputation may be upheld in an infinite game of perfect certainty as long as the firm adequately rewards its employees, else they all leave and the firm loses all value.

Naturally, creating a reputation is costly. We assume that a firm owner needs to make a large sunk investment to establish a process by which her actions are visible to a finite set of agents. To define this choice, we assume free entry and an upward-sloping supply curve of firms. Specifically, the j^{th} entrant faces a sunk fixed cost K_j, where K_j is distributed according to a cumulative distribution $\Omega(K_j)$ with density $\omega(K_j)$ over the range $K_j \in [K_{\min}, K^{\max}]$. K_j here reflects the sunk expense to establish a firm, which includes the cost of creating visibility, plus other fixed costs that are increasing in the number of firms.[17]

We assume that transparency of actions can only be achieved with a finite set of agents, the size of which we denote by E. Formally, the investment K_j allows the firm owner to establish a reputation among E agents. The firm owner hires these agents as employees. We assume that E is large but finite, and for tractability treat it as exogenous.[18] Once an owner commits to managing a firm, she no longer can

[17] This assumption reflects some scarce resource, such as increasing location costs.

[18] In principle we could allow for the possibility that larger investments create transparency among

generate or complement ideas.

Suppose the firm's reputation depends on maintaining a promise to reward idea generators with an amount bz for each idea originated and implemented internally. The reputation condition ensures that firm owners prefer to maintain their reputation over a deviation where the owner lets employees implement their ideas but refuses to pay any bonus. The maximal deviation payoff would occur in the rare event when all E had completed ideas at the same time. Not paying them would give the owner a deviation value of Ebz. After that the owner earns the normal agent return of U_O. So the reputation condition is as follows

$$Ebz + U_O < \delta\Pi$$

Later we derive the equilibrium value of the firm and formally prove this condition is always satisfied for δ sufficiently close to 1. This is a standard result, since the benefits of losing a reputation on the left hand side are bounded, whereas the benefits of keeping a reputation on the right had side is increasing in δ. For the remainder of the analysis we assume that this condition is satisfied.

3.2 Idea circulation within firms

To establish a claim on an idea, upon its disclosure by its inventor it is "recorded" as an internal project, 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. We assume that firms can always prevent idea stealing by threatening legal action. Once an idea is reported, the generator is assigned the task to implement it via internal matching. In managerial terms, he becomes an "internal project champion" or an "intrapreneur." Since no employee can leak the idea outside the firm, the generator can count on cooperation from all internal listeners. The firm uses an internal rotation system that corresponds to the random matching in markets. For simplicity we assume that the firm can avoid matching repeatedly two agents who didn't find a fit on their first match. Employees may leave the firm at will, but they need permission from the firm to pursue any reported idea.

a larger set of agent, so that E would be an increasing function of K_j. This would endogenize size of firm boundaries. In an earlier version, Hellmann and Perotti (2005) we allow for this, but note that this extension adds complexity without offering additional insight.

To make the analysis of the firm tractable and comparable to the market outcome, we assume that the chance of finding a complementor is the same, given by ϕ, and focus on the steady state number of ideas circulating and matched within the firm. The major difference is that a firm will fail to complete all ideas internally. The next subsection shows that if there is no internal fit, then it is optimal to allow idea generators to pursue their ideas outside the firm.[19]

In principle a finite-sized firm would have some fluctuations in idea completion. For analytical tractability our analysis focuses only on the steady-state properties of firms. For large E, any deviations from the steady state become negligible.

Let F be the number of agents that an idea-bearer talks to within a firm. This is a function of firm size E and rate of completion ϕ, i.e., $F = F(E, \phi)$. While there is no explicit solution, the appendix derives the implicit fixed point equation that defines F. It also shows that $dF/dE > 0$ - in larger firms there are more employees to talk to - and provides a sufficient condition for $dF/d\phi < 0$ - if finding an internal fit is easy, there is less turnover in the firm, and thus fewer new employees to talk to. The probability that an idea finds no match inside the firm is given by $\overline{\phi}^F$, so the probability of internal completion is $1 - \overline{\phi}^F$.

3.3 Optimal firm policies

In this section we derive a firm's optimal actions. It is useful to define

$$\widetilde{\phi} = \sum_{j=1}^{j=F} \delta^j \overline{\phi}^{j-1}, \; \widehat{\phi} = \sum_{j=1}^{j=F} \overline{\phi}^{j-1}$$

Consider first the firm's compensation decision. Let $U_{E,j}$ be the utility of an idea-bearing employee talking to his j^{th} internal match. For any $j = 1, ..., F$, we have $U_{E,j} = \phi(bz + \delta U_E) + \overline{\phi}\delta U_{E,j+1}$. Moreover, $U_{E,F+1} = U_I$, so that if the employee didn't find a fit after F internal matches, he leaves the firm and becomes an idea-bearer in the market. Since each agent has to first generate an idea, the ex-ante utility of joining a firm is given by $U_E = -\psi + \delta U_{E,1}$.

Firm profits are the sum of its profits per employee position, i.e., $\Pi = EU_F$, where U_F is the firm's lifetime profit from one employee's position (where the position is

[19] Realistically, we assume that firms allows registered ideas to be pursued as new ventures, but not within established competitors. As a result, market participants benefit from ideas leaving firms, a well established fact.

refilled every time an employee leaves). U_F behaves very similarly to U_E above, namely $U_F = \delta U_{F,1}$, $U_{F,j} = \phi(\bar{b}z + \delta U_F) + \overline{\phi}\delta U_{F,j+1}$, and $U_{E,F+1} = U_F$.

Consider now the entry decision. Let Π denote firm profitability, which is assumed to be equal for all firms. Free entry implies that agents will create firms until the marginal benefit equals their outside opportunity cost, i.e., until $\Pi - K_j \geq U_O$. In equilibrium, the number of firms is thus given by $n_F = \Omega(\Pi - U_O)$. The fraction of agents working in firms as employees is given by $n_E = E n_F$.

Firms are never viable if the entry cost of the first entrant, given by $K_{\min}$, is very high, nor if the cost of generating ideas ψ is too high. We denote ψ^F as the highest value for which there can be idea creation within firms. To focus on the most interesting part of the model, we assume that $K_{\min}$ is sufficiently small so that there exists a range of values $\psi \in (\psi^M, \psi^F)$ where firms can generate ideas and market cannot. The appendix formally derives an upper bound $\widehat{K_{\min}} > 0$, so that $K_{\min} < \widehat{K_{\min}} \Leftrightarrow \psi^F > \psi^M$ where $\psi^F = \phi\widetilde{\phi}z + \overline{\phi}^F \delta^{F+1}\Delta - \dfrac{(1-\delta)K_{\min}}{E}$.[20] Note also that the upper bound ψ^F is smaller than the socially efficient upper bound ψ^S, because firms cannot capture the full value of idea generation.

The following Proposition establishes the properties of the firm's optimal compensation policies.

Proposition 6 *(i) It is optimal for the firm to allow idea generators who could not complete an idea to seek to complete it outside the firm.*
(ii) The firm's optimal compensation for generators that satisfies the ex-ante participation constraint, and that provides incentives for idea generation, is given by

$$b = \frac{\psi + \theta\Delta - \overline{\phi}^F \delta^{F+1}\Delta}{\phi\widetilde{\phi}z}.$$

(iii) The firm's optimal compensation ensures that employees always have an incentive to disclose their ideas, rather than leaving the firm without reporting them.
∘ *If* $\psi < \psi^M$ *then* $U_E = U_G = U_O$ *and* $U_{E,j} = U_I \ \forall\ j = 1, ..., J$.
∘ *If* $\psi \in [\psi^M, \psi^F)$ *then* $U_E = U_O$ *and* $U_{E,j} > U_I \ \forall\ j = 1, ..., J$.

[20] For $K_{\min} > \widehat{K_{\min}}$, firms may still be viable, but only over a smaller range of ψ than markets, i.e., $\psi^F < \psi^M$. This is a straightforward extension to our main model, so we leave the details to be worked out by the interested reader.

(iv) The firm's profits per employee are given by

$$\Pi/E = U_F = \frac{\phi\widetilde{\phi}\overline{b}z}{1-\delta} = \widetilde{U} - U_O \text{ where } \widetilde{U} = \frac{\phi\widetilde{\phi}z + \overline{\phi}^F \delta^{F+1}\Delta - \psi}{1-\delta}$$

(v) The fraction of employees who generate ideas is given by $f_G = \dfrac{1}{1+\widehat{\phi}}$ *, and the fraction who circulate ideas is given by* $f_I = \dfrac{\widehat{\phi}}{1+\widehat{\phi}}$.

Proposition 6 explains how the firm chooses its optimal compensation. It is always optimal to give a departing employee all the rents from his idea. The intuition is that if the firm wanted to take a stake in the employee's spin-off it would have to increase its ex-ante compensation by an equivalent amount. To satisfy the ex-ante participation constraint, an employee needs to receive a utility comparable to what he could obtain in the market as an opportunist. The firm therefore sets b so that $U_E = U_O$, resulting in the expression above. Part (iii) verifies that this level of compensation ensures that an idea generator always has an incentive to disclose his idea within the firm, rather than leave. It shows that this incentive constraint is satisfied with equality whenever $\psi < \psi^M$, and has some slack for $\psi \in [\psi^M, \psi^F)$. Note also that the firm does not compensate complementors, because it ensures that employees cannot take reported ideas elsewhere: giving feedback to colleagues' ideas therefore becomes part of the job.

Part (iv) expresses the firms steady state profits, which are the discounted value of the expected per-period profits after paying out bonuses ($\phi\widetilde{\phi}\overline{b}z$). This can be re-expressed as the total value of ideas implemented in the firm (denoted by $\widetilde{U}$), minus the employees opportunity costs U_O. The firm's profits are negatively affected by the return to opportunism in the market. Note that the compensation and firm value depend on properties of the market equilibrium, and in particular θ, the fraction of opportunists in the market. We examine this in the next subsection.

Part (v) derives the steady-state task allocation within the firm. We denote the fraction of generators by f_G and the fraction of idea-bearers by f_I. The fraction of generators f_G is technologically determined, and does not depend on the market equilibrium payoff. It is increasing in ϕ: if implementation of ideas is easier, there is relatively more time to generate ideas.

The optimal policy described in Proposition 6 assumes that employees trust the firm owner. We now turn to the questions of how the firm owner can maintain a reputation. We have already seen that the maximal deviation is given by Ebz, so we simply state the following Proposition.

Proposition 7 *A firm's reputation is sustainable forever if*

$$Ebz + \delta U_O < \delta \Pi = \delta E \left(\widetilde{U} - U_O \right). \tag{1}$$

This condition is always satisfied for δ sufficiently close to 1.

The condition for sustaining a reputational equilibrium is satisfied for δ sufficiently close to 1, where the gains from a one-time deviation fall short of discounted profits, the benefit of maintaining the firm's reputation value.

3.4 Coexistence of firms and markets when only firms generate ideas

We now examine the full equilibrium where firms and markets interact. In the model, agents either belong to the firm sector, where they can be firm owners or employees that either generate or circulate ideas. Or they belong to the market sector, where they can either generate ideas or participate in the circulation of ideas. At the end of each period, agents can change sector: employees can leave their firm, and market agents can chose to become employees. The fraction of employees leaving the firm sector at the end of each period is given by $\overline{\phi}^F f_I$, i.e., this is the fraction of idea-bearers who did not find an internal match. The total number of employees leaving firms is thus given by $n_E \overline{\phi}^F f_I$.

Consider first the case where markets fail to generate ideas, i.e., where $\psi > \psi^M$. Under these circumstances, firms are necessary to create a protected environment for idea generation. Because employees can leave firms and match with other agents outside of firms, the market still plays an important role for the circulation of ideas. We now analyze a coexistence equilibrium, where all ideas are created inside firms, but markets play a role circulating and elaborating ideas.

Because departing employees are the only idea-generators, the density of ideas in the market (the fraction of idea-bearers) is given by $n_I = \dfrac{n_E \overline{\phi}^F f_I}{\phi} = \dfrac{n_E}{\phi} \dfrac{\overline{\phi}^F \widehat{\phi}}{1 + \widehat{\phi}}$. Using

$n_F + n_E + n_I + n_O = 1$, straightforward calculations reveal that

$$\theta = \frac{En_F}{1-(E+1)n_F}\frac{\overline{\phi}^F}{\phi}\frac{\widehat{\phi}}{1+\widehat{\phi}}.$$

Naturally, the higher is the density of firms, the higher the fraction of idea-bearers in the market. In this case the utility of being an opportunist in the market, given by $U_O = \theta\frac{\Delta}{1-\delta}$, which can be expressed as

$$U_O = \frac{En_F}{1-(E+1)n_F}\frac{\overline{\phi}^F}{\phi}\frac{\widehat{\phi}}{1+\widehat{\phi}}\frac{\Delta}{1-\delta} \tag{2}$$

We call this the market equation ($\mathcal{M}$), it expresses the utility of market agents as a function of the firm density n_F. Figure 1 graphically depicts this equation, showing how the market utility (on the vertical axis) changes with firm density (on the horizontal axis). The following summarizes the key properties of the $\mathcal{M}$ curve

Market equilibrium (part 1): For $\psi \in [\psi^M, \psi^F]$, the $\mathcal{M}$ curve is upward sloping, i.e., U_O is increasing in n_F. For a given n_F, U_O is increasing in z, and independent of ψ.

Clearly, the utility of independent agents increases with the number of firms. More firms means that more ideas leak out into the market, increasing the likelihood that an opportunist encounters an idea to either implement or steal.

The comparative statics of U_O are quite different from the corollary to Proposition 2, since now the market payoff is no longer determined by the indifference condition with generators ($U_O = U_G$), but depends solely on ideas escaping from firms. Indeed, as shown above, U_O is independent of generation costs (for given n_F), reflecting that ideas are now generated inside firms.[21]

Next we consider firm density. The firm's entry condition is given by

$$n_F = \Omega(EU_F - U_O) = \Omega(E\widetilde{U} - (E+1)U_O) \tag{3}$$

[21] The comparative static with respect to ϕ is ambiguous and not analytically tractable, because of the dependence of F on ϕ.

We call this the firm equation ($\mathcal{F}$), it expresses the firm density n_F as a function of market utility U_O, also depicted in Figure 1. Fundamentally, the $\mathcal{F}$ curve is a measure of firm profitability, which under free entry determines the number of firms. The following summarizes its key properties.

Firm equilibrium: The $\mathcal{F}$ curve is downwards sloping, i.e., n_F is decreasing in U_O. For a given U_O, n_F is increasing in z but decreasing in ψ.

The main insight is that a higher utility for market agents increases the firm's employment costs and thus reduces the density of firms.[22] The number of firms is higher when ideas are more valuable (higher z) and generation costs cheaper (lower ψ).

Since the $\mathcal{M}$ is upward sloping and the $\mathcal{F}$ curve downward sloping, there exists a unique equilibrium. We are now in a position to fully characterize the equilibrium and its comparative statics.

Proposition 8 *(i) For $\psi \in [\psi^M, \psi^F)$ there exists an equilibrium such that all ideas are generated inside firms, but a fraction $\overline{\phi}^F$ is implemented in the market.*
(ii) The equilibrium is determined by the intersection of the $\mathcal{M}$ and $\mathcal{F}$ curves. The comparative statics are as follows
∘ *An increase in ψ decreases U_O and n_F*
∘ *An increase in z increases U_O, and also increases n_F provided n_F is not too large.*

For $\psi \in [\psi^M, \psi^F)$ firms enter and hire employees to generate ideas, while market agents wait for spin-off ideas which cannot find an internal fit in their firms. The equilibrium of Proposition 8 occurs at the intersection of the $\mathcal{M}$ and $\mathcal{F}$ curves. Figure 2 shows that higher generation costs ψ always decrease the number of firms, as well as the utility of market agents. This can be seen from the fact that only the $\mathcal{F}$ curve depends on ψ.

Figure 3 shows the effect of increasing the value of ideas z. The utility of market agents is always increased, but the effect on the density of firms is ambiguous.

[22] Note that while it is individually rational for a firm to allow uncompleted ideas to leave, in the aggregate this increases the reward to opportunism in the market, and thus the firm cost to reward internal ideas for all firms.

Intuitively, a higher value of ideas should increase firm profits and thus increase the density of firms n_F, as reflected in the outward shift of the $\mathcal{F}$ curve. However, 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 of these two effects is ambiguous. In the appendix we show how for sufficiently low values of n_F (when the distribution Ω puts sufficient weight on higher values of K) the net effect is always positive.

3.5 Coexistence when both firm and market generate ideas

When $\psi < \psi^M$, idea generation in markets is feasible. Is there still an opportunity for firms to organize a parallel process of generating and circulating ideas? The answer is yes, because the market still allows for idea stealing, thus implicitly rewarding opportunism. Firms can ensure a safer return to idea generation, and thus increase idea generation overall. However, ideas leaving firms increase the return to opportunism, which reduces the rate of idea generation by market agents.

The new equilibrium is similar to the one discussed in section 3.4., except that ideas are now generated both in firms and markets. The $\mathcal{F}$ curve is the same as in section 3.4, but the $\mathcal{M}$ equation is different. In fact, the results from Propositions 2 and its corollary apply once again, which affects the $\mathcal{M}$ curve as follows:

Market equilibrium (part 2): For $\psi < \psi^M$, the $\mathcal{M}$ curve is entirely flat, i.e., U_O is independent of n_F. U_O is increasing in z, and decreasing in ψ.

For $\psi < \psi^M$, the $\mathcal{M}$ curve no longer depends on the density of firms n_F. The key intuition is that once ideas are generated in the market, the utility of market agents no longer depends on firms, but regains its own dynamics, as described in Proposition 2 and its corollary. We are now in a position to characterize the equilibrium and its comparative statics.

Proposition 9 *(i) For $\psi < \psi^M$ there exists an equilibrium such that ideas are generated both inside firms and in the market. The equilibrium is determined by the intersection of the flat $\mathcal{M}$ and the downwards sloping $\mathcal{F}$ curves. The comparative statics are as follows*

◦ *An increase in ψ decreases U_O but increases n_F.*
◦ *An increase in z increases U_O and n_F.*

Proposition 9 differs from Proposition 8, because in Proposition 9 market idea generation directly competes with idea generation inside firms. The reason that firms continue to exist, even when markets generate ideas, is that firms can solve some of the inefficiencies that occur in the market. Specifically, firms can provide incentives to their employees that discourage idea stealing and opportunism. This ensures that within firms all employees only generate and circulate their own ideas. However, firms can only provide a limited number of employee interactions, so that some employees leave with their ideas. In equilibrium, the strengths of market interactions, offering unlimited matching opportunities, thus augments the strengths of firms.

The most surprising part of Proposition 9 is that the firm density n_F is actually increasing in ψ. The intuition is that higher generation costs discourage idea creation in both firms and markets, but that markets are more affected because of the stealing problem.

Figure 4 integrates insights from Proposition 8 and 9, showing how the number of firms (n_F) depends on idea generation costs (ψ) across the entire parameter range. For low values of ψ, the number of firms is increasing in ψ, as shown in Proposition 9. Figure 4 shows that idea generation in the market declines rapidly with ψ. This means that the relative importance firms actually increases, allowing for the density of firms n_F to actually increase in ψ. Beyond ψ^M idea generation ceases up in the market entirely, so that ideas are only generated inside firms. At this stage, higher generation costs discourage firm activity, so that n_F decreases with ψ. Firms cease to exist beyond ψ^F.

4 Extensions and empirical evidence

Our approach has yielded two main results. The first concerns the effect of idea density on the open exchange of ideas. The second suggests an important symbiotic relationship between open firms and markets, with firms incubating ideas and markets both creating their own ideas as well as refining those that could not be elaborated within firms.

A natural environment to discuss the coincidence of these effects is Silicon Valley, often taken as evidence that innovation thrives in a free market environment. Hamel (1999) writes that "in Silicon Valley, ideas, capital, and talent circulate freely, gathering into whatever combinations are most likely to generate innovation ... traditional companies... spend their energy in resource allocation... the Valley operates through resource attraction–a system that nurtures innovation. . . . talent is free to go to the companies offering the most exhilarating work and the greatest potential rewards". This is broadly consistent with our sketch of ideas as combination of expertise, circulating to seek the right match without using NDA contracts, while firms reward creative agents and agents with unresolved ideas moving out of firms to start up ventures.

The intense and open idea exchange 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 symbiotic. Large firms are a natural source of innovative ideas, which at times may be realized only if matched with talented market agents. In turn, a market will attract creative entrepreneurial individuals and support a free circulation of ideas only for a certain idea density. In our context, a high density of firms increases idea density in surrounding markets. The open environment in Silicon Valley may thus thrive thanks to the historical presence of large firms in the area acting as idea incubators, in addition to the incubating role played by top academic institutions.

Indeed, there are many large firms in the area, which according to Business Week accounted for a remarkable 20% of the *largest* high tech firms in the world in 1997. Gompers, Lerner and Scharfstein (2005) provide extensive 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. Klepper and Sleeper (2002) provide evidence that established firms play a major role as incubators for innovative ideas which later are developed in new ventures by departing employees.[23] Aoki (2001) and Saxenian (1994) argue that firms with porous boundaries

[23] 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 that year investments in venture capital backed companies amounting to $18 billion.

increases the mutual local flow of ideas, while a secretive corporate culture - such as the hierarchical approach to R&D in Japan and Europe, as well as in some large US companies, notably the now defunct Digital Equipment Corporation (Saxenian, 1994) - suffocates circulation and thus elaboration of internal ideas. These concepts have led to the diffusion of open knowledge strategies (Chesbrough, 2003).

Naturally, many employee-generated ideas are implemented internally. Companies such as Google or 3M pride themselves of continually generating new ideas in house (The Economist, 2009; Bartlett and Mohammed, 1995). However, any history of Silicon Valley comprises a long list of talented people leaving large firms with novel ideas. In the semiconductor industry each generation of new firms was started by employees leaving their parent firms, and similar experiences occurred in the laser and computer storage industry. According to Bhidé (2000), over 70 % of the founders of firms in the Inc. 500 list of fast growing high tech firms developed ideas encountered in previous employment.

There is much anecdotal evidence that employees are allowed by employer to separate, after an idea has failed to be developed internally. Gene Amdahl pleaded for a long time with his colleagues at IBM, before starting Amdahl Computers. The empirical literature suggest that lack of local fit is an important determinant of spin-offs activity, and that firms often agree to let employees go to try out rejected concepts in start ups, even when the product may be in their line of business (Klepper and Sleeper, 2005).

In addition to idea incubation inside firms, our model shows idea generation can also occur by independent agents, even if exposed to free-riding and idea stealing incentives. Many entrepreneurs generated their ideas on their own and found appropriate partners to start their firm. Livingston (2007) documents many such examples, including PayPal and TiVo. Our model predicts that market agents have a comparative advantage in developing valuable ideas requiring modest development budgets, whereas firms focus on larger scale, complex ideas with substantial ex-ante investment. Interestingly, this result is not a consequence of financial constraints as often assumed, but of free riding in independent idea exchange, which induces independent innovators to invest in ideas with inexpensive development costs.

One of the sources for relatively low-cost production of ideas are universities. In is hardly a coincidence that environments such as Silicon Valley or Boston Route 128 cluster around top research universities. While there is a natural direct effect, these environments are characterized also by a freer circulation of ideas, which is consistent with the effect of local idea density in the model.

One limitation of the model is that all employee spin-offs are friendly and occur only after the internal fit has been fully explored. An earlier version (Hellmann and Perotti, 2005) considered a model extension where employees with an idea which fit poorly with the firm's specialization would leave prior to disclosure, as disclosing the idea would be a waste of time and effort.[24] It is hardly possible to test for unobservable actions, but there is strong indirect evidence. According to Bhidé (2000), over 70 % of the founders of firms in the Inc. 500 list of fast growing high tech firms developed ideas encountered in previous employment.

To offer a fair comparison of firms and markets, we assume that their probability of meeting a complementor (ϕ) is the same. In reality, firms do specialize in different types of ideas, seeking employees with complementary skills. Yet firms cannot plan their composition to favor novel ideas which call for unpredictable combinations of skills. For ideas that involve incremental innovation, the probability of finding an fit might be higher internally. However, the opposite may be true for more radical innovation. Christensen (1997) argues that many successful firms do not adapt well to radically new ideas and resist their internal development, leading in loss of market leadership and even exit. Kodak, a firm created and run by chemical engineers, turned out not to be a natural place to develop digital cameras.

A common perception, shaped by success stories, is that returns are greater for entrepreneurs than intrapreneurs or employees. The empirical evidence in contrast indicates that the average risk-adjusted return to entrepreneurship is quite low (Hamilton, 2000, Moskowitz and Vissing-Jorgensen, 2002). In our model, entrepreneurs and intrapreneurs achieve the same utility, but the structure of their payoffs is quite distinct. Specifically, intrapreneurs receive a lower compensation in case of success, but they have more chances of circulating their idea in a protected environment. Entrepreneurs by contrast receive the full value of their ideas, but have to share it with among founders. The model predicts that if there is a fit within the team, complementors receive as a substantial portion of founder equity, even if they didn't contribute the idea. Consistent with this, Marx and Wasserman (2008) find that equal splits

[24]Employees may also leave firms without disclosing ideas if these are exceptionally valuable (Chatterjee and Rossi-Hansberg, 2008), if firms do not adjust reward (see Gambardella and Panico, 2006), or if firms are pursuing a strategy of discouraging spin-offs (Hellmann, 2006).

among founders are common, even if only one of the founders contributed the initial idea. Evidence on idea stealing is naturally harder to come by. One well-known story is Steve Job's taking the idea of a computer mouse during his visit of Xerox Parc.

Our model provides a joint explanation for a variety of different types of new ventures: internal ventures, spin-offs and start-ups. As limitations, the model does not allow any form of idea stealing within firms, and assume that the reputation condition holds at all times. In an earlier version (Hellmann Perotti 2005) we showed how these extreme assumptions could be relaxed. For instance, the firm might be willing to compensate employees for smaller ideas, but may have an incentive to renege on highly valuable ideas (as in the classic corporate story at TetraPak).

Our model emphasizes the role of firm boundaries on idea circulation. In a related vein, Azoulay (2004) finds that pharmaceutical firms, while very active in outsourcing, maintain strong firm boundaries around knowledge intensive projects. Kremp and Mairesse (2004) also find a positive relationship between firms' internal knowledge management systems and their innovative performance.

Finally, one may ask if venture capital operate in some alternative form. As they clearly seek to build a reputation for fair dealing among local contacts, in this sense their behavior may resemble that of firms in our model. However, there are also fundamental differences. First, we study ideas at the very initial formation stage, when the product is not yet defined and there can be no business plan, well before the issue of financing arises. Even so-called 'seed stage' venture capitalists do not typically get involved at such a stage when neither the product nor the founding team are in place. Second, the governance of venture capital firms has a looser, network-style structure, rather than the hierarchical structure of firms. They also seeks ideas exclusively outside, in the language of the model acting as late stage complementors. In any case, as mentioned before, we concur that firms are not the only solution to control idea stealing. Further exploring alternative governance mechanisms of the protection of ideas is a promising area of research.

5 Conclusions

Early stage novel ideas may be seen as incomplete concepts needing to be matched with some complementary expertise for completion, yet facing uncertainty as to what exactly the required match may be. We analyze the trade-off between the necessity to share widely ideas, to identify agents able to elaborate them further, and the risk of idea stealing associated with sharing nonexcludable information. A free circulation of ideas in a market setting is efficient for elaboration, but fails to fully reward effort for invention. We show that individuals may voluntarily join firms with reputational capital to ensure that their ideas receive feedback without being stolen. Firms create a legal firm boundary which may contain appropriation of others' ideas, and manage a controlled circulation of ideas along with a credible reward system. Yet firms have limited capacity to elaborate ideas internally, and may therefore allow agents to leave to try out developing incomplete ideas in new ventures. Our model thus describes a natural symbiosis between the ability of firms to sustain idea generation and the comparative advantage of market in elaborating ideas. This approach rationalizes the process of idea incubation and spawning which seems to describe well the open exchange of ideas across firms and markets typical of successful innovative environments such as Silicon Valley.

The approach suggests interesting directions for future research. A first issue is to understand what environments are most conducive to promote both idea generation and completion, and to explain the movement of ideas by the incentives of inventors to seek the appropriate environment for completion.

A compelling new research agenda focuses on the generation of ideas in academia and industry (Aghion, Dewatripont and Stein, 2009). Academic researchers aim at diffusing their ideas, so they rarely capture any value created by their discoveries. The academic publication system may ensure a basis for public reward, which sustains the freedom of investigation and idea circulation which researchers value. Our model suggests that the innovative ideas incubated in academia may have a disproportional effect in supporting an open exchange environment where ideas circulate easily and widely. The empirical results in Aghion et al. (2009) support the importance of a free circulation of ideas, to ensure the maximum degree of elaboration and ultimately innovation.

Another issue is the self-selection of agents operating in firms and markets. Agents with a greater predisposition to complement ideas may be better off outside firms, where they can expect better rewards. Examples are serial entrepreneurs, venture capitalists, seasoned angel investors, and professional mentors and consultants able to help entrepreneurs to turn their ideas into viable businesses (Lee et al., 2000). Such specialized agents may organize alternative organizational structures, such as partnership and networks, to obtain greater rewards than firms would grant them.

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7 Appendix

7.1 Proof of Proposition 1

From a social efficient perspective, it is always preferable that an agent generates a new idea, rather than be an opportunist. The reason is that it is always more efficient for an idea-bearer to talk to another idea-bearer, and not an opportunist! Thus $n_O^S = 0$ so that $\theta = 1$.

The subscript t denotes periods. The basic flow equation for idea-bearers is given by $n_{I,t} = \overline{\phi} n_{I,t-1} + n_{G,t-1}$. This says that each period t, there is a fraction $\overline{\phi}$ of ideas left from the previous period, namely those that didn't find a match. Moreover, there are $n_{G,t-1}$ new ideas. Simple transformations reveal that in steady state we always have $n_I = \frac{n_G}{\phi}$. Using this and $n_G = 1 - n_I$ we get $n_I^S = \frac{1}{1+\phi}$ and $n_G^S = \frac{\phi}{1+\phi}$.

To derive utilities of the social equilibrium, consider any split s of the idea value z, and suppose naturally that there is no idea stealing. The utility of a idea-bearer is given by $U_I = \phi^2(z + \delta U_G) + \phi\overline{\phi}(sz + \delta U_G) + \overline{\phi}\phi(\overline{s}z + \delta U_I) + \overline{\phi}^2 \delta U_I$. A generator receives $U_G = -\psi + \delta U_I$. We can rewrite these as $U_I - \delta U_G = \phi z + \overline{\phi}\delta(U_1 - U_G)$ and $U_G - \delta U_G = -\psi + \delta(U_1 - U_G)$. We note that these expressions are independent of s. The split of the idea value does not matter, since all agents generate ideas, so it doesn't matter whether they receive their utility from their own or someone else's idea. We thus obtain $U_I - U_G = \phi z + \overline{\phi}\delta(U_1 - U_G) + \psi - \delta(U_1 - U_G) \Leftrightarrow U_I - U_G = \frac{\phi z + \psi}{1 + \delta\phi} \equiv \Delta^S$. Using this in the above utilities we obtain $U_G^S = \frac{\delta}{1-\delta}\Delta^S - \frac{\psi}{1-\delta}$ and $U_I^S = \frac{1}{1-\delta}\Delta^S - \frac{\psi}{1-\delta}$. The condition for idea creation to be socially efficient is given by $U_G = \frac{\delta}{1-\delta}\Delta^S - \frac{\psi}{1-\delta} \geq 0 \Leftrightarrow \psi \leq \delta\Delta^S \Leftrightarrow \psi \leq \frac{\delta\phi z}{1 - \delta + \delta\phi} \equiv \psi^S$.

7.2 Proof of Proposition 2

Consider the utility of an opportunist. We have $U_O = \overline{\theta}\delta U_O + \theta\phi(\frac{z}{2} + \delta U_O) + \theta\overline{\phi}(\frac{1}{2}\delta U_O + \frac{1}{2}\delta U_I)$ which we conveniently rewrite as $U_O - \delta U_O = \theta\phi\frac{z}{2} + \theta\overline{\phi}\frac{1}{2}\delta(U_I - U_O)$. Next, consider the utility of an idea-bearer, given by $U_I = \overline{\theta}[\phi(\frac{z}{2} + \delta U_O) + \overline{\phi}(\frac{1}{2}\delta U_O + \frac{1}{2}\delta U_I)] + \theta[\phi^2(z + \delta U_O) + 2\phi\overline{\phi}(\frac{z}{2} + \frac{1}{2}\delta U_O + \frac{1}{2}\delta U_I) + \overline{\phi}^2 \delta U_I]$, which we conveniently rewrite as $U_I - \delta U_O = \overline{\theta}\phi\frac{z}{2} + \overline{\theta\phi}\frac{1}{2}\delta(U_I - U_O) + \theta\phi z + \theta\overline{\phi}\delta(U_I - U_O)$. Subtracting the two expressions, we obtain after transformations $U_I - U_O = \phi\frac{z}{2} + \overline{\phi}\frac{1}{2}\delta(U_I - U_O)$ so that $U_I - U_O = \frac{\phi z}{2-\delta+\phi\delta} \equiv \Delta$. For future reference, we note that $\frac{d\Delta}{dz} = \frac{\phi}{2-\delta+\phi\delta} > 0$ and $\frac{d\Delta}{d\phi} = \frac{(2-\delta)z}{(2-\delta+\phi\delta)^2} > 0$. Using Δ in the above convenient expressions, we obtain after transformations $U_O = \frac{\theta\Delta}{1-\delta}$ and $U_I = \Delta + \frac{\theta\Delta}{1-\delta} = \frac{1-\delta+\theta}{1-\delta}\Delta$. The utility of generator is given by $U_G = -\psi + \delta U_I$, so that $U_G = \delta\frac{\theta\Delta}{1-\delta} + \delta\Delta - \psi$.

Suppose for a moment that $U_G \geq 0$, we will return to this below. Equilibrium requires that $U_G = U_O$, or else no agent would be willing to generate ideas. Using the above expressions for U_G and U_O we obtain $\delta\frac{\theta\Delta}{1-\delta} + \delta\Delta - \psi = \frac{\theta\Delta}{1-\delta} \Leftrightarrow \theta = \delta - \frac{\psi}{\Delta}$. Note that $\theta < 1$ since $1 > \delta > \delta - \frac{\psi}{\Delta}$. We can thus rewrite the market utilities as $U_G = U_O = \frac{\delta\Delta}{1-\delta} - \frac{\psi}{1-\delta}$ and $U_I = \frac{\Delta}{1-\delta} - \frac{\psi}{1-\delta}$. For future reference, we note that $\frac{d\theta}{d\psi} = -\frac{1}{\Delta} < 0$, $\frac{d\theta}{dz} = \frac{\psi}{(\Delta)^2}\frac{\phi}{2-\delta+\phi\delta} = \frac{\psi}{\Delta z} > 0$ and $\frac{d\theta}{d\phi} = \frac{\psi}{(\Delta)^2}\frac{(2-\delta)z}{(2-\delta+\phi\delta)^2} = \frac{\psi(2-\delta)}{\phi^2 z} > 0$. We also note that $\theta \geq 0$ whenever $\delta - \frac{\psi}{\Delta} \geq 0 \Leftrightarrow \psi \leq \delta\Delta \equiv \psi^M$. At $\psi = \psi^M$ we have $U_O = U_G = 0$. Thus, for all $\psi > \psi^M$ there is no idea generation in markets, but for $\psi < \psi^M$ markets allow for idea generation.

Consider the equilibrium number of types. We denote the fractions of generators, idea-bearers and opportunists by n_G, n_I, n_O, and note that $n_G + n_I + n_O = 1$. Using the same logic as in the proof of Proposition 1, we have $n_I = \frac{n_G}{\phi}$. Using $n_G + n_I + n_O = 1$ we obtain $\phi n_I = 1 - n_O - n_I$. From the definition of $\theta = \frac{n_I}{n_O + n_I}$, we obtain $n_O = \frac{1-\theta}{\theta}n_I$ which we use to obtain $\phi n_I = 1 - \frac{1-\theta}{\theta}n_I - n_I \Leftrightarrow n_I = \frac{\theta}{1+\theta\phi}$. Thus $n_O = \frac{1-\theta}{\theta}n_I = \frac{1-\theta}{1+\theta\phi}$ and $n_G = \frac{\theta\phi}{1+\theta\phi}$. Comparing the competitive with the socially optimal equilibrium, we note that $n_G = \frac{\theta\phi}{1+\theta\phi} < \frac{\phi}{1+\phi} = n_G^S$, $n_I = \frac{\theta}{1+\theta\phi} < \frac{1}{1+\phi} = n_I^S$ and $n_O = \frac{\overline{\theta}}{1+\theta\phi} > 0 = n_O^S$. The competitive market has too few idea-bearers and too few generators, but too many opportunists.

We now compare the market equilibrium with the socially efficient equilibrium. We note that $\Delta = \frac{\phi z}{2-\delta+\delta\phi} < \frac{\phi z}{1-\delta+\delta\phi} = \Delta^S$. It immediately follows that $\psi^M = \delta\Delta < \delta\Delta^S = \psi^S$, so that the range where the market equilibrium is feasible is smaller than the range of where idea generation is socially efficient. Similarly, we have $U_O = U_G = \frac{\delta}{1-\delta}\Delta - \frac{\psi}{1-\delta} < \frac{\delta}{1-\delta}\Delta^S - \frac{\psi}{1-\delta} = U_G^S$ and $U_I = \frac{\delta}{1-\delta}\Delta - \frac{\psi}{1-\delta} < \frac{\delta}{1-\delta}\Delta^S - \frac{\psi}{1-\delta} = U_I^S$.

Finally, note that the probability of a generator implementing his own idea if given by $\frac{2\phi}{2-\overline{\phi}(1+\theta\overline{\phi})} < 1$. To see this, note that for each match, the probability of a fit is given by $\theta(\phi^2 + \phi\overline{\phi}) + \overline{\theta}\phi = \phi$, the probability that the idea-bearer keeps his idea is given by $\theta(\overline{\phi}\phi\frac{1}{2} + \overline{\phi}^2) + \overline{\theta}\overline{\phi}\frac{1}{2} = \frac{\overline{\phi}(1+\theta\overline{\phi})}{2} = \xi$, and the probability of losing the idea is given by $\theta\overline{\phi}\phi\frac{1}{2} + \overline{\theta}\overline{\phi}\frac{1}{2} = \frac{\overline{\phi}}{2}(\theta\phi + \overline{\theta})$. Thus, the probability of a generator implementing his idea is given by $\phi + \xi\phi + \xi^2\phi + ... = \phi\sum_{j=0}^{j=\infty}\xi^j = \frac{\phi}{1-\xi} = \frac{2\phi}{2-\overline{\phi}(1+\theta\overline{\phi})}$.

7.3 Proof of Corollary to Proposition 2

We will prove the four parts out of sequence. For part (iv), consider $U_O = \frac{\delta\Delta}{1-\delta} - \frac{\psi}{1-\delta}$. We have $\frac{dU_O}{d\psi} = -\frac{1}{1-\delta} < 0$, $\frac{dU_O}{dz} = \frac{\delta}{1-\delta}\frac{\phi}{2-\delta+\phi\delta} > 0$, and $\frac{dU_O}{d\phi} = \frac{\delta}{1-\delta}\frac{z(2-\delta)}{(2-\delta+\phi\delta)^2} > 0$. Since $U_O = U_G$ we have the same results for U_G. For U_I we use $U_I = \Delta + U_O$ so that $\frac{dU_I}{d\psi} = \frac{dU_O}{d\psi} < 0$, $\frac{dU_I}{dz} = \frac{dU_O}{dz} + \frac{d\Delta}{dz} > 0$ and $\frac{dU_I}{d\phi} = \frac{dU_O}{d\phi} + \frac{d\Delta}{d\phi} > 0$.

For part (iii), consider $n_I = \frac{\theta}{1+\theta\phi}$, so that $\frac{dn_I}{dz} = \frac{dn_I}{d\theta}\frac{d\theta}{dz} = \frac{1}{(1+\theta\phi)^2}\frac{\psi}{\Delta z} > 0$, $\frac{dn_I}{d\psi} = \frac{dn_I}{d\theta}\frac{d\theta}{d\psi} = -\frac{1}{\Delta}\frac{1}{(1+\theta\phi)^2} < 0$, $\frac{dn_I}{d\phi} = \frac{dn_I}{d\theta}\frac{d\theta}{d\phi} + \frac{dn_I}{d\phi} = \frac{1}{(1+\theta\phi)^2}\frac{\psi(2-\delta)}{\phi^2 z} - \frac{\theta^2}{(1+\theta\phi)^2} = \frac{1}{(1+\theta\phi)^2}[\frac{\psi}{z}\frac{2-\delta}{\phi^2} - \theta^2]$. Note that $\theta = \delta - \frac{\psi}{\Delta}$ decreasing in ψ, implying that $\frac{\psi}{z}\frac{2-\delta}{\phi^2} - \theta^2$ is increasing in ψ. We define ψ^ϕ implicitly from $\frac{\psi}{z}\frac{2-\delta}{\phi^2} - \theta^2 = 0$, and claim that $\frac{dn_I}{d\phi} < 0$ for $\psi < \psi^\phi$ and $\frac{dn_I}{d\phi} < 0$ for $\psi \in (\psi^\phi, \psi^M)$. To see this, note that for $\psi \to 0$ we have $[\frac{\psi}{z}\frac{2-\delta}{\phi^2} - \theta^2] \to -\delta^2 < 0$ so that $\frac{dn_I}{d\phi} < 0$. Moreover, for $\psi \to \psi^M$ we have $\theta \to 0$ so that $[\frac{\psi}{z}\frac{2-\delta}{\phi^2} - \theta^2] \to \frac{\psi^M}{z}\frac{2-\delta}{\phi^2} > 0$ so that $\frac{dn_I}{d\phi} > 0$. Intuitively, there are two effects are work. A higher chance of meeting a complementor increases the generation of new ideas, which increases n_I. However, a higher chance also means that ideas clear the market faster, so that there are fewer idea-bearers in steady state.

For part (i) we use $n_G = \phi n_I$. We have $\frac{dn_G}{d\psi} = \phi \frac{dn_I}{d\psi} < 0$, $\frac{dn_G}{dz} = \phi \frac{dn_I}{d\theta}\frac{d\theta}{dz} > 0$ and $\frac{dn_G}{d\phi} = \phi \frac{dn_I}{d\phi} + n_I = \frac{\phi}{(1+\theta\phi)^2}[\frac{\psi}{z}\frac{2-\delta}{\phi^2} - \theta^2] + \frac{\theta}{1+\theta\phi} = \frac{1}{(1+\theta\phi)^2}[\frac{\psi}{z}\frac{2-\delta}{\phi} + \theta] > 0$

For part (ii) we can use $n_O = 1 - n_G - n_I$, so that $\frac{dn_O}{d\psi} = -\frac{dn_G}{d\psi} - \frac{dn_I}{d\psi} > 0$, $\frac{dn_O}{dz} = -\frac{dn_G}{dz} - \frac{dn_I}{dz} < 0$ and $\frac{dn_O}{d\phi} = -\frac{dn_G}{d\phi} - \frac{dn_I}{d\phi} = -\frac{1}{(1+\theta\phi)^2}[\frac{\psi}{z}\frac{2-\delta}{\phi} + \theta] - \frac{1}{(1+\theta\phi)^2}[\frac{\psi}{z}\frac{2-\delta}{\phi^2} - \theta^2] = -\frac{1}{(1+\theta\phi)^2}[\frac{\psi}{z}\frac{2-\delta}{\phi}(1+\frac{1}{\phi}) + \theta\overline{\theta}] < 0.$

7.4 Proof of Proposition 3

Each time two partners meet they each incur a transactions cost c to draft and sign their NDAs. We now consider the ensuing equilibrium behavior. We focus on the case of small transaction costs, so that all our proofs are evaluated in a neighborhood of $c = 0$.

We first examine the bargaining game in case of a match. We assume that bargaining outcomes are characterized by the Nash bargaining solution. Even in the signee cannot steal the idea, he still has some bargaining power, due to the fact that the issuer would still have to find another partner, which takes time. If two partners find a fit for both of their ideas, we are back to a symmetric bargaining game. In this case the two NDAs cancel out each other, and the bargaining outcome is an equal split. Consider now the case where only one idea fits, and let s be the share of profits for the idea-bearer (i.e., the NDA issuer). Suppose for a moment that the NDA signee is an idea-bearer himself, but that there was no fit for his idea. If the two agent cooperate, then the NDA issuer gets $sz + \delta U_0^N$ and the signee gets $\overline{s}z + \delta U_I^N$. In case of disagreement, the issuer retains δU_I^N and the signee also obtains δU_I^N. The Nash bargaining solution gives the NDA issuer a utility $sz + \delta U_0^N = \frac{1}{2}[z + \delta(U_O^N + U_I^N) + \delta U_I^N - \delta U_I^N] = \frac{1}{2}z + \frac{1}{2}\delta(U_O^N + U_I^N) \Leftrightarrow s = \frac{1}{2} + \frac{\delta\Delta^N}{2z}$ where $\Delta^N = U_I^N - U_O^N$. If instead the signee is an opportunist, it is easy to see that the Nash bargaining solution yields $sz + \delta U_0^N = \frac{1}{2}[z + \delta(U_O^N + U_O^N) + \delta U_I^N - \delta U_O^N]$ $\Leftrightarrow s = \frac{1}{2} + \frac{\delta\Delta^N}{2z}$, which is identical to the previous case.

We now derive the equilibrium utilities. We need to distinguish two cases, one where opportunists exist, and one where there are no more opportunists. Consider first the case where there are no opportunists. Below we derive the condition for when this applies. Without opportunists, the utility of idea-bearer is given by $U_I^N = \phi^2(z+\delta U_G^N)+\phi\overline{\phi}(sz+\delta U_G^N)+\overline{\phi}\phi(\overline{s}z+\delta U_I^N)+\overline{\phi}^2\delta U_I^N-c$. Using the above expression for s, this can be rewritten as $U_I^N-\delta U_G^N = \phi z+\overline{\phi}\delta(U_I^N-U_G^N)-c$. The utility of a generator is given by $U_G^N = -\psi+\delta U_I^N$ or $U_G^N-\delta U_G^N = -\psi+\delta(U_I^N-U_G^N)$. Subtracting the second from the first, we obtain after simple transformations $U_I^N - U_G^N = \dfrac{\phi z+\psi-c}{1+\phi\delta} = \Delta_c^S$. Using this in the above utilities we obtain $U_G^N = \dfrac{\delta}{1-\delta}\Delta_c^S - \dfrac{\psi}{1-\delta}$ and $U_I^N = \dfrac{1}{1-\delta}\Delta_c^S - \dfrac{\psi}{1-\delta}$. This shows that without opportunists, the equilibrium is always efficient, except for transactions costs.

Now suppose that there are some opportunists in equilibrium. Their utility is given by $U_O^N = \overline{\theta}\delta U_O^N+\theta\phi(\overline{s}z+\delta U_O^N)+\theta\overline{\phi}(\delta U_O^N)-c$ which we rewrite as $U_O^N-\delta U_O^N = \theta\phi\overline{s}z-c$. Using $\overline{s}z = \frac{1}{2}z - \frac{1}{2}\delta(U_I^N - U_O^N)$ this yields $U_O^N - \delta U_O^N = \dfrac{\theta\phi}{2}z - \dfrac{\theta\phi}{2}\delta\Delta^N - c$. The utility of an idea-bearer is given by $U_I^N = \overline{\theta}[\phi(sz+\delta U_O^N)+\overline{\phi}\delta U_I^N]+\theta[\phi^2(z+\delta U_O^N)+\phi\overline{\phi}(sz+\delta U_O^N)+\overline{\phi}\phi(\overline{s}z+\delta U_I^N)+\overline{\phi}^2\delta U_I^N]-c$. After standard transformations we obtain $U_I^N - \delta U_O^N = \theta\phi z+\overline{\theta}\phi\frac{1}{2}z+\overline{\theta}\phi\frac{1}{2}\delta\Delta^N+\overline{\phi}\delta\Delta^N-c$. Combing these two equations we obtain $\Delta^N = \dfrac{\phi z}{2-2\delta+\delta\phi}$. The utility of a generator is given by $U_G^N = -\psi+\delta U_I^N$. To find the equilibrium fraction θ^N we use again $U_O^N = U_G^N$ and obtain after simple transformations $\theta^N = \dfrac{2}{\phi}\dfrac{c-\psi+\delta\Delta^N}{z-\delta\Delta^N} = \dfrac{\delta}{1-\delta} - \dfrac{\psi-c}{(1-\delta)\Delta^N}$. From this we obtain $U_O^N = U_G^N = \dfrac{\delta\Delta^N}{(1-\delta)} - \dfrac{\psi}{(1-\delta)}$ and $U_I^N = \dfrac{\Delta^N}{(1-\delta)} - \dfrac{\psi}{(1-\delta)}$. This equilibrium is feasible for $U_G^N \geq 0 \Leftrightarrow \psi \leq \delta\Delta^N = \psi^N$. Note also that $s = \dfrac{1}{2}+\dfrac{\delta\Delta^N}{2z} = \dfrac{1}{2}+\dfrac{\delta}{2z}\dfrac{\phi z}{2-2\delta+\delta\phi} = \dfrac{1-\delta+\delta\phi}{2-2\delta+\delta\phi} < 1$.

We are now in a position to examine when opportunists actually exist in equilibrium. The condition is simply given by $\theta^N \leq 1 \Leftrightarrow \psi \geq c+(2\delta-1)\Delta^N = \psi^O$. I n case that $\delta < \frac{1}{2}(1+\frac{c}{\Delta^N})$, it is convenient to write $\psi^O = 0$. We note that at $\psi = \psi^O$ we have $\theta^N = 1$ so that $U_O = U_G$. However, for any lower values of ψ, an agent is better off generating an idea, rather than staying as an opportunist in the market. We conclude that for $\psi < \psi^O$ the equilibrium has no opportunists, and for $\psi > \psi^0$

the equilibrium always entails some positive fraction of opportunists. Note also that the overall feasible range of the NDA equilibrium is determined by the condition $\psi \leq \delta\Delta^N \equiv \psi^N$. This completes the proof of parts (i) to (iii).

For part (iv), we note that $\psi^N < \psi^S$ from $\Delta^N = \dfrac{\phi z}{2-2\delta+\delta\phi} < \dfrac{\phi z}{1-\delta+\delta\phi} = \Delta^S$. Also, $\psi^N > \psi^M$ from $\Delta^N = \dfrac{\phi z}{2-2\delta+\delta\phi} > \dfrac{\phi z}{2-\delta+\delta\phi} = \Delta$. Moreover, we now show that $\theta^M < \theta^N$. To see this, use $\delta - \dfrac{\psi}{\Delta} < \dfrac{\delta}{1-\delta} - \dfrac{\psi - c}{(1-\delta)\Delta^N}$. We evaluate this again at $c = 0$ and obtain after several transformations the condition $\psi < \delta\dfrac{\phi z}{1-\delta+\phi\delta} = \psi^S$, which is merely the condition for ψ to be in the socially efficient range. Using now from Proposition 2 the expressions $n_I = \dfrac{\theta}{1+\theta\phi}$, $n_O = \dfrac{1-\theta}{1+\theta\phi}$ and $n_G = \dfrac{\theta\phi}{1+\theta\phi}$, we note that n_I and n_G are increasing and n_O decreasing in θ. Using $\theta^M < \theta^N < 1 = \theta^S$ we immediately obtain the inequalities $n_G < n_G^N < n_G^S$, $n_I^M < n_I^N < n_I^S$ and $n_O^M > n_O^N > n_O^S = 0$. Finally, we note that the inequalities $U_G < U_G^N < U_G^S$ and $U_I < U_I^N < U_I^S$ immediately follow from $\Delta < \Delta^N < \Delta^S$.

7.5 Proof of Proposition 4

We first show how the agent's payoff depends on NDAs and disclosure. In the following three tables, the first row shows A's and the second row B's utility. The first table show the payoffs when both parties sign a mutual NDA. For simplicity we omit the superscripts throughout the proof.

With NDA	B is I	B is O
A is I	$\delta U_O + \phi z + \overline{\phi}\delta\Delta - c$ $\delta U_O + \phi z + \overline{\phi}\delta\Delta - c$	$\delta U_O + \frac{\phi z}{2} + (1 - \frac{\phi}{2})\delta\Delta - c$, $\delta U_O + \frac{\phi z}{2} - \frac{\phi}{2}\delta\Delta - c$
A is O	$\delta U_O + \frac{\phi z}{2} + \frac{\phi}{2}\delta\Delta - c$ $\delta U_O + \frac{\phi z}{2} + (1 - \frac{\phi}{2})\delta\Delta - c$	$\delta U_O - c$ $\delta U_O - c$

To explain the payoffs in the case where $A = I$ and $B = I$, note that $U_I = \phi^2(z + \delta U_O) + 2\phi\overline{\phi}(\frac{z}{2} + \frac{\delta}{2}(U_I + U_O)) + \overline{\phi}^2\delta U_I - c = \delta U_O + \phi z + \overline{\phi}\delta\Delta - c$. To explain the payoffs in the case where $A = I$ and $B = O$, note that A's utility is given by

$U_I^A = \phi(sz + \delta U_O) + \overline{\phi}\delta U_I - c$. Using $sz = \frac{1}{2}z + \frac{\delta}{2}\Delta$ we obtain $U_I^A = \delta U_O + \phi\frac{1}{2}z + \phi\frac{\delta}{2}\Delta + \overline{\phi}\delta\Delta - c = \delta U_O + \frac{\phi z}{2} + (1 - \frac{\phi}{2})\delta\Delta - c$. At the same time, B's utility is given by $U_I^B = \phi(\overline{s}z + \delta U_O) + \overline{\phi}\delta U_O - c$. Using $\overline{s}z = \frac{z}{2} - \frac{\delta\Delta}{2}$ we obtain $U_I^B = \delta U_O + \frac{\phi z}{2} - \frac{\phi}{2}\delta\Delta - c$.

The second table shows the payoffs when there is no NDA and idea-bearers disclose their idea.

No NDA, with disclosure	B is I	B is O
A is I	$\delta U_O + \phi z + \overline{\phi}\delta\Delta$ $\delta U_O + \phi z + \overline{\phi}\delta\Delta$	$\delta U_O + \phi\frac{z}{2} + \overline{\phi}\frac{\delta}{2}\Delta$ $\delta U_O + \phi\frac{z}{2} + \overline{\phi}\frac{\delta}{2}\Delta$
A is O	$\delta U_O + \phi\frac{z}{2} + \overline{\phi}\frac{\delta}{2}\Delta$ $\delta U_O + \phi\frac{z}{2} + \overline{\phi}\frac{\delta}{2}\Delta$	δU_O δU_O

To explain the payoffs in the case where $A = I$ and $B = I$, note that $U_I = \phi^2(z + \delta U_O) + 2\phi\overline{\phi}(\frac{z}{2} + \frac{1}{2}\delta U_O + \frac{1}{2}\delta U_I) + \overline{\phi}^2\delta U_I = \delta U_O + \phi z + \overline{\phi}\delta\Delta$. In the case where $A = I$ and $B = O$, note that $U_I^A = \phi(\frac{z}{2} + \delta U_O) + \overline{\phi}(\frac{1}{2}\delta U_O + \frac{1}{2}\delta U_I) = \delta U_O + \phi\frac{z}{2} + \overline{\phi}\frac{1}{2}\delta\Delta$. In that case we also have $U_I^B = U_I^A$. This is because without NDAs the two partners have the same bargaining power, irrespective of who generated the idea.

The third table shows the payoffs when there is no NDA in place and idea-bearers do not disclose their ideas.

No NDA, no disclosure	B is I	B is O
A is I	δU_I δU_I	δU_O δU_I
A is O	δU_I δU_O	δU_O δU_O

Comparing Table 1 with Table 2, and using standard transformations, we identify the net benefit of using a mutual NDA, when the default assumption is that idea-bearers disclose even without an NDA.

Benefit of NDAs, with disclosure	B is I	B is O
A is I	$-c$ $-c$	$\frac{\delta}{2}\Delta - c$ $-\frac{\delta}{2}\Delta - c$
A is O	$-\frac{\delta}{2}\Delta - c$ $\frac{\delta}{2}\Delta - c$	$-c$ $-c$

We note that not signing is a dominant strategy for O-types. Thus, only I-types would consider issuing or signing NDAs. Once it is understood that O-types do not sign, not signing also becomes the optimal strategy for I-types. It follows that NDAs are never signed.

Comparing Table 1 with Table 3 and using standard transformations, we identify the net benefit of using a mutual NDA, when the default assumption is that idea-bearers would not disclose an idea without an NDA.

Benefit of NDAs, no disclosure	B is I	B is O
A is I	$\phi(z - \delta\Delta) - c$ $\phi(z - \delta\Delta) - c$	$\frac{\phi}{2}(z - \delta\Delta) - c$ $\frac{\phi}{2}(z - \delta\Delta) - c$
A is O	$\frac{\phi}{2}(z - \delta\Delta) - c$ $\frac{\phi}{2}(z - \delta\Delta) - c$	$-c$ $-c$

We note that for small c (indeed, for any $c < \frac{\phi}{2}(z - \delta\Delta)$), signing an NDA is a dominant strategy.

We are now in a position to examine the disclosure decisions. Consider a candidate equilibrium without NDAs. In the main text we have already seen that, using the intuitive criterion, the refusal to sign an NDA does not help to eliminate any types, so that there is no updating of beliefs off the equilibrium path. Still, we have to verify that agents want to disclose their idea. Consider the deviation of agent A not to disclose. We will show that this deviation is not beneficial to A. The deviation not to disclose is unilateral, so we have to calculate payoff for the case where B discloses but A doesn't. Whether A's idea fits or not will never be discovered. If

B is O, there is nothing to disclose, so A gets δU_I and B gets δU_O. If B is I and there is no fit, then A gets δU_I and B gets δU_O. Finally, if B is I and there is a fit, we consider the following bargaining game. No cooperation gives each agent an outside option of utility δU_I. The joint value of cooperation is $z + \delta U_I + \delta U_O$. Thus, A's utility is given by $\frac{1}{2}[z + \delta U_I + \delta U_O + \delta U_I - \delta U_O] = \frac{z}{2} + \delta U_I$ and B's utility is $\frac{z}{2} + \delta U_O$. Combining all of these results, the expected utility to A of not disclosing is given by $U_A^{nodis} = \theta\phi(\frac{z}{2} + \delta U_I) + \theta\overline{\phi}\delta U_I + \overline{\theta}\delta U_I = \delta U_I + \theta\phi\frac{z}{2}$. We compare this against the equilibrium path payoff of disclosing the idea. From Proposition 2, we use $U_I^{dis} = \delta U_O + \overline{\theta}\phi\frac{z}{2} + \overline{\theta\phi}\frac{1}{2}\delta\Delta + \theta\phi z + \theta\overline{\phi}\delta\Delta$. Using standard transformations we obtain $U_I^{dis} - U_A^{nodis} = \phi(\frac{z}{2} - \delta\Delta) - \overline{\theta\phi}\frac{1}{2}\delta\Delta$. Further transformations show that $U_I^{dis} > U_A^{nodis} \Leftrightarrow 2 > \delta(2 - \overline{\phi}\theta)$, which is always true. Thus the deviation to unilaterally not disclose is never optimal.

In fact, we can show an even stronger result, namely that an agent cannot commit not to disclose even if he expects the other agent to be an opportunists. To show this, we redo the above calculations for $\theta = 0$, i.e., we consider the case where A believes that B is an O type for sure. A's payoff from disclosing his idea to a known opportunist is $U_A = \delta U_O + \phi\frac{z}{2} + \overline{\phi}\frac{1}{2}\delta\Delta$ while the payoff to refusing to disclose idea is δU_I. Thus A cannot commit not to disclose whenever $\delta U_I < \delta U_O + \phi\frac{z}{2} + \overline{\phi}\frac{1}{2}\delta\Delta$, which yields after transformations $2 > 2\delta$, which is always true. This last insight will be useful to understand why it is never optimal for an agent to induce the other sign an NDA by making a payment, which we examine next.

Consider the possibility of paying for an NDA. Again we start with an equilibrium where there are no NDAs. We now consider a one-period deviation where A makes a offer to B of a payment τ in exchange for signing an NDA. By the intuitive criterion, only I-type would make such an offer, i.e., B immediately infers that A is an I type. The questions are what the optimal level of τ is, and what B's response would be. Note that as this is a unilateral deviation, only one NDA is offered. For simplicity, we assume that the transaction costs are again given by c.

We have already seen that A can never commit not to disclose, irrespective of whether B signs the NDA or not. The question is under what circumstances B would thus sign the NDA. Consider the bargaining outcome after the NDA is signed. If B is O, he cannot steal the idea. The joint value from cooperation is $z + \delta U_O + \delta U_O$, while noncooperation gives δU_I and δU_O.From the Nash bargaining solution, A and B respectively obtain $\delta U_O + \frac{z+\delta\Delta}{2}$ and $\delta U_O + \frac{z-\delta\Delta}{2}$. Thus, if the NDA is signed and B is O we have $U_A = -c-\tau+\delta U_O+\phi\frac{z+\delta\Delta}{2}$ and $U_B = -c+\tau+\delta U_O+\phi\frac{z-\delta\Delta}{2}$. If the NDA is not signed, then B (as an O type) obtains $\delta U_O + \phi\frac{z}{2} + \overline{\phi}\delta\Delta$ as usual. B therefore signs the NDA if $\tau \geq c+(1-\frac{\phi}{2})\delta\Delta$. A's net benefit of offering the NDA is $-c-\tau+\delta U_O+\phi\frac{z+\delta\Delta}{2} - (\delta U_O + \phi\frac{z}{2} - \overline{\phi}\delta\Delta) = -c-\tau+(1-\frac{\phi}{2})\delta\Delta$. Whenever A offers the cheapest τ so that $B = O$ is just willing to sign, namely $\tau = c+(1-\frac{\phi}{2})\delta\Delta$, his net gain is $-2c$, i.e., A looses exactly the total transaction costs.

If instead B is I, there is no risk of stealing anyway. When both ideas fit, the usual bargaining gives each $z + \delta U_O$. If only one idea fits, the joint value is $z + \delta U_O + \delta U_I$. Notice the outside values δU_I are the same for both agents, thus the Nash bargaining solution gives $\delta U_O + \frac{z+\delta\Delta}{2}$ to both. Finally, if neither idea fits, each agent gets his outside option. Thus, if the NDA is signed and B is I we have after transformations $U_A = -c - \tau + \delta U_O + \phi z + \overline{\phi}\delta\Delta$ and $U_B = -c + \tau + \delta U_O + \phi z + \overline{\phi}\delta\Delta$. If the NDA is not signed, then B (as an I type) obtains $-c + \tau + \delta U_O + \phi z + \overline{\phi}\delta\Delta$ as usual. B therefore signs the NDA if $\tau \geq c$. The net benefit for A of offering the NDA is $-c-\tau$. Whenever A offers the cheapest τ so that $B = I$ is just willing to sign, namely $\tau = c$, his net gain is again $-2c$, i.e., A again looses the total transaction costs.

In summary, we see that A can use the payment τ to separate out types, i.e., by offering any payment $\tau \in [c, c + (1 - \frac{\phi}{2})\delta\Delta)$, only the I and not the O type would accept the offer. However, since the NDA does not increase the joint value, doing so is never profitable for A. Hence the deviation to offer a payment for an NDA is never beneficial, and the equilibrium without NDAs remains stable.

7.6 Proof of Proposition 5

We now consider a candidate equilibrium with NDAs, and show when non-disclosure after a refusal to sign an NDA is optimal. For this we look at a possible deviation from the expected behavior, where after a refusal to sign an NDA, one agent, call him B, deviates by still disclosing his idea. This is a unilateral deviation, so that the other agent, call him A, behaves as expected, refusing to disclose his idea. Whether A's idea fits is thus never discovered. For B, disclosure is obviously only relevant when B

is an I-type. Suppose first that $A = I$, then either B's idea doesn't fit, so that B gets δU_I and A gets δU_I; or B's idea fits. In case of non-cooperation, B's outside option is δU_I and A's outside option is δU_I. The joint value under cooperation is $z+\delta U_O+\delta U_I$. Using Nash bargaining, B gets $\frac{1}{2}[z+\delta U_O+\delta U_I+\delta U_I-\delta U_I] = \frac{z}{2}+\frac{\delta}{2}(U_I+U_O)$. We note that B extracts exactly the same amount as if he had an NDA. This is because if A has an idea, then A has no way of stealing the idea. Suppose next that $A = O$. Either B's idea doesn't fit, so that because of stealing, B and A both get $\frac{\delta}{2}(U_I+U_O)$. Or B's idea fits. In case of non-cooperation, the symmetric outside option is $\frac{\delta}{2}(U_I + U_O)$, and the joint value from cooperation is $z + \delta U_O + \delta U_O$. Using Nash bargaining, A and B both get $\frac{1}{2}[z + \delta U_O + \delta U_O + \frac{\delta}{2}(U_I + U_O) - \frac{\delta}{2}(U_I + U_O)] = \frac{z}{2} + \delta U_O$, which is the standard equal split. Overall, B's expected utility in the proposed deviation is $U^{dev} = \theta\phi[\frac{z}{2} + \frac{\delta}{2}(U_I + U_O)] + \theta\overline{\phi}\delta U_I + \overline{\theta}\phi[\frac{z}{2} + \delta U_O] + \overline{\theta\phi}\frac{\delta}{2}(U_I + U_O)$. We compare this payoff against the expected behavior of non-disclosure, which gives B a utility of δU_I. The equilibrium condition is thus $U^{dev} - \delta U_I < 0$. After transformations, this simplifies to $U^{dev} - \delta U_I = \phi\frac{z}{2} - (\phi + \overline{\theta})\frac{\delta\Delta}{2} < 0$. The first term measures the net benefit of an earlier idea resolution, the second term measures the loss of bargaining power to the idea-bearer.

Consider first an equilibrium with $\psi < \psi^O$, so that there are no opportunists. We have $\theta = 1$, so that $U^{dev} - \delta U_I = \phi\frac{2(1-\delta)z}{2-2\delta+\delta\phi} > 0$. This implies that the condition for the NDA equilibrium to exist is never satisfied. The intuition is simply that an NDA does not change the bargaining game if the partner is also an idea-bearer. Thus, if there are no opportunists, there is never a reason to sign an NDA, because the NDA isn't necessary to protect ideas.

Consider next the case where $\psi > \psi^O$, so that there are some opportunists. We can rewrite the condition $U^{dev}-\delta U_I = \phi z-(\phi+\overline{\theta})\delta\Delta < 0$ as $\theta < 3-\frac{2}{\delta}$. This shows that the fraction of opportunists has to be sufficiently high for non-disclosure to be credible. Using the equilibrium value of the NDA equilibrium $\theta^N = \frac{\delta}{1-\delta} - \frac{(\psi - c)}{(1-\delta)\Delta^N}$ we can rewrite the condition $U^{dev} < \delta U_I \Leftrightarrow \psi > c+\frac{2-5\delta+4\delta^2}{\delta}\Delta^N = \widehat{\psi}$. It is easy to verify that $\widehat{\psi} > \psi^O$. Moreover, we examine under what circumstances we have $\widehat{\psi} < \psi^N$. We evaluate $\widehat{\psi}$ at $c = 0$ and obtain $\widehat{\psi} < \psi^N \Leftrightarrow \frac{2-5\delta+4\delta^2}{\delta}\Delta^N < \delta\Delta^N \Leftrightarrow 2-5\delta+3\delta^2 < 0$. The quadratic equation $3\delta^2 - 5\delta + 2 = 0$ has two roots, at $\delta = \frac{2}{3}$ and at $\delta = 1$. It follows that for $\delta \in (\frac{2}{3}, 1)$ we have $2 - 5\delta + 3\delta^2 < 0 \Leftrightarrow \widehat{\psi} < \psi^N$ and for $\delta < \frac{2}{3}$ we have $2 - 5\delta + 3\delta^2 > 0 \Leftrightarrow \widehat{\psi} > \psi^N$. It follows that the NDA equilibrium exists for $\frac{2}{3} < \delta < 1$ and $\widehat{\psi} < \psi < \psi^N$.

Finally, note also that the possibility of offering a payment in exchange of an NDAs has no effect on an NDA equilibrium. In such an equilibrium the two parties would just swap the payment τ. Moreover, off the equilibrium path when one party refuses the NDA there are no payments, so the analysis is the same as before.

7.7 Proof of Proposition 6

We first derive an expression for the utility of a typical employee. This is derived from an iterative set of equations. U_E denotes the utility of a newly starting employee, or equivalently, of an employee without ideas. $U_{E,j}$ is the utility of an employee that is about to talk to the j^{th} internal match. We have $U_E = -\psi + \delta U_{E,1}$, $U_{E,j} = \phi(bz + \delta U_E) + \overline{\phi}\delta U_{E,j+1}$, for any $j = 1, ..., F$ and $U_{E,F+1} = U_I$, which is the utility of leaving the firm. Using the above equations we obtain after transformations $U_E - \delta U_E = -\psi + \phi bz[\delta + \overline{\phi}\delta^2 + \overline{\phi}^2\delta^3 + ... + \overline{\phi}^{F-1}\delta^F] + \overline{\phi}^F\delta^{F+1}(U_I - U_E)$. We define $\widetilde{\phi} = \sum_{j=0}^{j=F-1} \overline{\phi}^j \delta^{j+1}$ so that $U_E - \delta U_E = -\psi + \phi\widetilde{\phi}bz + \overline{\phi}^F\delta^{F+1}(U_I - U_E)$. In a market equilibrium we must have $U_E = U_O$, so that $U_I - U_O = \dfrac{\phi z}{2 - \delta + \delta\phi} = \Delta$ as before. It follows that $U_E = \dfrac{-\psi + \phi\widetilde{\phi}bz + \overline{\phi}^F\delta^{F+1}\Delta}{1 - \delta}$. The firm sets bz so that $U_E = U_O = \dfrac{\theta\Delta}{1 - \delta}$. Thus the optimal compensation satisfies $b^* = \dfrac{\psi + \theta\Delta - \overline{\phi}^F\delta^{F+1}\Delta}{\phi\widetilde{\phi}z}$. This shows the first part (ii).

For part (iii) we need to verify that this optimal compensation ensures that employees want to disclose their ideas to the firm, rather than leaving the firm without disclosing their idea. In fact, we will demonstrate a slightly stronger property of the optimal compensation, namely that the optimal b is such that the employee never has an incentive to leave the firm, up until he has talked to all available internal matches. Consider the utility of an employee that is meeting with his last internal match, i.e., $j = F$. He either finds an internal match this time to get the bonus bz, or he will leave the firm. Formally, we have $U_{E,F} = \phi(b_F z + \delta U_E) + \overline{\phi}\delta U_I = \delta U_E + \phi bz + \overline{\phi}\delta\Delta$. We compare this with the utility of taking the idea outside the firm, in which case the employee becomes an idea-bearer in the market and gets (from Proposition 2) $U_I = \delta U_O + (\theta + \frac{\overline{\theta}}{2})\phi z + (\theta + \frac{\overline{\theta}}{2})\overline{\phi}\delta\Delta$. The employee prefers to stay inside the firm for one more round whenever $U_{E,F} \geq U_I$. We define $\widehat{b}$ as the bonus that ensures that the employee is just indifferent between staying and leaving, i.e., $U_{E,F}(\widehat{b}) = U_I \Leftrightarrow \phi\widehat{b}z + \overline{\phi}\delta\Delta = (\theta + \frac{\overline{\theta}}{2})\phi z + (\theta + \frac{\overline{\theta}}{2})\overline{\phi}\delta\Delta$. Using $\Delta = \dfrac{\phi z}{2-\delta+\delta\phi}$ we obtain after transformations $\widehat{b} = \dfrac{1+\theta-\delta+\delta\phi}{2-\delta+\delta\phi}$. As a next step, we show that if the firm uses $\widehat{b}$, the employee is not only indifferent at the time of the last internal match, but in fact he is indifferent at any time that he is circulating an idea inside the firm. To see this, consider the penultimate match, i.e., $j = F - 1$. We have $U_{E,F-1} = \phi(\widehat{b}z + \delta U_E) + \overline{\phi}\delta U_{E,F} = \delta U_O + \phi\widehat{b}z + \overline{\phi}\delta\Delta$. But this means that $U_{E,F-1}(\widehat{b}) = U_{E,F}(\widehat{b})$. Using an iterative logic, we find that $U_{E,,j}(\widehat{b}) = U_I$ for $j = 1, ..., F$. This shows that for any $b \geq \widehat{b}$ the employee is willing to disclose his idea to the firm, and stay inside the firm as long as there are internal matches.

The question remains what the relationship is between $\widehat{b}$ and the optimal b^* derived above. Consider first an equilibrium where ideas are generated in the market, i.e., $\psi < \psi^M$. In this case we know from Proposition 2 that $U_G = -\psi + \delta U_I$ and $U_G = U_O$. The iterative equations above already established that $U_E = -\psi + \delta U_{E,1}$, and we just saw that $U_{E,,j}(\widehat{b}) = U_I$ so that for $j = 1$ we have $U_E(\widehat{b}) = -\psi + \delta U_I$. At the time of hiring, the firm has to match the employees' outside option, so that $U_E = U_O = U_G = -\psi + \delta U_I$. It follows that $b^* = \widehat{b}$, i.e., that the optimal compensation is such that the employee is just indifferent between leaving and staying. This proves the first bullet point under part (iii). For the second bullet point of part (iii), we consider the case where $\psi > \psi^M$. In this case there is no idea generation in the market, implying $U_G < U_O$ (where U_O is driven off the benefits of listening to ideas that were generated by employees who subsequently left the firm). If the firm were to set a bonus $\widehat{b}$, it would still be true that $U_{E,j}(\widehat{b}) = U_I$ for $j = 1, ..., F$. The problem, however, would be that employees now have insufficient incentives to generate ideas, since $U_E = -\psi + \delta U_{E,1} = -\psi + \delta U_I = U_G < U_E$. The firm therefore sets $b^* > \widehat{b}$, where b^* still given by $b^* = \dfrac{\psi + \theta\Delta - \overline{\phi}^F \delta^{F+1}\Delta}{\phi\widetilde{\phi}z}$. Since b^* is strictly larger than $\widehat{b}$, we have $U_{E,,j}(b^*) > U_{E,,j}(\widehat{b}) = U_I$ for $j = 1, ..., F$. This completes the proof of part (iii).

Note also that the firm wanted to take a stake in the employee's spin-off. This corresponds to reducing Δ by some given amount. If the firm were to do this, then this would reduce the employee's ex-ante utility, and the firm would therefore require an equivalent raise in b^*. W.l.o.g. we therefore assume that the firm lets the employee go without taking a stake in spin-off. This explains part (i).

For part (iv), finally, consider now the total revenues that a firm makes on a new employee. The firm's utility from an employee has a similar recursive structure than before. We have $U_F = \delta U_{F,1}$, $U_{F,j} = \phi(\overline{b}z + \delta U_F) + \overline{\phi}\delta U_{F,j+1}$ for any $j = 1, ..., F$ and $U_{F,F+1} = 0$. Similar to before we obtain $U_F - \delta U_F = \phi\overline{b}z[\delta + \overline{\phi}\delta^2 + \overline{\phi}^2\delta^3 + ... + \overline{\phi}^{F-1}\delta^F] + \overline{\phi}^F\delta^{F+1}(U_F - U_F)$ so that $U_F = \dfrac{\phi\widetilde{\phi}\overline{b}z}{1-\delta}$. We then rewrite this as $U_F = U_F + U_E - U_E = \dfrac{\phi\widetilde{\phi}\overline{b}z - \psi + \phi\widetilde{\phi}bz + \overline{\phi}^F\delta^{F+1}\Delta}{1-\delta} = \widetilde{U} - U_O$ where $\widetilde{U} = \dfrac{\phi\widetilde{\phi}z - \psi + \overline{\phi}^F\delta^{F+1}\Delta}{1-\delta}$. The j^{th} entrant's condition is given by $EU_F - K_j \geq U_O \Leftrightarrow E\widetilde{U} - (E+1)U_O \geq K_j$ where K_j are fixed entry costs. Given a distribution $\Omega(K_j)$, the number of firms is given by $n_F = \Omega(E\widetilde{U} - (E+1)U_O)$. This completes the proof of part (iv).

To determine the fractions of employees generating and circulating ideas as follows, let $f_{E,j}$ be the fraction of employees that are at the j^{th} stage of circulating an idea. We have $f_{E,1} = f_G$ and $f_{E,j+1} = \overline{\phi}f_{E,j}$ for all $j = 1, ..., F$. The total number of idea-bearers inside the firm is $f_I = \sum_{j=1}^{j=F} f_{E,j} = \sum_{j=1}^{j=F} f_G\overline{\phi}^{j-1} = f_G\widehat{\phi}$ where we define $\widehat{\phi} = \sum_{j=1}^{j=F}\overline{\phi}^{j-1}$. Using $f_G + f_I = 1$ we immediately obtain $f_G = \dfrac{1}{1+\widehat{\phi}}$ and $f_I = \dfrac{\widehat{\phi}}{1+\widehat{\phi}}$. This completes the proof of part (v).

To determine the upper bound of ψ above which firms are not feasible, we consider the condition $\Pi \geq K_{\min} + U_O$. We have $\Pi = EU_F = E(\widetilde{U} - U_O) = E(\dfrac{\phi\widetilde{\phi}z + \overline{\phi}^F\delta^{F+1}\Delta - \psi}{1-\delta} - U_O)$. Suppose for now that $\psi^F > \psi^M$, then the first entrant faces a complete absence of ideas, so that $U_O = 0$. Thus the first entrants entry condition simplifies to $E\dfrac{\phi\widetilde{\phi}z + \overline{\phi}^F\delta^{F+1}\Delta - \psi}{1-\delta} \geq K_{\min} \Leftrightarrow \psi \leq \phi\widetilde{\phi}z + \overline{\phi}^F\delta^{F+1}\Delta - \dfrac{(1-\delta))K_{\min}}{E} = \psi^F$. The condition $\psi^F > \psi^M$ requires $\phi\widetilde{\phi}z + \overline{\phi}^F\delta^{F+1}\Delta - \dfrac{(1-\delta))K_{\min}}{E} > \delta\Delta \Leftrightarrow K_{\min} < \dfrac{E}{1-\delta}[\phi\widetilde{\phi}z + \overline{\phi}^F\delta^{F+1}\Delta - \delta\Delta] \equiv \widehat{K_{\min}}$. Note that $\widehat{K_{\min}} > 0$ since $\phi\widetilde{\phi}z > \delta\Delta \Leftrightarrow \widetilde{\phi} > \dfrac{\delta}{2-\delta+\phi\delta}] \Leftrightarrow \delta + \sum_{j=2}^{j=F}\overline{\phi}^{j-1}\delta^j > \dfrac{\delta}{2-\delta+\phi\delta} \Leftrightarrow \delta\dfrac{1-\delta+\phi\delta}{2-\delta+\phi\delta} + \sum_{j=2}^{j=F}\overline{\phi}^{j-1}\delta^j > 0$.

Consider now the relationship between E and F. Define $F = E + R$ where E is fixed number of employment slots and R is number of 'relevant' replacements. Not all replacement are relevant to an idea-bearer who we call A. In particular, if employee B

is replaced by B' before A managed to talk to B, the replacement is irrelevant for A. We therefore define relevant replacements as those that occur after the idea-bearer talked to the particular employee. To calculate the steady-state expected number of replacements, consider the following. An idea-bearing employee first talks to E employees. As noted above, some of them like B' may have joined the firm only recently, this does not matter here. After talking to the first E employees, the only employees left to talk to must be replacements. Naturally we also need to take into account that there may be replacements of replacement. Consider thus the expected number of replacements that would be in the firm after A talked to N employees, where N can take any value for now. To calculate the number of replacements $R(N)$, we note that the employee that A talked to one period ago will have left with probability $\chi_1 = \overline{\phi}^F$. The employee A talked to two periods ago will have left with probability $\chi_2 = \overline{\phi}^F + (1-\overline{\phi}^F)\overline{\phi}^F$. More generally, the employee A talked to n periods ago will have left with probability $\chi_n = \overline{\phi}^F + (1-\overline{\phi}^F)\overline{\phi}^F + +(1-\overline{\phi}^F)^2\overline{\phi}^F .... + (1-\overline{\phi}^F)^{n-1}\overline{\phi}^F = \overline{\phi}^F \sum_{j=1}^{j=n}(1-\overline{\phi}^F)^{n-1}$. After N periods, the expected number of employees that will have left is therefore $R(N,F,\phi) = \sum_{n=1}^{n=N}\chi_n$. Using the definition of χ_n this can also be rewritten as $R(N,F,\phi) = \sum_{j=0}^{j=N-1}(N-j)(1-\overline{\phi}^F)^j\overline{\phi}^F$. This expression can be evaluate for any N. Of particular interest is the case where $N = F$. With a slight abuse of notation we write $R(N = F, F, \phi) = R(F,\phi) = \sum_{j=0}^{j=F}(F-j)(1-\overline{\phi}^F)^j\overline{\phi}^F$. At $N = F$, A will have talked to all employees plus all relevant replacements. At that point A will have talked to everyone. If there still is not internal fit, it is time to leave the firm.

From a mathematical perspective, F is found by a fixed point argument. On the one hand, it must be that $F = E + R$. On the other hand, the number of replacement must satisfy $R = R(F,\phi)$. The number of replacements is thus given by the implicit equation $F = E + R(F,\phi)$, which does not have an explicit solution. However, we can determine some properties. Using the standard stability requirement of the fixed point implies $0 < \dfrac{dR}{dF} < 1$. Totally differentiating the fixed point equation we obtain $dF = dE + \dfrac{dR}{dF}dF + \dfrac{dR}{d\phi}d\phi$. We immediately obtain $\dfrac{dF}{dE} = \dfrac{1}{1-(dR/dF)} > 0$. We also note that $\dfrac{dF}{d\phi} = \dfrac{(dR/d\phi)}{1-(dR/dF)}$. Thus $sign(\dfrac{dF}{d\phi}) = sign(\dfrac{dR}{d\phi})$. We note that $\dfrac{dR}{d\phi} = \dfrac{dR}{d\overline{\phi}^F}\dfrac{d\overline{\phi}^F}{d\phi} = -F\overline{\phi}^{F-1}\dfrac{dR}{d\overline{\phi}^F} = -F\overline{\phi}^{F-1}\sum_{j=0}^{j=F}(F-j)[(1-\overline{\phi}^F)^j - j(1-\overline{\phi}^F)^{j-1}\overline{\phi}^F]$

$= -F\overline{\phi}^{F-1}\sum_{j=0}^{j=F}(F-j)(1-\overline{\phi}^{F})^{j-1}[1-(j+1)\overline{\phi}^{F}]$. The terms in the square brackets are positive. To formally ensure that a sufficient (but by now means necessary) condition is that $(F+1)\overline{\phi}^{F} < 1$. If this condition is satisfied, we have $sign(\frac{dF}{d\phi}) = sign(\frac{dR}{d\phi}) < 0$.

7.8 Proof of Proposition 7

To show that the firm always preserves it reputation, we need to ensure that it never has an incentive to deviate. We therefore only need to consider the payoff from the largest possible deviation. The most profitable deviation for the firm would be to refuse paying out bonuses. Moreover, the largest possible gain would occur of all employees had implemented an idea at the same time. In that case, the firm could make a one-time profit of Ebz. After that, the firm owner would lose her reputation. In our local reputation model, we assume that the firm owner can slip back into the pool of agents, possible under a disguised identity. In this case, her continuation payoff after a deviation is U_O. Thus, the reputation condition is given by

$$Ebz + \delta U_O < \delta EU_F \Leftrightarrow Ebz < \delta(EU_F - U_O)$$

We note that $\underset{\delta\to 1}{lim}\widetilde{\phi} = \widehat{\phi} < \infty$, $\underset{\delta\to 1}{lim}\Delta = \frac{\phi z}{2-\delta+\phi\delta} = \frac{\phi z}{1+\phi} < \infty$ and $\underset{\delta\to 1}{lim}\theta^M = 1-\frac{\psi}{\Delta} < \infty$, so that $\underset{\delta\to 1}{lim}Ebz = \frac{\psi+\theta\Delta-\overline{\phi}^{F}\Delta}{\phi\widehat{\phi}} < \infty$. Moreover, we have $EU_F - U_O = E\widetilde{U} - (E+1)U_O = \frac{E(\phi\widetilde{\phi}z+\overline{\phi}^{F}\delta^{F+1}\Delta)-(E+1)\delta\Delta+\psi}{1-\delta}$, so that $\underset{\delta\to 1}{lim}(EU_F - U_O) = \underset{\delta\to 1}{lim}\frac{E(\phi\widetilde{\phi}z+\overline{\phi}^{F}\delta^{F+1}\Delta)-(E+1)\delta\Delta+\psi}{1-\delta} = \infty$. The benefits of stealing all employee bonuses is finite for all δ, but the benefit of keeping a reputation is unbounded for $\delta \to 1$. It follows that for δ sufficiently close to 1, the reputation condition is always satisfied.

7.9 Proof of Proposition 8

As a preliminary step, we show how the equilibrium fractions n_I and n_O depend on the density of firms n_F. Given the finite size of firms, every period, there are some employees leaving with ideas, which we denote by $n_L = n_E\overline{\phi}^{F}f_I = n_F E\overline{\phi}^{F}\frac{\widehat{\phi}}{1+\widehat{\phi}}$.

Idea-bearer in the market are either newly departed employees, or else preexisting idea-bearers that either stole an idea, or generated it as an employee and circulate it already in the market. Formally, $n_{I,t} = n_{L,t-1} + \overline{\phi} n_{I,t-1} \Leftrightarrow n_I = \dfrac{n_L}{\phi} \Leftrightarrow n_I = n_F E \dfrac{\overline{\phi}^F}{\phi} \dfrac{\widehat{\phi}}{1+\widehat{\phi}}$. Using $n_F + n_E + n_I + n_O = 1$ we get $n_O = 1 - n_F(E + 1 + E\dfrac{\overline{\phi}^F}{\phi}\dfrac{\widehat{\phi}}{1+\widehat{\phi}})$. Using $\theta = \dfrac{n_I}{n_I + n_O}$ we get $\theta = \dfrac{En_F}{1-(E+1)n_F}\dfrac{\overline{\phi}^F}{\phi}\dfrac{\widehat{\phi}}{1+\widehat{\phi}}$.

We now derive the $\mathcal{M}$ curve, which shows how the market utility varies with the density of firms. The market utility is given by $U_O = \theta \dfrac{\Delta}{1-\delta}$, where θ is now given by the above expression. The $\mathcal{M}$ equation is thus defined by $U_O = \dfrac{En_F}{1-(E+1)n_F}\dfrac{\overline{\phi}^F}{\phi}\dfrac{\widehat{\phi}}{1+\widehat{\phi}}\dfrac{\Delta}{1-\delta}$. Clearly, $\dfrac{\partial U_O}{\partial n_F} = \dfrac{\overline{\phi}^F}{\phi}\dfrac{\widehat{\phi}}{1+\widehat{\phi}}\dfrac{\Delta}{1-\delta}\dfrac{E}{(1-(E+1)n_F)^2} > 0$. For the comparative statics we have $\dfrac{\partial U_O}{\partial z} = \dfrac{En_F}{1-(E+1)n_F}\dfrac{\overline{\phi}^F}{\phi}\dfrac{\widehat{\phi}}{1+\widehat{\phi}}\dfrac{1}{1-\delta}\dfrac{\phi}{2-\delta+\phi\delta} > 0$ and $\dfrac{\partial U_O}{\partial \psi} = 0$. The comparative static w.r.t. ϕ is ambiguous and analytically difficult to trace, so we don't examine it here.

For the $\mathcal{F}$ curve, we examine the number of firms, given by $n_F = \Omega(E\widetilde{U} - (E+1)U_O))$. We immediately note that $\dfrac{\partial n_F}{\partial U_O} = -(E+1)\omega < 0$. Moreover, for a given U_O, we have $\dfrac{\partial n_F}{\partial \psi} = E\omega \dfrac{d\widetilde{U}}{d\psi} = -E\omega \dfrac{1}{1-\delta} < 0$.

The total effect of increasing ψ is thus given by $\dfrac{dn_F}{d\psi} = \dfrac{\partial n_F}{\partial \psi} + \dfrac{\partial n_F}{\partial U_O}\dfrac{\partial U_O}{\partial \psi} = \dfrac{\partial n_F}{\partial \psi} < 0$, so that an increase in ψ leaves the $\mathcal{M}$ unaffected and shifts the $\mathcal{F}$ curve backwards, resulting in a lower n_F and also a lower U_O.

7.10 Proof of Proposition 9

For $\psi < \psi^M$ there can be generators in the market. This means that there are five types of agents: firm owners, firm employees, market idea-bearers, market opportunists, and market idea generators. We have $n_F + n_E + n_I + n_O + n_G = 1$. The number of employees leaving in any period is again given by $n_L = n_E \overline{\phi}^F f_I = n_F E \overline{\phi}^F \dfrac{\widehat{\phi}}{1+\widehat{\phi}}$, but now ideas are also generated by market agents, so that the number of idea-bearer in the market is now given by $n_{I,t} = n_{L,t-1} + \overline{\phi} n_{I,t-1} + n_G \Leftrightarrow$

$n_I = \dfrac{n_L + n_G}{\phi} \Leftrightarrow n_I = n_F E \dfrac{\overline{\phi}^F}{\phi} \dfrac{\widehat{\phi}}{1+\widehat{\phi}} + \dfrac{1}{\phi} n_G$. From $\theta = \dfrac{n_I}{n_I + n_O}$ we get $n_O = \dfrac{1-\theta}{\theta} n_I$ which we use in $(E+1)n_F + n_G + n_I + n_O = 1 \Leftrightarrow n_I = \theta(1 - n_G - (E+1)n_F)$. Thus $\theta(1 - n_G - (E+1)n_F) = n_F E \dfrac{\overline{\phi}^F}{\phi} \dfrac{\widehat{\phi}}{1+\widehat{\phi}} + \dfrac{1}{\phi} n_G$ which we solve to obtain $n_G = \dfrac{\phi\theta - \phi\theta(E+1)n_F - E n_F \overline{\phi}^F \dfrac{\widehat{\phi}}{1+\widehat{\phi}}}{1+\phi\theta}$. This expresses n_G as a function of n_F and θ. We can do the same for n_I using $n_I = \theta(1 - n_G - n_F)$ and for n_O using $n_O = \dfrac{1-\theta}{\theta} n_I$. This implies that we can express all of the equilibrium fractions as a function of n_F and θ. We now show how these two variables are determined in equilibrium.

A market equilibrium requires $U_E = U_G = U_O$. From Proposition 2, we know that $U_G = U_O$ implies $\theta = \theta^M = \delta - \dfrac{\psi}{\Delta}$ and that as a result we have $U_O = \dfrac{\delta\Delta}{1-\delta} - \dfrac{\psi}{1-\delta}$. This constitutes the $\mathcal{M}$ curve. It says that the market utility is now established by market exchange, and that the number of firms does not affect it. Formally, $\dfrac{\partial U_O}{\partial n_F} = 0$, which makes the $\mathcal{M}$ flat. Moreover, we have $\dfrac{\partial U_O}{\partial \psi} = -\dfrac{1}{1-\delta} < 0$ and $\dfrac{\partial U_O}{\partial z} = \dfrac{\delta\Delta}{1-\delta} \dfrac{\phi}{2-\delta+\phi\delta} > 0$. The $\mathcal{F}$ curve is again given by $n_F = \Omega(E\widetilde{U} - (E+1)U_O))$, so that its comparative statics are identical to those of Proposition 8.

An increase in ψ shift down both the $\mathcal{F}$ and $\mathcal{M}$ curves, implying a lower value of U_O. The total effect on n_F, however, is ambiguous since an inward shift of the $\mathcal{F}$ curve decreases n_F, but the downward shift of the $\mathcal{M}$ curve increases n_F. To examine the total effect, we note that $\dfrac{dn_F}{d\psi} = \dfrac{\partial n_F}{\partial \psi} + \dfrac{\partial n_F}{\partial U_O} \dfrac{\partial U_O}{\partial \psi} = -E\omega \dfrac{1}{1-\delta} + \dfrac{1}{1-\delta}(E+1)\omega = \dfrac{\omega}{1-\delta} > 0$.

Table 1: Key notation

b	Bonus for idea generation: percentage share of idea value
c	Transaction of cost of using NDAs
E	Total number of employees within a firm
F	Total number of matches available within the firm (includes replacements)
K_j	Fixed entry cost of j^{th} entrant
n_i	Number (or density) of agents if type i
s	Equity share of idea-bearer with NDA
U_i	Life–time utility of type i
z	Value of completed idea
ψ	Private idea generation costs
ψ^i	Upper boundary of the feasible range, under i equilibrium
δ	Discount factor across periods
Δ	$= U_I - U_O$: Premium of being an idea-bearer
ϕ	Probability that listener is complementor
θ	Fraction of idea-bearer in the market
Ω	Distribution of fixed costs

Common subscripts

E	Subscript for employees
F	Subscript for firms
G	Subscript for idea generators
I	Subscript for idea-bearers
O	Subscript for opportunists

Common superscripts

M	Superscript for market equilibrium
N	Superscript for NDA equilibrium
S	Superscript for socially efficient equilibrium

Figure 1: Coexistence equilibrium

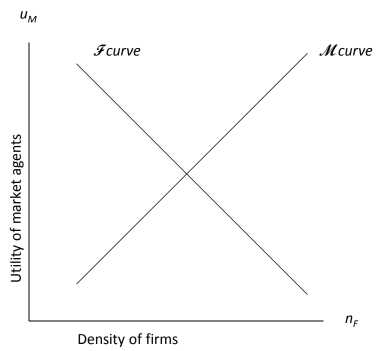
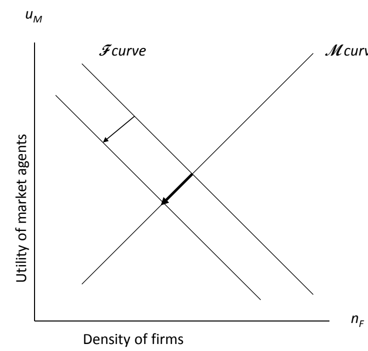
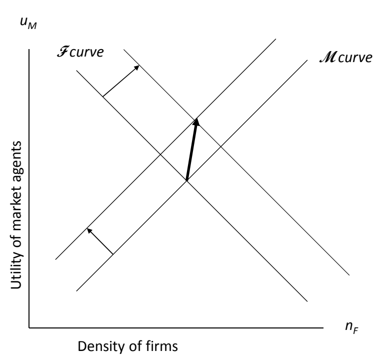


Figure 2: The effect of higher generation cost (ψ)



Higher costs decrease firm density and the utility of market agents

Figure 3: The effect of higher idea values (z)



Higher idea values increase utility of market agents

Figure 4: Firm density and idea generation costs