

Innovation and Corporate Conservatism*

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Abstract

This paper focuses on firms' incentives to promote innovation. Innovative employees choose whether to disclose their ideas within their firms, or to form spin-outs. Renegotiations ensue upon internal disclosure, and outcomes are affected by information leakage and status-quo contracts. If the innovators' bargaining position is weak, they prefer forming spin-outs, and firms use status-quo contracts to deter the increase in competition generated by them. If the innovators' bargaining position is strong, firms stifle innovation to prevent the rent reshuffling caused by renegotiation. Innovation bonuses implement bargaining efficiency, while stock-based compensation mitigates, but does not erase, firms' incentives to discourage innovation.

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1 Introduction

The management of innovation presents an increasingly difficult problem for firms' survival and growth. On one hand, generating new ideas is crucial for a firm to maintain its position on the market. On the other hand, these ideas typically originate from employees working in areas close to the firm's own technology. Innovative employees may decide to renegotiate their contracts, or to leave the firm to build new enterprises with the knowledge acquired during their tenure. Since firms may anticipate costly renegotiations and departures, the design of the employees' compensation schemes is a complicated balancing act of harvesting innovation while containing it within.

Firms differ substantially in the ways they approach and foster innovation. For example, much has been written about the corporate culture of the Silicon Valley firms, and how their informal management practices contrast with the traditional structure of East-Coast high-tech firms.¹ While some firms actively promote employees' creativity through intra-firm policies (e.g., encouraging cross-department communication, creating independent units within the organization, etc.) and monetary incentives (e.g., setting MBOs, innovation bonuses, etc.), others are more cautious and sometime tend to suppress innovative behavior.

A vast literature addresses the optimal design of incentives in a firm.² However, designing incentives to innovate is atypical for several reasons. First, innovation is, by its own nature, hard to forecast and to describe in an ex-ante contract. Therefore, the division of the rents generated by innovation is often determined by ex-post contract renegotiations. The second peculiar aspect of innovation incentives' design is that ex-post renegotiations typically entail a disclosure of innovative employees' new idea to their employer (*"information leakage"*). This disclosure affects the bargaining position of all parties involved and,

¹E.g., see Saxenian (1996) and references therewith.

²For a survey, see for example Gibbons (1998).

in particular, it negatively affects the employee's outside option. Indeed, if the negotiation fails, the employee and the firm go their separate ways and both sides are in the position of implementing the new idea. As intellectual property rights (IPR, henceforth) may prevent either of the two parties from fully exploiting the idea, they ultimately determine the extent to which information leakage influences bargaining outcomes.

In this paper, we analyze a firm's optimal innovation-management problem when the firm anticipates the effects described above. Consider a firm producing an original patented product and one of its employees. The model has three periods. In the first period, the firm designs its innovation-management strategy by offering the employee a contract. The structure of this contract includes a status-quo payment (which can take the form of a fixed payment or, as discussed in Section 5, a share of the firm's profit) and, if the disclosure of innovation is verifiable in court, a payment associated to the discovery of a new idea (e.g. an innovation bonus). In the second period, after the contract is signed, the employee has the possibility of investing some effort in the discovery of innovative ideas.

If the employee discovers a new idea, there are several actions he might take in the third period. First, the employee can leave the firm and form a spin-out without disclosing the idea internally. Second, the employee has the option to keep his idea to himself without implementing it, maintaining his current contract and position in the firm. Finally, the innovator can disclose his idea within the firm.³ We assume that whenever an idea is disclosed, all the information that is relevant for its implementation leaks to the firm.⁴

If an idea is disclosed internally, the employee can renegotiate his contracts within the firm. The outcome of this renegotiation depends on the bargaining power of the players involved and on their outside options in case of a renegotiation breakdown. In particular,

³As a spin-out always increases the degree of competition on the product market, implementing the new idea within the original firm is the bargaining-efficient outcome of the game.

⁴This implies that it is impossible for an employee to convince the firm about an idea's potential and to implement the idea within the firm without revealing its essential aspects to the firm's higher management.

the innovator's outside options include staying employed under the initial contract as well as leaving the firm and forming a spin-out. In the latter case, because of information leakage, the original firm will be able to compete against the spin-out on the new product market. The extent of this competition crucially depends on the intellectual property rights (IPR henceforth) legislation and its enforcement: If the employee has the legal tools to protect himself against the risk of expropriation, his outside option in the renegotiation is relatively high. On the other hand, if the firm has IPR over its employees' innovations, the innovator's outside option is relatively low.

As a first step, we analyze the effect of the initial contract on the decisions of the employee in the subsequent stages. We then step back and focus on the optimal contract problem from the firm's point of view. By choosing the initial contract, the firm affects the employee's incentives in two fundamental ways: First, by setting the status-quo payment above the expected rents from both a spin-out and an internal disclosure, the firm can discourage the innovator from being innovative. Second, the firm can manipulate *ex-ante* the innovator's outside option in the renegotiation. Indeed, if the employee's compensation after an internal disclosure is high enough (in particular, higher than the innovator's payoff in a spin-out *after* the information has been leaked to the firm), the innovator's threat of forming a spin-out upon negotiation breakdown loses credibility. Therefore, the presence of information leakage allows the firm to protect its bargaining position at a relatively low price.

In Section 3, we consider the benchmark case in which internal disclosure is verifiable by a court, so that the firm is able to commit to a payment to be paid upon an employee's disclosure of a new idea. Indeed, while internal disclosure is often hard to verify, there are some examples of firms that have successfully implemented innovation-based bonus schemes.⁵ In our first result, we show that innovation-contingent rewards are a contractual

⁵Examples documented in the literature are the innovation bonuses paid sometimes by Japanese compa-

tool powerful enough to always promote innovation within the firm and implement the bargaining efficient outcome in equilibrium. The intuition for this result is the following: In order to invest in innovation, the employee must anticipate a large enough increase in payoff as a result of a new idea. Such payoff increase can come either from the formation of a spin-out, or a successful intra-firm renegotiation, or an innovation bonus. The ability to commit to innovation bonuses allows the firm to compensate the employee for the payoff a spin-out would yield if he leaves the firm without internal disclosure. Moreover, since information leakage always lowers the spin-out profit, such compensation is also sufficient to make the threat of departure from the firm in case of negotiation breakdown not credible. This effectively guarantees that no renegotiation ever happens in equilibrium. Finally, by introducing a wedge between the status-quo payment and the innovation bonus, the firm guarantees that the innovator's incentives to innovate are preserved.

In Section 4 we analyze the optimal contract problem in the case in which internal disclosures are impossible to verify in court. In this case the payments promised in the contract cannot be conditional on an internal disclosure, and the firm is left with one contractual tool, the status-quo fixed payment, to preserve the incentives to innovate as well as to prevent the innovator from leaving the firm. The optimal contract in this case depends on the employee's relative bargaining position vis-à-vis the firm in case of internal disclosure.

In particular, we identify two effects that motivate firms to discourage innovation in their firms. When the employee's bargaining position is relatively weak, he is more inclined to leave the firm and form a spin-out than disclosing his ideas to his employer. The main problem that the firm faces in this case is its own inability to commit not to expropriate the

nies, as well as reward schemes connected to an internal database for collecting and processing new product ideas (see Herstatt and al., 2006). The ability of these firms to sustain such remuneration policies could be due to strong reputational concerns.

employee's invention if he were to disclose his idea internally. We name this effect the "*inner hold-up*". If new ideas are sufficiently threatening from the firm's point of view, this effect might yield an optimal contract entailing a status-quo payment high enough to discourage the employee from investing in innovation. This suggests that, in an environment in which employees' IPR vis-à-vis their employers are weak, innovative ideas are either implemented by start-ups (when sufficiently distinct from preexisting products), or not implemented at all. This result is supported by a large body of empirical work, which shows how in states in which established firm's IPR (such as no-compete agreements or trade secrets) are strongly enforced, new ideas' implementation within established firms tends to stagnate.⁶

On the other hand, when the innovator's position is strong, the employer's main concern is the potential threat of a contract renegotiation. In particular, an employee with a strong bargaining position will be able to appropriate a large part of the innovation rents at the expense of the original firm's owners. We term this effect on the owners of the firm the "*reverse hold-up*". However, the employer still has a tool to manipulate this outcome, which is setting the status-quo payment at a level high enough to damage the employee's bargaining position at the renegotiation stage—that is, by making the threat of leaving the firm after a disclosure not credible. The firm might decide to take this route if the reshuffling of rents caused by a contract renegotiation is large relative to the cost of the status-quo contract that guarantees the innovator not to undertake an innovation's effort.

Since innovation-based payments achieve the first best but are hard to implement, and fixed-payment contracts yield bargaining inefficient outcomes, it is natural to consider how other firm's policies, such as stock-based compensation, would change the incentives of an innovative employee. In Section 5 we show that the additional possibility of compensating the employee with shares mitigates both the inner and the reverse hold-up effects, but does

⁶For example, see the comparison between Massachusetts and California in Saxenian (1996) and the references therein.

not completely solve them. Indeed, in the case of the inner-hold-up problem, stock-based compensation enables the firm to promote internal disclosure, but the firm does not always find it profitable to induce it. Similarly, in the case of the reverse hold-up problem, stock-based compensation allows the firm to weaken the bargaining position of the innovator, and to mitigate the loss of rents in ex-post renegotiation. However, we show that the firm might still find it profitable to discourage innovation. In addition, we show that when both contractual tools are available, innovation bonuses perform better than stock-based compensation from the firm's point of view.

The rest of the paper is organized as follows. After a literature review, we introduce the model in Section 2. In Section 3, we study the case in which an internal disclosure is verifiable by a court, and, in Section 4, we turn to the case of non-verifiable internal disclosure. Section 5 addresses the extension of our model to the cases in which the employee's compensation scheme includes firm's shares, and in Section 6 we conclude.

1.1 Literature Review

Our analysis is related to several strands of existing work. First, there is a growing literature that analyzes different aspects of the optimal design of incentives to encourage innovation within a firm. Hellman and Thiele (2011) develop a multi-tasking model to analyze the workers' trade-off between performing standard tasks and investing in new investment opportunities. Hvide and Kristiansen (2011), study the firm's optimal litigation policies with respect to workers that invest in innovation and may leave the firm after new ideas are discovered. Manso (2011) shows that encouraging CEOs and managers to be innovative requires the use of specific contractual tools such as tolerance for failure and commitment to long-term compensation.⁷ Parallel to this literature, several papers study the nature of

⁷See also Amador and Landier (2003), Anand and Galetovic (2000), Anand, Galetovic and Stein (2004), Gambardella and Panico (2006), Gans and Stern (2000), and Gromb and Scharfstein (2001).

incentives (monetary and pecuniary) that motivate researchers to innovate. For example, an empirical analysis by Sauermann and Cohen (2010) shows that monetary incentives play a significant role in encouraging R&D research, as well as other motives such as desire for intellectual challenge, or responsibility do.⁸ Our work focus on monetary incentives only, and their desirability from a firm's perspective.

Anton and Yao (1994) and (1995), Baccara and Razin (2007), d'Aspremont, Bhattacharya and Gerard-Varet (2000), and Bhattacharya and Guriev (2006), are all papers that analyze the informational concerns of innovators facing the risk of expropriation when they reveal their ideas to other parties.⁹ Among these, the most relevant reference for our approach is Anton and Yao (1995), which, similarly to our paper, focuses on an innovator's decision regarding whether to leave the firm and form a spin-out. Anton and Yao's paper shares our emphasis on information leakage, and as in our paper, the risk of information leakage modifies the innovator's incentives to reveal his idea within the firm and may result in inefficient spin-outs. In contrast, our focus is on the firms' incentives to manage innovation.

The patterns of worker mobility and spin-out formation have been analyzed also by several others including Scotchmer (1991), Klepper and Sleeper (2000), Klepper (2001), Franco and Filson (2006), and Lewis and Yao (2003). Moreover, Pakes and Nitzan (1983) analyze the optimal contract problem for personnel that may leave the firm to form spin-out enterprises. Since in their setting both parties have complete information about the value of innovations, and the impact of information leakage on bargaining is not considered, the equilibrium outcome are always efficient. Hellman and Perotti (2011) model the difference

⁸Among others, see also Lazear (1997), and Stern (2004).

⁹In Baccara and Razin (2007) we analyze a bargaining protocol that allows for information leakage and study its implications on the rent division across an innovator and a development team. In this paper, we take a reduced-form approach to the bargaining stage while still allowing for a parameterization that captures a rich range of innovation types and legal environments.

between intra-firm innovation and innovation through spin-out as a difference in the level of protection of intellectual property rights. Hellmann (2007) builds a model that describes how alternative corporate policies can affect the rate at which new ideas are generated. Franco and Mitchell (2008) and Rauch and Watson (2010) study the impact of the legal environment (and, more precisely, the presence of non-compete covenants) and the workers' financial constraints on the rate of entrepreneurship in the economy.¹⁰ Finally, Chatterjee and Rossi-Esteban (2012) develop an adverse selection argument to predict what types of ideas are more likely to be implemented in spin-outs rather than being sold on the market.

Our paper also relates to a literature that highlights the consequences and the potential inefficiencies caused by ex-post bargaining within a firm. This literature includes Stole and Zwiebel (1994), Wolinski (2000), and Matouschek (2004).

Finally, our analysis formalizes the notion that large established firms are often stagnant and prone to dissolution by small innovative spin-outs. Explanations for this puzzle are often based on unawareness or bounded rationality of established firms when making decisions regarding new technologies. In particular, Christensen (1997) suggests that established firms tend to focus too much attention on their current customer base, not realizing that existing customers are not necessarily the best predictors of tomorrow's market trends. In our analysis the same prediction arises due to the bargaining position of employees vis-à-vis the firm and the constraints on contracting over future innovations.

¹⁰Note that this paper shares with Rauch and Watson (2010) an interest in the factors that may lower the entry rate of spin out in the economy. However, our analysis and focus differ from theirs since, while we assume throughout that the employee is financially constrained at $t = 0$, we study the problem of an innovative employee facing contract renegotiation in the presence of information leakage. Instead, they focus on an employee who, after given access to a client, faces a contract renegotiation with the possibility of continuing to serve the client by himself, within the limits set by a non-covenant agreement.

2 The Model

Assume that there is a firm producing an established product and that production requires labor as input. Let us assume for simplicity that in order to produce, the firm needs to hire exactly one employee. Potential employees have a reservation value of zero.

There are three periods, $t = 0, 1, 2$. In period $t = 0$, the firm selects a contract to offer to the employee. At $t = 1$, while working for the firm, the employee decides whether to exert a costly and unobservable effort to discover an innovative idea for a product. Let the cost of effort be $c > 0$. For the sake of simplicity, we assume that if the employee decides to exert the effort, he discovers a new idea with probability one. If he discovers a new idea the period before, at $t = 2$, the innovator must decide whether to implement his idea within the firm (“*internal disclosure*”), to leave the firm to form a rival spin-out firm, or to keep his idea to himself and remain in the firm under his original contract. As specified in Section 2.3, an internal disclosure may yield to a renegotiation of the employee’s contract. A crucial assumption of our analysis is that of *information leakage*: if he decides to implement his idea within the firm (and possibly renegotiate his contract) the employee has to disclose his idea to the firm’s officials. Since an extension of the model in which internal implementation entails only a partial disclosure of the idea would yield results qualitatively similar to ours, for simplicity here we assume that the employee willing to implement his idea within the firm has to fully disclose his idea to the employer. Thus, upon disclosure, both the employee and the employer hold the technology to produce the new product. We describe how the game unfolds in Sections 2.2 and 2.3.

2.1 Market Structure Assumptions

The market can accommodate two firms, the incumbent firm (F) and a potential spin-out (S), and two products, the original product (O) and the new one (N). The profits

for firm $j \in \{F, S\}$, are given by $\pi_j(\rho)$ where $\rho \in \{(O, \emptyset), (N, \emptyset), (O, N), (N, N)\}$ represents one of the following market configurations: (O, \emptyset) is a market in which there is only the incumbent producing the old product; (N, \emptyset) is a market in which there is only the incumbent producing both the old and the new products; (O, N) is a market in which the incumbent produces the old product and the spin-out is the only firm holding the technology of the new product; and (N, N) is a market in which both the incumbent and the spin-out hold the technology to produce the new product. We also have $\pi_F(N, \emptyset) \geq \pi_F(O, N) + \pi_S(O, N)$, where the inequality may be strict due to some degree of interrelation (substitutability or complementarity) between the old and the new products. Moreover, there is rent loss due to competition in the new-product market—i.e., $\pi_F(N, \emptyset) \geq \pi_F(O, N) + \pi_S(O, N) \geq \pi_F(N, N) + \pi_S(N, N)$. Finally, we have $\pi_F(N, \emptyset) \geq \pi_F(O, \emptyset)$, $\pi_F(O, N) \leq \pi_F(N, N)$ and $\pi_S(O, N) \geq \pi_S(N, N)$. Note that *bargaining efficiency* requires the incumbent to implement the new product in-house and to realize the surplus of $\pi_F(N, \emptyset)$.

This framework allows to capture different IPR regimes, and innovation types. For example, if the innovative employee can acquire full IPR on his idea before disclosing it within the firm, the incumbent is not able to profit from it upon disclosure. In this case, we have $\pi_F(O, N) = \pi_F(N, N) \leq \pi_F(O, \emptyset)$ and $\pi_S(O, N) = \pi_S(N, N)$; if the incumbent has full IPR on all new ideas developed by his employees, then $\pi_F(O, N) = \pi_F(N, N) > \pi_F(O, \emptyset)$ and $\pi_S(O, N) = \pi_S(N, N) = 0$. Moreover, if the new product is an innovation that makes the old product obsolete, then $\pi_F(O, N) = 0$; if the new product does not compete with the old one, then $\pi_F(O, \emptyset) = \pi_F(O, N)$, and so on.

We will often use combinations of the above terms. First, we denote the value of monopoly on the innovative idea by

$$V_M \equiv \pi_F(N, \emptyset) - [\pi_F(N, N) + \pi_S(N, N)]$$

We define the value generated by the innovation if it is implemented through a spin-out as

$$V_S \equiv [\pi_F(O, N) + \pi_S(O, N)] - \pi_F(O, \emptyset)$$

Note that, while V_M is always non-negative, if the new idea is sufficiently close to the original product V_S could be negative.

2.2 Timing

At $t = 0$, the incumbent offers the employee a contract. The contract takes the form (v, v_{ID}) , where v is the payment to the employee in the status quo, and v_{ID} is the payment if the employee discloses a new idea within the firm.^{11,12} We impose the following restrictions on the feasible contracts: (i) The employee is financially constrained—i.e., $v, v_{ID} \geq 0$; (ii) In the analysis in Section 3, the disclosure of a new idea within a firm is verifiable by a court, implying $v \neq v_{ID}$. In Section 4, we analyze the case in which disclosure of a new idea is not-verifiable, or $v = v_{ID}$.

At $t = 1$, the employee decides whether to invest c to discover a new idea. If he does, a new idea is discovered, and the employee has three choices at $t = 2$:

1. The employee discloses the idea within the firm. The ensuing renegotiation of his contract (see below) will determine the rent division between the incumbent and employee.
2. The employee leaves the firm without disclosing his idea, forms a spin-out, and appropriates $\pi_S(O, N)$, while the incumbent gets $\pi_F(O, N)$.¹³

¹¹It is immediate to see that, if the firm can impose a penalty on the employee for leaving the firm, it will always set this penalty as high as possible. Therefore, for simplicity, we set the maximal penalty to be zero.

¹²In Section 5, we allow for a stock-based contract, in which the owner of the original firm offers the employee a share $1 - \beta$ of the firm's profits.

¹³In this setting we do not allow the employee to join a different established firm, where he would

3. The employee does not innovate and gets v , while the firm receives $\pi_F(O, \emptyset) - v$.

If the employee doesn't invest c , the game ends after $t = 1$, and payoffs are v for the innovator and $\pi_F(O, \emptyset) - v$ for the incumbent. We assume that the cost of effort c , while strictly positive, is very low. In particular, we assume $c < \min\{\pi_F(N, \emptyset) - \pi_F(O, \emptyset), \pi_S(O, N) - \pi_S(N, N)\}$. This allows us to focus on the cases in which innovation is always desirable from a monopolist's perspective—that is, a firm able to maintain a monopoly on new products would always choose to innovate.

2.3 Contract Renegotiation with Information Leakage

If the employee decides to exert the effort to be innovative and discloses the idea within the firm he is working for, a renegotiation of his contract might ensue. As mentioned above, a central feature of the model is the fact that negotiation cannot take place without the employer fully learning the employee's idea. This affects the outside option of the players in case of negotiation breakdown. In fact, once internal disclosure takes place, the technology of the new idea has leaked to the original firm, and the incumbent earns $\pi_F(N, N)$ (rather than $\pi_F(O, N)$) if the employee leaves the firm.

If the intra-firm bargaining breaks down, the firm's and the innovator's outside options are not independent of each other. In particular, upon bargaining breakdown, the innovative employee can still decide whether to leave the firm and form a spin-out (which would yield a payoff of $\pi_S(N, N)$ for the employee and $\pi_F(N, N)$ for the firm), or to stay in the firm under the original contract (which would yield a payoff of v_{ID} for the employee and $\pi_F(N, \emptyset) - v_{ID}$ for the firm). In our analysis, we assume that, if the bargaining breaks down, the employee will choose to maximize his outside option. Thus, if $\pi_S(N, N) \geq v_{ID}$,

face another negotiation with the risk of idea expropriation. The possibility of endogenously unfolding negotiations with information leakage is analyzed in a full-blown bargaining protocol in Baccara and Razin (2007).

the employee can credibly commit to leave upon negotiation breakdown, and the outside option payoffs of the incumbent and the employee implied by the (optimal) choice of the employee are, respectively, $\pi_F(N, N)$ for the firm and $\pi_S(N, N)$ for the employee. On the other hand, if $\pi_S(N, N) < v_{ID}$, the threat to leave the firm is not credible as the employee will stay under his original contract in case of negotiation breakdown. Therefore, the outside options for firm and employee are, $\pi_F(N, \emptyset) - v_{ID}$ and v_{ID} , respectively.

The bargaining outcome follows a Nash bargaining solution. We denote the bargaining power of the firm as $\alpha \in (0, 1)$ and the bargaining power of the employee as $1 - \alpha$. The bargaining weight α captures exogenous characteristics of the bargaining parties, such as their bargaining skills.

Note that $V_M \equiv \pi_F(N, \emptyset) - [\pi_F(N, N) + \pi_S(N, N)] \geq 0$ represents the bargaining surplus in the intra-firm renegotiation. Then, when $\pi_S(N, N) \geq v_{ID}$, the payoff of the firm is

$$s_F \equiv \pi_F(N, N) + \alpha V_M,$$

and the payoff of the employee is

$$s_E \equiv \pi_S(N, N) + (1 - \alpha) V_M.$$

If $\pi_S(N, N) < v_{ID}$, the Nash bargaining solution payoffs are equal to the outside options—i.e., $\pi_F(N, \emptyset) - v_{ID}$ for the firm and v_{ID} for the employee. To summarize, if we let z_F and z_E be the payoffs of the firm and the innovator after an internal disclosure, we have

$$(z_F, z_E) = \begin{cases} (s_F, s_E) & \text{if } \pi_S(N, N) \geq v_{ID} \\ (\pi_F(N, \emptyset) - v_{ID}, v_{ID}) & \text{if } \pi_S(N, N) < v_{ID}. \end{cases}$$

3 Verifiable Internal Disclosure ($v \neq v_{ID}$)

In this section, we consider the benchmark case in which firms are able to commit to a payment conditional on the disclosure of a new idea—that is, we allow for $v \neq v_{ID}$. Although internal disclosure is typically difficult to verify in court, reputation considerations or internal protocols sometimes enable firms to make such commitments. For example, Harryson (1996) reports that Japanese firms frequently implement an internal proposal system of new ideas connected with a rewarding scheme. Also, Herstatt and al. (2006), after surveying a representative sample of Japanese firms, document that about 30% of them use databases to store and process new product ideas sought internally. Moreover, innovation bonus systems as a way to reward creative employees have been implemented increasingly often in Europe.¹⁴

In the next result, we show that the presence of innovation bonuses allows the incumbent to always reach the efficient bargaining outcome.

Proposition 1 (Verifiable Internal Disclosure) *When internal disclosure is verifiable, it always occurs in equilibrium.*

The intuition of Proposition 1 is the following. When idea disclosure is verifiable, the firm has two tools, v and v_{ID} , to influence the employee’s subsequent behavior. First, by creating a wedge between v and v_{ID} , the firm can ensure the innovator pays the cost c and generates a new idea. Second, since the outside option of the employee in the renegotiation with the firm is the maximum between v_{ID} (the payoff of staying in his contract upon negotiation break-up) and $\pi_S(N, N)$ (the payoff from walking away after the idea has been

¹⁴For example, data from the Federation of Enterprises in Belgium (FEB) show that, in 2006, about 50% of local companies had internal policies to encourage internal innovation, and about 20% of them rewarded employees who discover innovative ideas. To encourage the distribution of innovation bonuses, the FEB negotiated and tabled guidelines for innovation bonuses exempt from social security and income taxes (see “The Innovation Bonus, or How to Reward Creative Employees,” FEB publication, 2006).

disclosed), the firm has the ability to make the employee's threat of forming a spin-out in case of a negotiation breakdown not credible by setting any $v_{ID} \geq \pi_S(N, N)$. As for the employee walking out with his idea without disclosure and appropriating $\pi_S(O, N)$, it is enough for the firm to set $v_{ID} = \pi_S(O, N)$ (which is higher than the lower bound $\pi_S(N, N)$), to guarantee that internal disclosure dominates this option from the employee's point of view. After paying the innovator $v_{ID} = \pi_S(O, N)$, the firm is able to appropriate the residual monopolist rent $\pi_F(N, \emptyset) - \pi_S(O, N)$, making this the optimal course of action from the firm's perspective.

4 Non-Verifiable Internal Disclosure ($v_{ID} = v$)

In this section, we consider the case that internal disclosure is not verifiable by a court—that is, the contract has to satisfy the condition $v_{ID} = v$. This is the case, for instance, when there is no verifiable intra-firm record of the ideas disclosed by the employees, or the firms do not have enough reputational concerns to be able to commit to a payment scheme conditional on employees' disclosure of their ideas.

The next Lemma characterizes the optimal decision of the innovator as a function of the contract v .

Lemma 1 (Innovator's Choice) *The innovator's optimal decision is as follows:*

1. *If $v > \pi_S(O, N) - c$, the employee does not innovate;*
2. *If $\pi_S(O, N) - c \geq v > \pi_S(N, N)$, the employee forms a spin-out;*
3. *If $v \leq \pi_S(N, N)$, two cases are possible: If $s_E \geq \pi_S(O, N)$, there is internal disclosure, and if $s_E < \pi_S(O, N)$, the employee forms a spin-out.*

Lemma 1 highlights that if the firm sets a v high enough to prevent intra-firm renegotiation ($v > \pi_S(N, N)$), the employee may form a spin-out or may not innovate depending on the level of the comparison between the contract v and the total payoff in case of a spin-out $\pi_S(O, N) - c$.

In case the employee can pose a credible threat of walking away in an intra-firm negotiation—that is, if $v \leq \pi_S(N, N)$, his optimal course of action depends on the comparison between the rents he is able to extract in such renegotiation, s_E , vis-à-vis the rents that can be extracted through a spin-out, $\pi_S(O, N)$.

Let us now turn to the characterization of the optimal contract. If disclosure is not verifiable, the firm has just one contractual tool, v to affect both the employee’s incentives to invest in innovation and the course of action to take when an idea comes about. Given the cost of innovation c , inducing the employee to innovate requires creating a wedge between his original contract v and the rents he appropriates from a new idea. Since disclosure is not verifiable, this cannot be no longer contractually designed by setting v_{ID} far enough from v , as in Section 3. Therefore, this wedge must originate from either the formation of a spin-out, or the anticipation of an increase in salary via an intra-firm renegotiation.

Below we highlight two effects that can potentially lead to inefficient equilibrium outcomes. The first effect, that we name “*inner hold-up*”, occurs when the bargaining position of the employee in a renegotiation is relatively weak—that is, $s_E < \pi_S(O, N)$. In this case, the incumbent firm lacks the ability to commit to compensate the innovator when he discloses his idea internally, causing an intra-firm hold-up problem. Thus, by Lemma 1, an internal disclosure cannot occur in equilibrium, and the innovator will leave the firm as soon as innovation occurs. The only way for the firm to prevent a spin-out is setting a high v (in particular, $v = \pi_S(O, N) - c$) to effectively discourage innovation. Thus, the incumbent allows a spin-out to form if and only if the firm’s payoff in the case of a spin-out

$\pi_F(O, N)$, is higher than the status-quo profit $\pi_F(O, \emptyset)$ net of the payment v , and will discourage innovation otherwise. Recalling that $V_S \equiv [\pi_F(O, N) + \pi_S(O, N)] - \pi_F(O, \emptyset)$, the following proposition follows.

Proposition 2 (Inner Hold-Up) *If $s_E < \pi_S(O, N)$, the optimal contract is as follows:*

1. *If $V_S \geq c$, the incumbent sets $v = 0$ and a spin-out occurs in equilibrium;*
2. *Otherwise, the incumbent sets $v = \pi_S(O, N) - c$, and the employee does not innovate.*

The above Proposition implies that the bargaining efficient outcome (implementation of the new product within the original firm, and realization of the maximum profit $\pi_F(N, \emptyset)$), is never achieved if $s_E < \pi_S(O, N)$.

Proposition 2 implies that, if $s_E < \pi_S(O, N)$, two cases are possible. First, if $V_S < c$ —that is, $\pi_F(O, N) + \pi_S(O, N)$ is relatively low with respect to $\pi_F(O, \emptyset)$, or the new idea and the original product are relatively similar to each other—spin-out formation is a severe threat for the incumbent, who will therefore discourage innovation by setting a high status-quo compensation $v = \pi_S(O, N) - c$. On the other hand, if the new idea is sufficiently different from the original product ($\pi_F(O, N) + \pi_S(O, N)$ is relatively high with respect to $\pi_F(O, \emptyset)$), the incumbent allows a spin-out to form in equilibrium. This suggests that, in an environment in which employees' IPR vis-à-vis the original firm are weak, innovative ideas are either implemented by start-ups (when sufficiently different from the preexisting products), or not implemented at all. This result is supported by a large body of empirical work, which shows how in states in which established firm's IPR (such as no-compete agreements or trade secrets) are strongly enforced, new ideas' implementation within established firms tends to stagnate.¹⁵

¹⁵For example, see the comparison between Massachusetts and California in Saxenian (1996) and the

Let us now move on to the case in which the employee's bargaining position in the intra-firm renegotiation is strong—that is, when $s_E \geq \pi_S(O, N)$. In this case, the owner of the firm might discourage innovation out of fear that the intra-firm renegotiation may yield lower rents than the status-quo ("*reverse hold-up*"). The next result addresses characterizes the optimal firm's strategy for this case.

Proposition 3 (Reverse Hold-Up) *If $s_E \geq \pi_S(O, N)$, the optimal contract is as follows:*

1. *If $s_F \leq \pi_F(O, \emptyset) - \pi_S(O, N) + c$, the firm sets $v = \pi_S(O, N) - c$ and the employee does not innovate;*
2. *Otherwise, the firm sets $v = 0$, the employee innovates and he discloses his idea internally.*

The intuition of Proposition 3 is the following. If $s_E \geq \pi_S(O, N)$, Lemma 1 suggests that there are three options available to the firm. First, by setting $v < \pi_S(N, N)$, the firm can create a credible commitment for the employee to walk away in case of renegotiation breakdown. This allows a renegotiation to happen, which will push the payoff of the innovator all the way to s_E , and leave the firm with s_F . Second, the firm can allow a spin-out to form by setting, as Lemma 1 suggests, any $v \in (\pi_S(N, N), \pi_S(O, N) - c)$. If this is the case, the innovative employee lacks a credible threat in the intra-firm renegotiation, which would yield him v , and he anticipates doing better forming a spin-out and getting $\pi_S(O, N)$. Third, the firm can discourage innovation at the lowest possible cost by setting $v = \pi_S(O, N) - c$. By doing so, the firm compensates the employee for the payoff he would appropriate by generating a new idea and leaving the firm to form a spin-out.

references therein.

Note that, from the firm's point of view, an internal renegotiation entails learning the information and being able, at least to some extent, to compete against a spin-out in case of negotiation breakdown. Therefore an internal renegotiation always guarantees the firm $\pi_F(N, N)$, which dominates the payoff if a spin-out forms, $\pi_F(O, N)$.

Since allowing a spin-out is never optimal, identifying the best strategy for the firm's point of view amounts to comparing the payoff in case of an intra-firm renegotiation with the payoff the firm appropriates discouraging innovation. Setting a contract scheme that discourages innovation is optimal if the cost such a contract, $\pi_S(O, N) - c$, is smaller than the shift of rents to the employee that the firm will suffer in case of an internal disclosure with respect to the status-quo. Such shift is equal to $\pi_F(O, \emptyset) - s_F$.

Proposition 3 has a few implications. First, the condition $\pi_F(O, \emptyset) - s_F \geq \pi_S(O, N) - c$ suggests that the incentives to discourage innovation are more severe the stronger the employee's bargaining position in the renegotiation is. In particular, the reshuffling effect is stronger as $\pi_S(N, N)$ increases with respect to $\pi_F(N, N)$, i.e., the stronger the IPR of the employee vis-à-vis the firm in the new-product market.

Second, suppose that the potential competition on the new product market is strong enough to drive $\pi_S(N, N) = \pi_F(N, N) = 0$. In this case, Proposition 3 implies that, when $(1 - \alpha)\pi_F(N, \emptyset) \geq \pi_S(O, N)$, innovation is discouraged if $\pi_F(O, \emptyset) - \alpha\pi_F(N, \emptyset) \geq \pi_S(O, N) - c$ and internal disclosure occurs otherwise.

Finally, Proposition 3 implies that if $s_E \geq \pi_S(O, N)$ —that is if the employee's bargaining position in the firm is strong enough, spin-outs never form in equilibrium.

Figure 1 describes the equilibrium outcomes for the case of Bertrand competition in the new product market—that is, $\pi_S(N, N) = \pi_F(N, N) = 0$ as a function of $\pi_S(O, N)$ and $\pi_F(N, \emptyset)$. Indeed, note that in the Bertrand case we have $s_E = (1 - \alpha)\pi_F(N, \emptyset)$ and $s_F = \alpha\pi_F(N, \emptyset)$. Thus, for $\pi_S(O, N) \geq (1 - \alpha)\pi_F(N, \emptyset)$, Proposition 2 implies that spin-

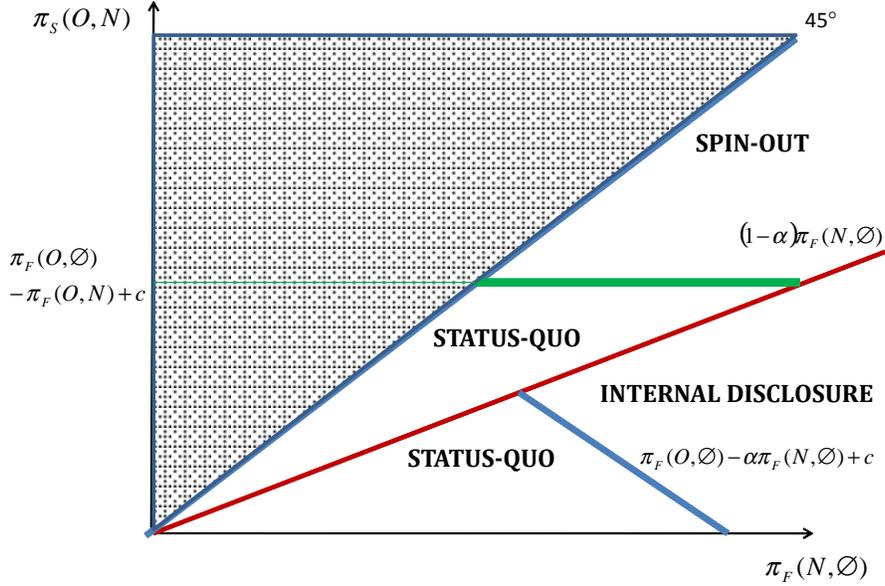


Figure 1: Equilibrium Outcomes in the Bertrand Case ($\pi_S(N, N) = \pi_F(N, N) = 0$).

outs occur if $\pi_S(O, N)$ is sufficiently high with respect to $\pi_F(O, \emptyset) - \pi_F(O, N) + c$ (which is equivalent to the condition $V_S \geq c$), and no innovation occurs otherwise. On the other hand, if $\pi_S(O, N) < (1-\alpha)\pi_F(N, \emptyset)$, Proposition 3 suggests that internal disclosure occurs if $s_F = \alpha\pi_F(N, \emptyset) \geq \pi_F(O, \emptyset) - \pi_S(O, N) + c$, or $\pi_S(O, N) \geq \pi_F(O, \emptyset) - \alpha\pi_F(N, \emptyset) + c$.

5 Stock-Based Contracts

Since in Section 3 we saw that innovation-based payments yield the first best but are hard to implement, and in Section 4 we showed that fixed-payment contracts lead to inefficient outcomes, a natural question to ask is other types of contractual tools can help firms to improve their performance and achieve efficiency more often. In particular, in this Section we analyze the possibility of offering the employee a stock-based compensation rather than

a fixed wage v on our results in Section 4. The benefit of such an contract scheme is that, by internalizing the effects of his actions on the original firm's value, it can increase the incentives of the employee to disclose his idea within the firm.¹⁶

Let us assume that the original owner offers the employee a share of the firm's value $(1 - \beta)$, while keeping β for himself. Under this scenario, specifying the payoffs upon agent's departure requires making some assumption on how competition will unfold with two firms on the market, one of which is partially owned by the founder of the second. In order to highlight the main point of our analysis, we maintain the assumption that the payment to the employee does not include any control stake, so that ownership overlaps do not affect the way in which the competition unfolds between two firms. Also, some stock-based compensation schemes might require an agent to surrender their shares in case of departure. We assume that shares' ownership can be maintained upon departure from the firm.

The payoff of the innovator in the status-quo is $(1 - \beta)\pi_F(O, \emptyset)$, while the original owner gets $\beta\pi_F(O, \emptyset)$. Also, the innovator's payoff after a spin-out is $(1 - \beta)\pi_F(O, N) + \pi_S(O, N)$, while the original owner's is $\beta\pi_F(O, N)$. Consider now an internal disclosure. An ex-post bargaining over the agent's share will ensue, and, upon renegotiation breakdown, the agent might still form a spin-out, getting $(1 - \beta)\pi_F(N, N) + \pi_S(N, N)$, or may stay under his original contract, getting $(1 - \beta)\pi_F(N, \emptyset)$. Similarly to Section 2, if $(1 - \beta)\pi_F(N, N) + \pi_S(N, N) \geq (1 - \beta)\pi_F(N, \emptyset)$, then the threat of leaving is credible. In this case, the payoff for the original firm's owner is

$$\tilde{s}_F \equiv \beta\pi_F(N, N) + \alpha V_M,$$

¹⁶It is important to note that more complex contracts based on the value of the stock, such as the commonly used option-based contracts, would lead to results and conclusion qualitatively similar to the ones in this section.

and the employee's payoff is

$$\tilde{s}_E \equiv (1 - \beta)\pi_F(N, N) + \pi_S(N, N) + (1 - \alpha)V_M.$$

When $(1 - \beta)\pi_F(N, N) + \pi_S(N, N) < (1 - \beta)\pi_F(N, \emptyset)$, then upon negotiation breakdown the agent stays under the initial contract and gets $(1 - \beta)\pi_F(N, \emptyset)$, while the owner gets $\beta\pi_F(N, \emptyset)$.

To summarize, if we define as \tilde{z}_F and \tilde{z}_E the payoffs of the firm and the innovator, respectively, after an internal disclosure, we have

$$(\tilde{z}_F, \tilde{z}_E) = \begin{cases} (\tilde{s}_F, \tilde{s}_E) & \text{if } (1 - \beta)\pi_F(N, N) + \pi_S(N, N) \geq (1 - \beta)\pi_F(N, \emptyset) \\ (\beta\pi_F(N, \emptyset), (1 - \beta)\pi_F(N, \emptyset)) & \text{if } (1 - \beta)\pi_F(N, N) + \pi_S(N, N) < (1 - \beta)\pi_F(N, \emptyset) \end{cases}$$

We now show that the availability of stock-based compensation enhances the firm's profits with respect to the fixed payments schemes considered in Section 4. Consider the case of the inner hold-up first (i.e., $s_E < \pi_S(O, N)$). Lemma 1 and Proposition 2 suggest that, since the bargaining position of an innovator in an ex-post renegotiation is weak, an internal disclosure never occurs in equilibrium. However, the option of offering a partnership allows the firm to mitigate the expropriation suffered by the innovator in the ex-post renegotiation in case of an internal disclosure, and to promote internal disclosure. The next proposition shows that, although stock-based compensation is a tool that allows the firm to implement internal disclosure, in some cases the firm will still find profitable to allow spin-out to form, or to discourage innovation altogether. Thus, the option of stock-based compensation mitigates, but does not solve completely, the inner hold-up problem.

Proposition 4 (Inner Hold-Up with Stock-Based Contracts) *Offering a stock-based*

compensation always allows the incumbent firm to promote internal disclosure. However, if $s_E < \pi_S(O, N)$, both spin-out formation and innovation inhibition can still arise as equilibrium outcomes.

To get the intuition of Proposition 4, note that the firm can set the innovator's share at a level $\widehat{\beta}$ that makes him indifferent between forming a spin-out (and getting $(1 - \widehat{\beta})\pi_F(O, N) + \pi_S(O, N)$) and staying in the original firm under the compensation $(1 - \widehat{\beta})\pi_F(N, \emptyset)$ upon internal disclosure. Since such share is large enough to guarantee that the threat of walking away and forming a spin-out is not credible in an intra-firm renegotiation, $(1 - \widehat{\beta})\pi_F(N, \emptyset)$ is exactly the innovator's payoff in case of internal disclosure. In contrast with the fixed payment case, the innovator now internalizes the firm's increase in profit under the original contract, and, for small enough c , has an incentive to invest in new ideas.

However, for such contract to be used in equilibrium when $s_E < \pi_S(O, N)$ instead of the ones characterized in Proposition 2, the profit share left for the firm's owner, $\widehat{\beta}\pi_F(N, \emptyset)$, has to be large enough. In particular, when $V_S > c$, Proposition 2 states that under fixed payment contracts a spin-out will occur in equilibrium. Thus, a stock-based compensation is used to induce internal disclosure if $\widehat{\beta}\pi_F(N, \emptyset) \geq \pi_F(O, N)$ and a spin-out forms otherwise. On the other hand, when $V_S \leq c$, innovation is discouraged under fixed payment contracts, and the firm appropriates $\pi_F(O, \emptyset) - \pi_S(O, N) + c$. Therefore, innovation will arise under a stock-based contract if and only if $\widehat{\beta}\pi_F(N, \emptyset) \geq \pi_F(O, \emptyset) - \pi_S(O, N) + c$, while innovation is still discouraged otherwise.

Next, consider the case of the reverse hold-up problem. Recall from Proposition 3 that in the fixed-payment case, if $s_E \geq \pi_S(O, N)$, the bargaining position of the innovator is strong, and the firm discourages innovation to avoid the reshuffling of rents due to an ex-post renegotiation if $s_F \leq \pi_F(O, \emptyset) - \pi_S(O, N) + c$.

However, the option of offering a partnership allows the firm to weaken the bargaining position of the innovator in case of an internal disclosure, and ensure a more profitable bargaining outcome for itself. Proposition 5 shows that sometimes this is an optimal route from the firm's perspective, but, similarly to Proposition 4, sometimes the firm will still find it profitable to discourage innovation.

Proposition 5 (Reverse Hold-Up with Stock-Based Contracts) *If $s_E \geq \pi_S(O, N)$, a stock-based compensation allows the incumbent firm to promote internal disclosure more often than in the fixed-payment contract case. However, sometimes innovation is still discouraged in equilibrium.*

As for Proposition 4, consider the share $\hat{\beta}$ that makes the innovator indifferent between forming a spin-out (and getting $(1 - \hat{\beta})\pi_F(O, N) + \pi_S(O, N)$) and staying in the original firm under the compensation $(1 - \hat{\beta})\pi_F(N, \emptyset)$ upon internal disclosure. As before, such compensation is sufficient to make the threat of walking away from the firm not credible in case of an internal renegotiation. Thus, it effectively weakens the bargaining position of the innovator in case of internal disclosure, leaving the firm with a profit of $\hat{\beta}\pi_F(N, \emptyset)$. Therefore, depending on how the firm's payoffs s_F (fixed-payment contract $v = 0$), $\hat{\beta}\pi_F(N, \emptyset)$ (stock-based contract $\hat{\beta}$), and $\pi_F(O, \emptyset) - \pi_S(O, N) + c$ (fixed-payment contract $v = \pi_S(O, N) - c$) stand with respect to each other, the firm may still promote an internal disclosure under a fixed-payment contract $v = 0$, or promote internal disclosure under the stock-based contract $\hat{\beta}$, or discourage innovation setting $v = \pi_S(O, N) - c$. So, while the option of offering stock-based contracts does not solve the reverse hold-up problem entirely, such contracts allow an internal disclosure to occur more frequently than in their absence. Indeed, internal disclosure through a contract $\hat{\beta}$ occurs if $\hat{\beta}\pi_F(N, \emptyset) \geq \pi_F(O, \emptyset) - \pi_S(O, N) + c \geq s_F$, while in these cases innovation was discouraged in Proposition 3.

To conclude, although the option of offering stock-based compensation to potential employees mitigates both the inner and the reverse hold-up problems, and it increases bargaining efficiency with respect to fixed-payment contracts (as analyzed in Section 4), it doesn't not solve either of these problems entirely, as innovation bonuses do. In addition, the next corollary shows that when both these contractual tools are available, from the firm's point of view innovation bonuses perform better than stock-based contracts.

Corollary 1 *When both contractual tools are available, the firm is better off using innovation bonuses than stock-based contracts.*

6 Conclusion

In this paper, we analyze the incentives to promote innovation in firms. We find that when the innovator's IPR in the firm are weak, in order to prevent expropriation, the innovator may leave the firm to form a spin-out without first trying to disclose his idea internally. In that case, the firm may set up an ex-ante compensation scheme to prevent spin-out formation. On the other hand, when IPR protect the position of innovative employees in the intra-firm renegotiation process, the firm may have an incentive to stifle innovation, fearing the rent reshuffling caused by innovation implementation. We show that, if innovation bonuses are a viable contractual tool, they are always sufficient to implement the bargaining efficient outcome. We also address the possibility for the firm to offer stock-based compensation and we show that such additional tool mitigates bargaining inefficiencies, but does not solve them entirely.

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Appendix

Proof of Proposition 1 The employee's optimal choice is as follows: (a) If $v \geq \max[\pi_S(O, N) - c, z_E - c]$, the employee does not innovate; (b) If $\pi_S(O, N) - c \geq \max[v, z_E - c]$, the employee forms a spin-out; (c) If $z_E \geq \max[v, \pi_S(O, N) - c]$, there is internal disclosure. Let us distinguish two cases: the case in which the innovator's bargaining power in a renegotiation is relatively high ($s_E \geq \pi_S(O, N)$), and the case in which it is relatively low ($s_E < \pi_S(O, N)$).

First, suppose that $s_E \geq \pi_S(O, N)$. In this case, the firm has the following options: (i) Discourage innovation by setting $v = \pi_S(O, N) - c$ and $v_{ID} = \pi_S(N, N)$. The firm gets $\pi_F(O, \emptyset) - \pi_S(O, N) + c$. (ii) Inducing internal disclosure by setting $v_{ID} = \pi_S(O, N)$ and $v = 0$. The firm gets $\pi_F(N, \emptyset) - \pi_S(O, N)$. Alternatively, internal disclosure can be induced by setting $v_{ID} = v = 0$, with the firm getting s_F . From firm's point of view, the first option dominates the second since $s_E \geq \pi_S(O, N)$, so $\pi_F(N, \emptyset) - \pi_S(O, N) \geq \pi_S(N, \emptyset) - s_E = s_F$. (iii) Inducing the formation of a spin-out by setting $v_{ID} = \pi_S(N, N)$ and $v = 0$. The firm gets $\pi_F(O, N)$.

Suppose now that $s_E < \pi_S(O, N)$. The firm has now the following options: (i) Set $v = \pi_S(O, N) - c$, $v_{ID} = \pi_S(N, N)$, and discourage innovation. The firm gets $\pi_F(O, \emptyset) - \pi_S(O, N) + c$. (ii) Set $v_{ID} = \pi_S(O, N)$, $v = 0$, and the employee discloses internally. The firm gets $\pi_F(N, \emptyset) - \pi_S(O, N)$ (iii) Choose $v_{ID} = 0$, $v = 0$, and the employee spins out. The firm gets $\pi_F(O, N)$.

Note that, for any option chosen by the firm, the payoff of the firm is the same across the two cases $s_E \leq \pi_S(O, N)$. Then, internal disclosure dominates discouraging innovation since, if $c < \pi_F(N, \emptyset) - \pi_F(O, \emptyset)$, we have

$$\pi_F(N, \emptyset) - \pi_S(O, N) > \pi_F(O, \emptyset) - \pi_S(O, N) + c$$

Moreover, note that, from the firm's point of view, since $\pi_F(O, N) < \pi_F(N, \emptyset) - \pi_S(O, N)$, an internal disclosure is always better than a spin-out. ■

Proof of Lemma 1 (1) If $v > \pi_S(O, N) - c$, the employee is better off not innovating and getting v rather than innovating and getting the maximum between $v - c$ (through an internal disclosure, since $v \geq \pi_S(N, N)$) and $\pi_S(O, N) - c$ (through a spin-out). (2) In this case, an internal disclosure yields $v - c$ (since $v \geq \pi_S(N, N)$), while forming a spin-out yields $\pi_S(O, N) - c > v > v - c$. (3) In this case, since $v < \pi_S(N, N)$, an intra-firm renegotiation yields a payoff of s_E . In the case of an internal disclosure, the innovator gets $s_E - c$, and in the case of a spin-out, the innovator gets $\pi_S(O, N) - c$. Note that, by not innovating, the employee gets $v < \pi_S(O, N) - c$; Thus, forming a spin-out dominates not innovating. ■

Proof of Proposition 2 If $s_E \geq \pi_S(O, N)$, by Lemma 1, internal disclosure can be promoted by setting $v < \pi_S(N, N)$. Note that, from the firm's point of view, an internal disclosure is better than a spin-out if

$$\pi_F(O, N) \leq s_F = (1 - \alpha)\pi_F(N, N) + \alpha(\pi_F(N, \emptyset) - \pi_S(N, N)).$$

However, this condition is always satisfied since $\pi_F(O, N) < \pi_F(N, N)$ and $\pi_F(O, N) < \pi_F(N, \emptyset) - \pi_S(N, N)$ (the second inequality follows from $\pi_F(O, N) + \pi_S(N, N) < \pi_F(N, N) + \pi_S(N, N) < \pi_F(N, \emptyset)$). On the other hand, by Lemma 1, discouraging innovation requires setting $v = \pi_S(O, N) - c$. Thus, if $\pi_F(O, \emptyset) - \pi_S(O, N) + c > \pi_F(O, N)$, or $V_S < c$, discouraging innovation dominates an internal disclosure and vice-versa. ■

Proof of Proposition 4 Step 1. First, the optimal choice of the innovator as a function of the contract β are as follows:

1. If $(1 - \beta)\pi_F(O, N) + \pi_S(O, N) - c \geq \max[\tilde{z}_E - c, (1 - \beta)\pi_F(O, \emptyset)]$ the employer forms a spin-out;
2. If $(1 - \beta)\pi_F(O, \emptyset) \geq \max[\tilde{z}_E - c, (1 - \beta)\pi_F(O, N) + \pi_S(O, N) - c]$ the employer does not innovate;
3. If $\tilde{z}_E - c \geq \max[(1 - \beta)\pi_F(O, \emptyset), (1 - \beta)\pi_F(O, N) + \pi_S(O, N) - c]$ there is an internal disclosure.

Step 2. Let the firm set $\hat{\beta} = \frac{\pi_F(N, \emptyset) - \pi_F(O, N) - \pi_S(O, N)}{\pi_F(N, \emptyset) - \pi_F(O, N)}$. Note also that such $\hat{\beta}$ makes the innovator indifferent between appropriating $(1 - \hat{\beta})\pi_F(N, \emptyset)$ and forming a spin-out (yielding $(1 - \hat{\beta})\pi_F(O, N) + \pi_S(O, N)$). Recalling that $\pi_F(O, N) + \pi_S(O, N) \geq \pi_F(N, N) + \pi_S(N, N)$, it is easy to see that, for such $\hat{\beta}$, we have $(1 - \hat{\beta})\pi_F(N, N) + \pi_S(N, N) < (1 - \hat{\beta})\pi_F(N, \emptyset)$. Thus, an internal disclosure yields the innovator a payoff of $(1 - \hat{\beta})\pi_F(N, \emptyset)$. Also, note that for c small enough, we have $(1 - \hat{\beta})(\pi_F(N, \emptyset) - \pi_F(O, \emptyset)) > c$, so that the innovator has incentive to invest in new ideas. Thus, by Step 1, under such contract the employee discloses internally and the incumbent firm gets a payoff of $\hat{\beta}\pi_F(N, \emptyset)$.

Step 3. Finally, let us see when using stock-based compensation rather than a fixed-payment contract is profitable for the firm. First, take the case $V_S \geq c$. In this case, under a fixed-payment contract, a spin-out occurs in equilibrium and the firm gets $\pi_F(O, N)$. Thus, if $\hat{\beta}\pi_F(N, \emptyset) > \pi_F(O, N)$ offering a partnership is a profitable strategy for the firm, and a spin-out forms otherwise. On the other hand, if $V_S < c$, under a fixed-payment contract innovation is discouraged, and the firm appropriates $\pi_F(O, \emptyset) - \pi_S(O, N) + c$. Thus, if $\hat{\beta}\pi_F(N, \emptyset) > \pi_F(O, \emptyset) - \pi_S(O, N) + c$, offering a partnership is a profitable strategy for the firm, and innovation is still discouraged otherwise. ■

Proof of Proposition 5 As in Proposition 4, let

$$\widehat{\beta} = \frac{\pi_F(N, \emptyset) - \pi_F(O, N) - \pi_S(O, N)}{\pi_F(N, \emptyset) - \pi_F(O, N)}$$

and recall that, since $(1 - \beta)\pi_F(N, N) + \pi_S(N, N) < (1 - \beta)\pi_F(N, \emptyset)$, under this contract the innovator internally discloses and does not renegotiate its shares. The payoff of the firm is $\widehat{\beta}\pi_F(N, \emptyset)$. Therefore, the optimal contract offered by the firm in this case can be one of the following three types: If $s_F \geq \max[\pi_F(O, \emptyset) - \pi_S(O, N) + c, \widehat{\beta}\pi_F(N, \emptyset)]$ still promotes an internal disclosure under a fixed-payment contract $v = \pi_S(O, N) - c$; If $\widehat{\beta}\pi_F(N, \emptyset) \geq \max[\pi_F(O, \emptyset) - \pi_S(O, N) + c, s_F]$ the firm promotes internal disclosure under the stock-based contract $\widehat{\beta}$; Finally, if $\pi_F(O, \emptyset) - \pi_S(O, N) + c \geq \max[s_F, \widehat{\beta}\pi_F(N, \emptyset)]$, the firm still discourages innovation. \blacksquare

Proof of Corollary 1 We need to compare the firm's payoff under the stock-based contract $\widehat{\beta}$

$$\widehat{\beta}\pi_F(N, \emptyset) = \frac{\pi_F(N, \emptyset) - \pi_F(O, N) - \pi_S(O, N)}{\pi_F(N, \emptyset) - \pi_F(O, N)}\pi_F(N, \emptyset)$$

to the firm's payoff when innovation bonuses are available $\pi_F(N, \emptyset) - \pi_S(O, N)$. However, note that

$$\pi_F(N, \emptyset) - \pi_S(O, N) = \frac{\pi_F(N, \emptyset) - \pi_S(O, N)}{\pi_F(N, \emptyset)}\pi_F(N, \emptyset).$$

Since

$$\frac{\partial \left[\frac{\pi_F(N, \emptyset) - x - \pi_S(O, N)}{\pi_F(N, \emptyset) - x} \right]}{\partial x} = \frac{-(\pi_F(N, \emptyset) - x) + \pi_F(N, \emptyset) - x - \pi_S(O, N)}{(\pi_F(N, \emptyset) - x)^2} < 0,$$

we have

$$\frac{\pi_F(N, \emptyset) - \pi_F(O, N) - \pi_S(O, N)}{\pi_F(N, \emptyset) - \pi_F(O, N)}\pi_F(N, \emptyset) < \pi_F(N, \emptyset) - \pi_S(O, N). \blacksquare$$