

The 80/20 Rule: Corporate Support for Innovation by Employees*

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Abstract

We model an employee's decision to pursue an innovative idea at his employing firm (internally) or as a start-up (externally). We characterize an idea by its market profitability and the degree of positive/negative externality that it imposes on the employing firm's profits. The innovation process consists of exploration and development. Exploring an idea internally grants the employee access to exploration support provided by the firm, but reduces his appropriability of the idea. We demonstrate that ideas exhibiting weak externalities are explored and developed externally whereas ideas with strong externalities are explored and handled internally. Moderate externalities are associated with internal exploration, but subsequent external development. An increase in the firm's exploration support attracts internal exploration of a wider range of ideas, but may increase the likelihood of subsequent external development. We further show that while the optimal level of exploration support rises with the firm's innovation appropriability, overall profits may decline.

Keywords: Innovation, R&D, Entrepreneurship, Exploration support.

JEL Codes: O31, O34, L51.

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1 Introduction

Evidence indicates that innovations developed by start-ups are often conceived by former employees of established firms who undertake projects that had been overlooked by their employers (Sørensen and Fassiotto, 2011). These innovations are frequently related to the respective parent firms' lines of business (Bhide, 1994; Agarwal et al., 2004; Klepper and Sleeper, 2005; Franco and Filson, 2006; Cassiman and Ueda, 2006). For instance, FriendFeed, Aardvark, and Nextstop were founded by former Google employees, with each closely connected to their founders' work at Google.¹ Similarly, former Microsoft employees Rob Glaser, Gabe Newell, and Rich Barton famously went on to found RealNetworks, Valve, and Zillow, each directly connected to their past responsibilities at Microsoft (Rich Barton also co-founded Expedia.com as part of his employment at Microsoft in 1994; it was later spun off).

While innovations may eventually be developed outside of their respective parent firms, the initial exploration often occurs within. In fact, many of the firms that bear a reputation for employees leaving to form start-ups, including Amazon, Google, and Microsoft, also have in place generous policies for supporting exploration of new ideas. Firms such as Chubb,² LinkedIn,³ and Apple⁴ followed Google in implementing generous company policies for allowing employees to explore new ideas "on the company's dime." Google's renowned 80/20 "Innovation Time Off" (ITO) policy encourages employees to take 20 percent of their time to work on company-related projects of their choosing. The policy has led to some exceptionally successful commercial products, including Gmail, AdSense, and Google News, and in-house utility tools like Google Moderator.⁵

A firm's choice to support exploration of new ideas by its employees, in lieu of negotiating exploration-contingent contracts, can be understood in light of the nature of the innovation process. Innovative ideas are frequently the result of unpredictable and non-contractible initiatives, which go beyond employees' normally

¹Numerous other start-ups that bear a relationship to Google's product line were founded by former Google employees, including Ooyala, Dasient, TellApart, Cuil, Redbeacon, Mixer Labs, Howcast, MyLikes, Weatherbill, Doapp, reMail, Hawthorne Labs, and AppJet, among others.

²<http://sloanreview.mit.edu/article/redesigning-innovation-at-chubb/>

³<http://www.wired.com/2012/12/11linkedin-20-percent-time/>

⁴<http://goo.gl/42rer7>

⁵<http://goo.gl/CJq38>

prescribed tasks (Aghion and Tirole, 1994; Hellmann and Thiele, 2011). Thus, incentive contracts based on measurable performance objectives studied in the literature (e.g., Holmström, 1991; Holmström and Milgrom, 1991, 1994; Gibbons, 1998) are often hard to structure and evaluate in practice. Policies for corporate innovation, such as Google’s ITO policy, have attracted considerable media and practitioners’ attention in recent years,⁶ and their profitability has been questioned.⁷ This paper aims to gain a better understanding of the relationship between a firm’s support for innovation and employees’ choice of whether to innovate and where to pursue new ideas.

We present an integrated model that incorporates both the firm’s problem of incentivizing innovation by its employees as well as an employee’s choice of pursuing an innovation internally or externally. Similar to Pakes and Nitzan (1983), a new idea in our framework can be turned into a marketable innovation in two stages — exploration and development. Exploration turns a non-verifiable and non-contractible idea into a working prototype that can be evaluated by a third party, while the development stage turns the prototype into a marketable product.

From the employee’s perspective, external exploration has the advantage of a higher appropriability of the innovation. The benefit of internal exploration is two-fold. First, the employee can take advantage of the firm’s exploration support, which may increase the likelihood of successful exploration. Second, internal exploration and handling of an idea may be more efficient if the idea is related to the firm’s line of business (e.g., due to better output coordination and tailoring of new products to existing ones). Given the trade-offs that the employee faces upon coming up with an idea, he chooses whether to ignore the idea, explore the idea internally, or explore the idea externally. Our objective is to understand how the firm’s level of support and the conceived idea’s characteristics interact with the employee’s exploration and retention incentives.

Our model gives rise to the prediction that at the early exploration stage, firms tend to bleed out ideas that impose weak (positive or negative) externalities on existing profits, and retain ideas with strong externalities. This is primarily because ideas exhibiting stronger externalities are associated with higher efficiency gains from joint development, which the firm and the employee share in the downstream. This prediction is consistent with some empirical evidence. In particular,

⁶<http://www.forbes.com/innovative-companies/>.

⁷http://blogs.hbr.org/cs/2010/08/free_time_innovation.html

in the semiconductor, laser and disk-drive industries, spinoffs are likely to enter new niche markets that do not significantly affect the profits of parent firms (Christensen, 1993; Klepper and Sleeper, 2005; Klepper, 2010).

Our model also incorporates heterogeneity of employees' entrepreneurship potential (e.g., due to varying managerial abilities and access to capital), where an employee's type is private information and affects his profitability from the external pursuit of an idea. This gives rise to an adverse selection problem for the firm in the downstream once an innovation has been internally explored; that is, once a prototype has been completed. In particular, in the development stage, the firm may fail to provide sufficient compensation to the high-type employee, resulting in the employee's departure to form his own start-up. Our model gives rise to the prediction that internal exploration and subsequent external development occurs for valuable ideas exhibiting moderate externalities. These ideas generate sufficient surplus inside the firm to encourage internal exploration by all entrepreneurship types, but not enough to induce a high compensation offer by the firm to the employee in the development stage. As a result, the high entrepreneurial type leaves the firm in favor of independent development.

In equilibrium, since low-type employees have less attractive outside options, and consequently weaker incentives to pursue ideas externally, their initial exploration decision may signal their types. Interestingly, as the firm increases its support for exploration, the firm's ability to infer the employee's type diminishes — as all employee types find internal exploration more attractive. Therefore, while increasing exploration support attracts more ideas for internal exploration by existing employees, it may also have the undesirable consequence of increasing downstream disagreements as higher exploration support exacerbates the firm's adverse selection problem in the downstream. This suggests that increasing the level of support that the firm offers may play a significant role in changing the timing of the employee's departure, but may fail to eliminate such departures.

When choosing its optimal exploration support, the firm will take into account both its impact on the success of internal exploration (productivity effect) and on the employee's exploration choice (retention effect). From a policy perspective, we consider how the firm's optimal choice of support and its expected profit interact with its ability to appropriate the returns from the employee's exploration. The firm's appropriability is affected by numerous policy variables such as the allocation and strength of property rights, enforcement of non-compete agreements,

and the firm's control over vital production inputs. Higher idea appropriability by the firm increases the firm's profit from internal exploration at the expense of the employee's profit. We show that the optimal level of support rises with the firm's degree of appropriability. The reason for this is two-fold. First, the increase in the firm's profit from internal exploration strengthens the productivity effect, making internal exploration more attractive for the firm. Second, the corresponding reduction in the employee's profit from internal exploration makes the employee's retention harder. This, in turn, causes the firm to further increase its level of support in order to encourage internal exploration and enable the firm to reap the benefits of its higher appropriability.

However, a higher degree of appropriability does not necessarily benefit the firm — and may in fact reduce its ex-ante expected profit. This is because the cost of maintaining the flow of ideas brought internally can outweigh the gains from appropriating larger proceeds in the downstream. We show that as a result of a higher level of appropriability by the firm, the productivity effect increases firm's expected profit, but the retention effect decreases it. When the firm's appropriability increases past a threshold, its expected profitability may decrease. This suggests that innovative firms may favor balanced property rights that give employees sufficient control over innovation output inside the firm.

2 Related Literature

There is a significant body of literature that addresses different aspects of innovation within firms. Questions related to employees' incentives to leave established companies to form start-ups (e.g., Pakes and Nitzan, 1983; Anton and Yao, 1995; Amador and Landier, 2003; Klepper and Sleeper, 2005; Cassiman and Ueda, 2006; Hellmann, 2007; Thompson and Chen, 2011) and inducing innovation within firms (e.g., Holmström, 1989; Holmström and Milgrom, 1991; Aghion and Tirole, 1994; Inderst and Klein, 2007; Bernardo et al., 2009; Hellmann and Thiele, 2011; Manso, 2011) have been at the forefront of the entrepreneurship literature. Interestingly, the analysis of these two important aspects of innovation within firms — inducing innovation and new venture formation — has been largely disconnected. We bridge this gap by studying the choices of (i) exploration support by the firm, and (ii) start-up formation by employees, in an integrated model.

Some of the emerging explanations for employee departure include labor market frictions (Astebro et al., 2011); information asymmetries and overly optimistic employees (e.g., Amador and Landier, 2003; Thompson and Chen, 2011); lack of commitment by established firms to not expropriate innovative ideas (e.g., Pakes and Nitzan, 1983; Anton and Yao, 1994, 1995; Wiggins, 1995; Gans et al., 2002; Gans and Stern, 2003); firm's optimal pre-commitment to reject innovation by employees in order to incentivize effort on the firm's core business (Hellmann, 2007); know-how acquisition by employees that increases their potential for entrepreneurship (Franco and Filson, 2006); inability of the established firm to prevent the development of profit-eroding innovations (Klepper and Sleeper, 2005); and limited capacity for internal ventures (Cassiman and Ueda, 2006).

Our paper is closest to the literature that models start-up formation as the result of informational asymmetries (e.g., Thompson and Chen, 2011), which in our model include the firm's limited information about the characteristics of ideas conceived by its employees as well as the employees' entrepreneurship potential. In line with the empirical evidence (e.g., Agarwal et al., 2004; Franco and Filson, 2006; Klepper, 2009), we allow for new ideas to interact with the firm's existing line of business — by either complementing or competing with the firm's existing offerings. This is an important aspect of our model that distinguishes our work from much of the existing literature. It allows us to characterize an employee's departure as a function of the employee's entrepreneurial ability, the market profitability of an idea, as well as the degree of externality that this idea may impose on the parent firm.

Existing literature that incorporates innovation externalities includes Gilbert and Newbery (1980), Reinganum (1983), Klepper and Sleeper (2005), Hellmann (2002) and Cassiman and Ueda (2006). With the exception of Hellmann (2002) and Cassiman and Ueda (2006), this literature focuses only on innovations that cannibalize profits from existing products, while omitting the possibility of complementary innovations. More importantly, private agreements for joint development between potential entrants and existing firms are ruled out. This gives rise to the prediction that entrants may have stronger incentives compared to existing firms to develop substitute ideas, which goes contrary to our findings.

By allowing for both complementary and substitute ideas, and the possibility of emerging innovations being developed within established firms, our work is closest to Cassiman and Ueda (2006) and Hellmann (2002). Similar to our framework,

Cassiman and Ueda consider an established firm's choice to retain employees' innovations in-house, where complete information results in an efficient retention outcome. Unlike our framework, however, the idea's proximity to the firm's existing products does not impact the choice between internal versus external exploration. This is because the externality imposed on the firm is assumed to be invariant to this choice. Instead, the development choice is driven by the trade-off between the firm's superior commercialization capability, which is independent of the idea's characteristics, and its limited capacity to develop new ideas. They observe that while external commercialization of projects with low profitability and/or high cannibalization is not efficient, their internal commercialization may be efficient due to the firm's superior commercialization capability. As a result, Cassiman and Ueda's model predicts that internally-commercialized ideas are on average more cannibalizing and less profitable compared to externally commercialized ideas. In contrast, our model predicts that the established firm will retain innovations that are closely related to the firm's line of business, which includes both more cannibalizing and more complementary products. A key distinction is that our model accounts for the firm's ability to more efficiently manage externalities imposed on its existing business. As a result, the choice between internal and external exploration in our framework is directly affected by the idea's proximity to the firm's line of business.

Hellmann (2002) studies the optimal choice of a financier of a new venture that has originated outside an existing firm, but whose market entry may impact the value of some financier's existing assets. He predicts that the new venture will always partner with financiers holding complementary assets, but may avoid financiers with substitute assets. A key driver of this result is that development support in Hellmann's model is non-contractible and occurs after the formation of the partnership. Subsequently, the financier with substitute assets has reduced incentives to provide development support after financing. This framework is very different from our model, in which the firm's support encourages initial exploration by employees and is thus set prior to the conception of the innovative idea.

Our paper is also closely related to the growing literature on inducing innovation within established firms. While much of this literature (e.g., Holmström, 1989; Inderst and Klein, 2007; Bernardo et al., 2009; Manso, 2011) takes a mechanism-design approach of characterizing optimal innovation-inducing contracts, some papers (e.g., Aghion and Tirole, 1994; Hellmann and Thiele, 2011) characterize in-

novation activity as unplanned, non-contractible, and not subject to the standard incentive contract. The closest paper to ours on this topic is Hellmann and Thiele (2011), who consider a multitask incentive problem in which the employee chooses between exploring new ideas and focusing on the core task. They study how the firm may influence non-contractible exploration by employees by varying the contractual terms of the core task. Since they focus on how the level of innovation activity is impacted by the firm’s contractual design, their model precludes employees’ departure or an interaction between the emerging ideas and the firm’s existing products, which is at the core of our analysis.

The remainder of the paper is organized as follows. Section 3 formally sets up the model. Section 4 consists of equilibrium analysis with the following subsections: 4.1 and 4.2 solve for the expected payoffs from internal exploration and characterize an employee’s optimal exploration strategy; 4.3 addresses the employee’s development strategy as a function of the firm’s exploration support; 4.4 characterizes the firm’s optimal level of support and derives comparative statics results. Section 5 concludes. Proofs are relegated to an Appendix. For convenience, Table 1 contains a summary of the notation and is provided on the last page of the Appendix.

3 Model

The model consists of a firm (denoted by f) and a research employee (denoted by e , where we make use of the terms researcher and employee interchangeably). The researcher receives a base competitive wage, w , to work on a core task assigned by the firm. Consistent with the literature (e.g., Pakes and Nitzan, 1983; Cassiman and Ueda, 2006; Hellmann, 2007), we assume that in the course of his work, the researcher may serendipitously come up with an innovative idea. The idea is characterized by two components: (i) market profitability, v_i , and (ii) an externality, Δ , that is imposed on the firm’s existing profit. Market profitability is drawn from a Bernoulli distribution taking a high value $v_i = v$ with probability ψ and a low value $v_i = 0$ with probability $1 - \psi$. The externality imposed on the firm is drawn from a conditional distribution $F(\Delta|v_i)$ with support $[\underline{\Delta}, \bar{\Delta}]$, where $\underline{\Delta} < 0$ and $\bar{\Delta} > 0$, allowing for both positive and negative externalities (complementary and substitute ideas, respectively). Moreover, the general specification of $F(\Delta|v_i)$

allows us to capture possible correlation between market profitability and the externality to the firm.⁸

The innovation process consists of two stages: exploration and development. At the exploration stage, the employee privately observes (v_i, Δ) . The probability of successful internal exploration is given by $p(L)$, where L denotes the pre-committed exploration support by the firm. We assume that $p'(L) > 0$ and $p''(L) \leq 0$, reflecting the positive and diminishing marginal effect of L . External exploration succeeds with probability p_o , which is common knowledge. Successful exploration results in a working prototype. If exploration takes place internally, the characteristics of the prototype are also observed by the firm. The subsequent development stage transforms a prototype into a marketable product. In either stage, the employee may choose to leave the firm to independently pursue the innovation.

The timing of the game is illustrated in Figure 1. At the onset, the firm chooses its level of exploration support L . Upon coming up with an idea for an innovation, the employee can choose to (1) remain within the firm (denoted by R) and explore internally, or (2) drop the idea and work on his core task for the wage w ; or (3) explore his idea externally (denoted by E).⁹

Successful external exploration results in a prototype with market profitability v_i . The extent to which the employee appropriates this value externally depends on his privately known type, β , which reflects the subsequent share of start-up proceeds retained by the employee. We allow for high (β_H) and low (β_L) types, with $1 \geq \beta_H > \beta_L \geq 0$, and a prior $\Pr\{\beta = \beta_H\} = \theta \in (0, 1)$. Therefore, given an externality of level Δ , the respective expected payoffs for the employee and the firm from external exploration are $\pi_e^E(v_i, \beta) = p_o \beta v_i$ and $\pi_f^E(v_i, \Delta) = p_o \Delta \mathbf{1}(v_i = v)$, where $\mathbf{1}(\cdot)$ denotes the indicator function.

Successful *internal* exploration reveals the characteristics of an idea, (v_i, Δ) , to

⁸For instance, a close substitute to the firm's existing products is likely to exhibit both a high negative externality to the firm as well as a low market profitability, as market competition erodes profits. The relationship between market value and the degree of externality to the firm is less clear for complementary products.

⁹It is possible that the firm's support can also provide the employee with benefits that can be used by non-innovating employees. For instance, the employee may use "Innovation Time Off" support for leisure purposes. Our model can be easily extended to incorporate such additional benefits of the firm's support. However, since an increase in the base wage would have the same impact in our model, we focus only on the type of exploration support that affects the incentives for internal exploration.

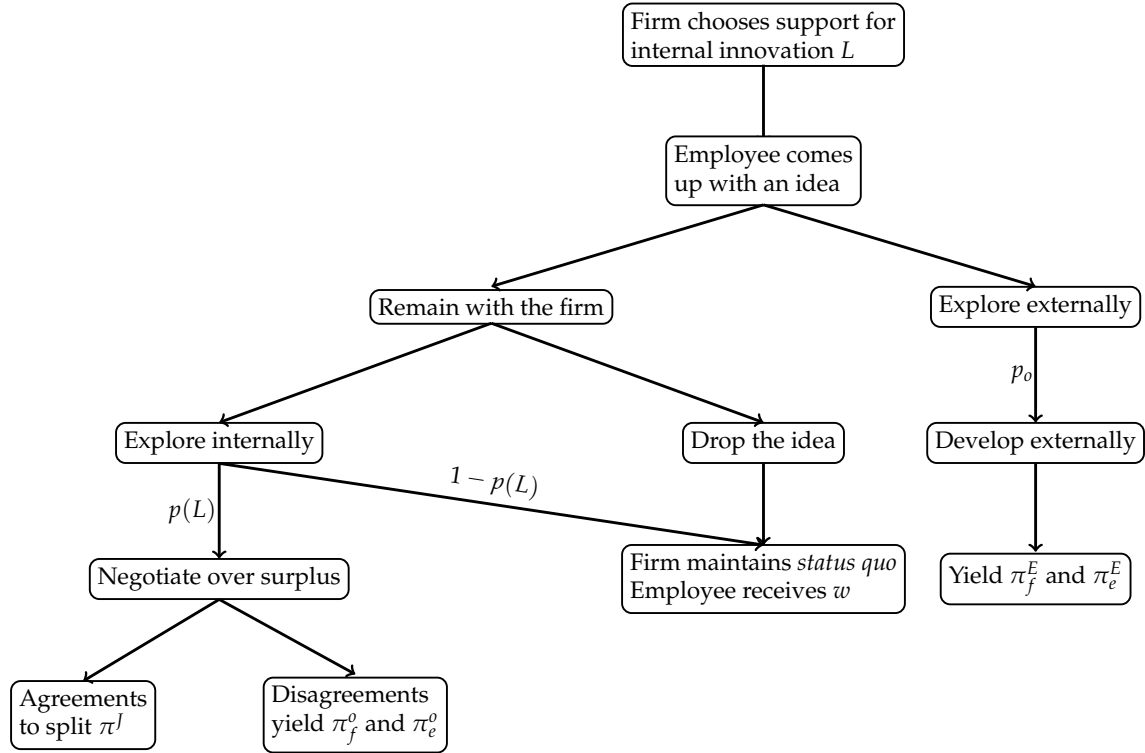


Figure 1: Timing of the game.

the firm and allows it to gain some control over its intellectual property.¹⁰ Consequently, the firm and the employee negotiate over the division of potential proceeds from the development stage. The outcome of this negotiation depends both on the surplus from joint development and on the two parties' outside options.

The surplus from joint development is denoted by $\pi^J(v_i, \Delta) = \max\{g\Delta + v_i, 0\}$, where the parameter g captures any efficiencies from joint development (with $g_s < 1$ for substitutes and $g_c > 1$ for complements) resulting from the efficient management of the externality Δ . Such synergies may be due to a reduced competitive pressure or a superior technological and commercialization potential of joint development to better position the new product along the firm's existing products.¹¹ Thus, internal development results in the highest surplus.

¹⁰Internal exploration may allow the firm to gain access to the know-how from the exploration stage and establish an intellectual property claim over the idea.

¹¹For explicit treatment of externality management through integration see Economides and Salop (1992). A defining feature of integration is the integrated firm's internalization of externalities when making output decisions. This results in reducing the negative externality stemming from

The disagreement payoffs of the employee and the firm in the development stage are given by $\pi_e^o(v_i, \beta) = \beta\alpha_e v_i$ and $\pi_f^o(v_i, \Delta) = (\alpha_f v_i + \Delta)\mathbf{1}(v_i = v) + \max\{0, \Delta\}\mathbf{1}(v_i = 0)$. The parameters α_e and α_f , which denote respective resultant market shares for the employee and the firm, are assumed to be common knowledge. To incorporate the profit-eroding effects of possible competition or property-rights disputes between the firm and the employee, we assume $\alpha_e + \alpha_f \leq 1$. For low-profitability ideas, we have $\pi_e^o(0, \beta) < w$. Henceforth, we assume that for high-value ideas, $\pi_e^o(v, \beta) \geq w$ holds, making external development a credible outside option for the employee.

Disagreements over the joint development of an innovation may arise in equilibrium due to the unobservability of the employee's type. The negotiation stage is modeled as a random-proposer bargaining game, with γ denoting the probability that the firm makes a take-it-or-leave-it offer. The parameter γ captures factors that would interact with the firm's relative bargaining position, such as corporate policies the firm has put in place for tracking the exploration of new ideas and defending its intellectual property, contractual policies for allocating proceeds from innovations, and factors pertaining to the firm's organizational structure (for instance, hierarchical vs. flat).¹²

Remarks: The absence of exploration-contingent contracts in our model is consistent with common corporate policies, such as Innovation-Time-Off, and reflects the difficulty of structuring and enforcing contingent contracts as they pertain to innovation. We focus on unconditional corporate exploration support as a primary mechanism affecting employees' exploration choice. Increasing the wage compensation for the core task may also impact the exploration choice by the employee by making both internal and external exploration less desirable. However, as long as the base wage does not exceed the high type's payoff from external exploration, departures will take place in equilibrium, which would give rise to qual-

substitutes and enhancing the positive externality stemming from complements. We capture this effect in a reduced form through the parameter g .

¹²Based on surveys of 1478 R&D labs in the US manufacturing sector in 1994, Cohen et al. (2000) provide a comparison of several appropriability mechanisms that firms commonly employ. Those include patents, secrecy, and lead time advantages. They find that firms in different industries employ different appropriability mechanisms to different extents. Their findings indicate that, for instance, appropriability mechanisms in the chemicals, metals, and machinery (both general and special purpose) industries were considered more effective across the board than in the electrical equipment industry.

itatively similar results.¹³ The assumption of a common belief about the likelihood of the researcher’s exploration success, coupled with an informational advantage by the researcher pertaining to his type, can be explained with the different set of skills required for successful research and commercialization. While the employee’s research skills may be revealed in the course of his employment, his ability to successfully manage an external venture may be more difficult to observe.¹⁴ Our approach to modeling the effect of the employee’s type on his outside option is consistent with a well-functioning market, where successfully prototyped valuable ideas realize their market value — but the extent to which the researcher appropriates this value is affected by his type (e.g., entrepreneurial ability and/or accessibility to human capital via, for example, the employee’s “network,” and access to financing). For instance, a researcher with costlier access to financing may be inclined to surrender a larger equity stake to a venture capitalist; similarly, a researcher who lacks entrepreneurial skills may need to partner with additional co-founders, increasing dilution.

4 Equilibrium characterization

We solve for the Perfect-Bayesian equilibrium of the game. We begin by examining the negotiation subgame that follows the employee’s decision to explore internally. We are specifically interested in the expected payoffs of the firm and the employee given internal exploration. Armed with these payoffs, we next determine how the level of exploration support L , the employee’s type β , and the characteristics of a newly conceived idea (v_i, Δ) , interact with the employee’s incentives for exploration. Then, by weighing in the costs and benefits of widening the spectrum of ideas that the firm attracts for internal exploration, we characterize the firm’s optimal level of exploration support and derive comparative statics.

¹³Clearly, the wage rate plays a significant role of incentivizing and compensating the employee for his effort on the core task. Since we abstract from this aspect of the employee’s job in our model, we opt to treat the wage rate as exogenous. In this respect, an underlying assumption in our model is that the firm’s optimal wage rate cannot prevent all idea leakage outside the firm, which is consistent with the empirical regularities highlighted in the introduction (e.g., Sørensen and Fassioto, 2011; Bhidé, 1994; Agarwal et al., 2004).

¹⁴Our model assumes that the value of the employee’s idea and his entrepreneurship type are independent. However, the model can easily account for correlation, as long as it is imperfect. The reason is that in such cases, there will be residual uncertainty regarding the employee’s outside option, giving rise to disagreements that are analogous to our setting.

4.1 Internal Exploration: Negotiation Subgame

In the negotiation subgame, the firm and the employee bargain over the proceeds from joint development of the innovation. This stage determines the extent to which internally explored ideas are ultimately retained by the firm. We recall that following internal exploration, ideas are completely revealed to the firm; however, the employee is still privately informed about his type. Thus, disagreements may arise if the firm fails to sufficiently compensate high-ability employees. The firm's willingness to pay in order to retain an employee depends on the parameters of the idea, v_i and Δ , and on the firm's posterior belief regarding facing a high type — conditional on an internally explored idea. Let θ_I denote this posterior belief. We note that this belief may be different from the prior, given by θ , since the employee's choice of internal exploration may serve as a signal about his type. The following Proposition characterizes the type of ideas that may give rise to disagreements.

Proposition 1 *There exist cutoffs $\Delta_s^d(v_i, \theta_I)$ and $\Delta_c^d(v_i, \theta_I)$ such that disagreements occur if and only if $\beta = \beta_H$, $v_i = v$ and $\Delta \in (\Delta_s^d(v, \theta_I), \Delta_c^d(v, \theta_I))$. Furthermore, $\Delta_s^d(v, \theta_I)$ ($\Delta_c^d(v, \theta_I)$) is increasing (decreasing) in θ_I and $\Delta_s^d(v, \theta_I) = \Delta_c^d(v, \theta_I) = 0$ for $\theta_I \geq \frac{(\beta_H - \beta_L)\alpha_e}{1 - \alpha_f - \beta_L\alpha_e} \in (0, 1)$.*

Proposition 1 states that the firm may fail to reach an agreement with a high-type employee over ideas characterized by high market values and weak relationships to the firm's existing products. In such cases, the probability of a disagreement is given by $\gamma\theta_I$; that is, negotiations will break down over some ideas (a fraction $\gamma\theta_I$) that fall into this group.

To glean some insight into this result, let us consider the case of complementary ideas. With probability $1 - \gamma$ the employee makes a take-it-or-leave-it offer of π_f^o to the firm, which is always accepted. With probability γ , the firm has an upper hand in the negotiations and faces an adverse selection problem due to the unobservability of the employee's type. The firm chooses between a high offer $\pi_e^o(v, \beta_H)$, which accrues rents to the low-type of employee, and a low offer $\pi_e^o(v, \beta_L)$, which results in a departure by the high-type employee. For ideas featuring weak complementarities (i.e., $\Delta < \Delta_c^d(v, \theta_I)$), the loss of surplus due to the employee's departure is relatively low compared to the loss of rents resulting from a high offer by the firm. As a result, the firm opts for a low compensation offer, which is rejected by the high-type employee. The converse is true for ideas featuring strong

complementarities (i.e., $\Delta > \Delta_c^d(v, \theta_I)$). Because the firm experiences a significant loss of surplus from the employee's departure to form a start-up, it makes a high compensation offer and retains these ideas in-house. Furthermore, the disagreement region for complementary ideas, $[0, \Delta_c^d(v, \theta_I)]$, shrinks as the firm's posterior θ_I increases. This is due to the fact that low compensation offers are rejected more frequently, increasing the expected surplus loss associated with a low offer. This induces the firm to increase its offers over a wider range of complementary ideas, thereby reducing disagreements.

The intuition for substitute ideas is analogous. In this case, the firm is concerned about losing ideas that would result in substantial profit erosion when developed externally. Consequently, the firm makes high compensation offers whenever faced with ideas that exhibit large negative externalities. As the likelihood of facing a high type increases, the firm in turn increases its offer over a wider range of substitute ideas.

Proposition 1 further notes that there exists a cutoff value for the firm's posterior belief, θ_I , specified by $\frac{(\beta_H - \beta_L)\alpha_e}{1 - \alpha_f - \beta_L\alpha_e} < 1$, above which no ideas are lost in the downstream. In other words, despite incomplete information about the employee's type, disagreements are avoided entirely when the firm puts sufficient weight on facing a high-type employee.

Armed with the equilibrium characterization of the negotiation subgame, we can derive the employee's and the firm's expected payoffs — both of which are important determinants of the incentives for internal exploration and the level of support offered by the firm. The following Corollary characterizes the interaction between these payoffs and the degree of externality imposed by an innovation, Δ .

Corollary 1 *Let $\pi_f^N(v_i, \Delta, \theta_I)$ and $\pi_e^N(v_i, \Delta, \beta, \theta_I)$ denote the firm's and the employee's ex-ante expected continuation payoffs in the negotiation subgame.*

1. If $\Delta > 0$, then $\frac{d\pi_f^N(v_i, \Delta, \theta_I)}{d\Delta} > 0$ and $\frac{d\pi_e^N(v_i, \Delta, \beta, \theta_I)}{d\Delta} \geq 0$ with strict inequality for $\Delta > \hat{\Delta}(v_i) = \begin{cases} 0 & \text{for } v_i = v \\ \frac{w}{g_c - 1} & \text{for } v_i = 0 \end{cases}$

2. If $\Delta < 0$, then:

- a) $\frac{d\pi_f^N(0, \Delta, \theta_I)}{d\Delta} = \frac{d\pi_e^N(0, \Delta, \beta, \theta_I)}{d\Delta} = 0$, and
- b) $\frac{d\pi_f^N(v, \Delta, \theta_I)}{d\Delta} > 0$, while $\frac{d\pi_e^N(v, \Delta, \beta, \theta_I)}{d\Delta} < 0$.

Henceforth, it will be useful to define the *bargaining surplus* from an idea as the additional surplus gained from joint development relative to independent pursuits by the (now former) employee and the firm. That is, the bargaining surplus is given by $\pi^I - \pi_f^o - \pi_e^o$.

We observe that a consequence of Corollary 1 is that the employee and the firm both benefit from an idea being a stronger complement. As the magnitude of the externality of an idea rises, the bargaining surplus and the firm's outside option π_f^o both increase, leading to an overall increase in both the firm's and the employee's expected continuation payoffs.

For substitute ideas, the employee benefits from having the outside option of pursuing an idea with a stronger negative externality, since the firm then has a greater incentive to retain the innovation. If the idea has a low market profitability, the employee no longer possesses the credible threat of independently pursuing the idea, whereby the bargaining surplus is 0. In contrast, for high-value ideas, external development is feasible and the bargaining surplus shrinks as Δ increases (that is, as the externality of a substitute idea weakens), since a weaker substitute idea constitutes less of a threat to the firm's existing profit. Consequently, for substitute ideas, the firm's (employee's) expected payoff from the negotiation subgame is increasing (decreasing) in Δ .

To summarize, Corollary 1 highlights the observation that the employee benefits from ideas that impose stronger externalities on the firm. In turn, the employee requires weaker incentives to choose to explore such ideas within the firm — an observation that will be key in characterizing the employee's exploration strategy.

4.2 Optimal Exploration Strategy

Upon coming up with an idea, the employee considers the level of support offered by the firm and chooses whether to explore the idea externally (E) or remain with the firm (R). Recall that external exploration results in $\pi_e^E(v_i, \beta) = p_o \beta v_i$. Internally, the employee can either drop the idea (D), resulting in a payoff of $\pi_e^D(L) = w$, or explore the idea internally (I), with a payoff $\pi_e^I(v_i, \Delta, \beta, \theta_I, L) = p(L)(\pi_e^N(v_i, \Delta, \beta, \theta_I) - w) + w$. The employee chooses the exploration strategy that maximizes his expected payoff. Thus, he will choose to remain with the firm when

$$\max\{\pi_e^D(L), \pi_e^I(v_i, \Delta, \beta, \theta_I, L)\} \geq \pi_e^E(v_i, \beta) \quad (1)$$

We assume that the employee breaks indifferences in favor of exploring internally over externally and in favor of dropping the idea over exploring.¹⁵

Consider first the case of low-profit ideas; that is, $v_i = 0$. We observe that the employee would not choose to pursue low-profit ideas externally since $\pi_e^E(0, \beta) = 0$; thus, the employee either chooses to drop such ideas (D) or to explore them internally (I). Internal exploration occurs only if $\pi_e^I(v_i, \Delta, \beta, \theta_I, L) > \pi_e^D(L)$. From the employee's payoffs specified above, this implies that $\pi_e^N(0, \Delta, \theta_I) > w$ and requires the idea to be complementary. Corollary 1 shows that $\pi_e^N(0, \Delta, \theta_I)$ is increasing in the degree of complementarity. Thus, for ideas with $v_i = 0$, the employee would only consider internal exploration if the ideas are sufficiently complementary, and would drop them otherwise.

Proposition 2 *Let $v_i = 0$. Then, both employee types choose to ignore an idea if $\Delta \leq \frac{w}{g^c - 1}$ and explore internally otherwise.*

In contrast, high-value ideas are always profitable to explore because of our assumption that $\pi_e^o(v, \beta) > w$. Hence, internal exploration occurs if $\pi_e^I(v, \Delta, \beta, \theta_I, L) \geq \pi_e^E(v, \beta)$. From Corollary 1, the employee's continuation payoff, $\pi_e^I(v, \Delta, \beta, \theta_I, L)$, is strictly increasing in the magnitude of the externality, Δ . Thus, if $\pi_e^I(v, 0, \beta, \theta_I, L) \geq \pi_e^E(v, \beta)$, then all ideas will be explored internally. Otherwise, let $\tilde{\Delta}_j(L, v, \beta, \theta_I)$ denote the solution of

$$\pi_e^I(v, \tilde{\Delta}_j, \beta, \theta_I, L) = \pi_e^E(v, \beta) \text{ for } j = \{s, c\} \quad (2)$$

Because of the strict monotonicity of $\pi_e^I(v, \Delta, \beta, \theta_I, L)$ in Δ for both complements and substitutes, there exists a unique $\tilde{\Delta}_j(L, v, \beta, \theta_I)$ for each $j = \{s, c\}$. Moreover, the employee prefers internal exploration of ideas with an externality stronger than $\tilde{\Delta}_j(L, v, \beta, \theta_I)$ and prefers external exploration otherwise. The following Proposition formalizes this observation and describes how the firm's level of support, L , the employee's type, β , and the firm's posterior, θ_I , interact with the employee's exploration strategy.

Proposition 3 *Let $v_i = v$. There exist cutoffs $\Delta_s^I(L, v, \beta, \theta_I)$ and $\Delta_c^I(L, v, \beta, \theta_I)$ such that the employee explores internally if $\Delta \notin (\Delta_s^I(L, v, \beta, \theta_I), \Delta_c^I(L, v, \beta, \theta_I))$ and explores externally otherwise. These cutoffs have the following properties:*

¹⁵Such tie breaking rule is efficient whenever exploration is associated with a non-negligible cost. For technical simplicity and because the qualitative nature of the results is unchanged, we abstract from incorporating costly exploration.

- (1) $\frac{\partial \Delta_s^I(L, v, \beta, \theta_I)}{\partial L} > 0$ for $\Delta_s^I(L, v, \beta, \theta_I) < 0$.
- (2) $\frac{\partial \Delta_c^I(L, v, \beta, \theta_I)}{\partial L} < 0$ for $\Delta_c^I(L, v, \beta, \theta_I) > 0$.
- (3) $\Delta_s^I(L, v, \beta_H)$ and $\Delta_c^I(L, v, \beta_H)$ are independent of θ_I .
- (4) $\Delta_s^I(L, v, \beta_L, \theta_I)$ is non-decreasing in θ_I and $\Delta_c^I(L, v, \beta_L, \theta_I)$ is non-increasing in θ_I .
- (5) $\Delta_s^I(L, v, \beta_H) \leq \Delta_s^I(L, v, \beta_L, \theta_I)$ with strict inequality for $\Delta_s^I(L, v, \beta_H) < 0$ and $\Delta_s^I(L, v, \beta_L, \theta_I) > \underline{\Delta}$.
- (6) $\Delta_c^I(L, v, \beta_H) \geq \Delta_c^I(L, v, \beta_L, \theta_I)$ with strict inequality for $\Delta_c^I(L, v, \beta_H) > 0$ and $\Delta_c^I(L, v, \beta_L, \theta_I) < \bar{\Delta}$.

Proposition 3 states that the employee chooses internal exploration of high-value ideas that feature stronger externalities. Properties (1) and (2) reveal the impact of increased exploration support on the employee's choice of an exploration venue. As expected, a higher support for exploration by the firm has a positive effect on the employee's incentive to choose internal exploration. Thus, by increasing its support, the firm is able to attract a wider range of ideas.

Properties (3) and (4) reveal how the employee's exploration incentives are impacted by the firm's posterior. Notice that the high-type's outside option $\pi_e^o(v, \beta_H)$ serves as an upper bound on the firm's offer in the negotiation stage. Thus, the high type's payoff is not impacted by the firm's belief θ_I . In contrast, a low-type employee may benefit from a higher posterior, since the firm may increase its offer in the downstream above the low type's outside option. As a result, for higher posteriors, a low-type employee would be more likely to bring ideas in-house.

Properties (5) and (6) reveal that for any given idea, a high-type employee is less willing to pursue internal exploration due to his higher outside option. In turn, the firm needs to provide higher-powered incentives to attract internal exploration by high types.

Internal exploration may also provide an opportunity for the firm to update its prior belief regarding the employee's type. This occurs for ideas exhibiting relatively weak externalities since then the exploration strategies by the two types diverge. The following result characterizes the unique equilibrium exploration strategies by the two employee types and the corresponding equilibrium posterior.

Proposition 4 *Let $v_i = v$. Then, for a given level of support L :*

- 1) If $\Delta \notin (\Delta_s^I(L, v, \beta_H), \Delta_c^I(L, v, \beta_H))$, then both employee types explore internally and $\theta_1^* = \theta$ is the unique equilibrium belief.
- 2) If $\Delta \in (\Delta_s^I(L, v, \beta_H), \Delta_s^I(L, v, \beta_L, 0)]$ or $\Delta \in [\Delta_c^I(L, v, \beta_L, 0), \Delta_c^I(L, v, \beta_H))$, a high-type employee explores externally while a low type explores internally and $\theta_1^* = 0$ is the unique equilibrium belief.
- 3) If $\Delta \in (\Delta_s^I(L, v, \beta_L, 0), \Delta_c^I(L, v, \beta_L, 0))$, then both employee types explore externally and the equilibrium is supported by $\theta_1^* = 0$.

It follows from Proposition 4 that strongly complementary and substitute ideas are explored internally by both employee types; consequently, for ideas in this parameter range, no new information about the employee's type is conveyed to the firm, whereby $\theta_1^* = \theta$. Since a low type is more inclined to explore ideas internally, ideas with intermediate level of externalities would only be explored internally by low-type employees, whereby their type is revealed to the firm and hence $\theta_1^* = 0$. In contrast, ideas that are weakly related to the firm's existing offerings are explored externally by both employee types. For ideas in this parameter range, an off-equilibrium belief $\theta_1^* = 0$ ensures no deviation by the low type.

Combining the findings from Propositions 1-4, the model gives rise to the predictions that employees who leave their employment to form start-ups pursue high-value ideas that are likely to be weakly related to their firm's existing offerings. Moreover, an employee may end up leaving his firm either at the initial exploration stage or prior to the downstream development stage.

The next subsection examines how the firm's level of exploration support interacts with the likelihood and timing of an employee's potential pursuit of a start-up.

4.3 Timing of the Researcher's Departure

The firm's chosen level of exploration support has a direct impact on the employee's choice of an exploration venue, where a higher level of support leads to an increase in exploration activity within the firm. However, as pointed out by Proposition 1, not all internally explored ideas are subsequently retained within the firm. Building on this result, the following finding indicates that increasing the level of support indeed results in the internal exploration of a wider range of ideas.

However, doing so may also lead to more departures by employees of the high entrepreneurship type, as it becomes increasingly difficult for the firm to distinguish between high- and low-type employees.

Proposition 5 *The likelihood of internal exploration is (weakly) increasing in L for both types. For $\theta \geq \frac{(\beta_H - \beta_L)\alpha_e}{1 - \alpha_f - \beta_L\alpha_e}$, no downstream disagreements occur. For $\theta < \frac{(\beta_H - \beta_L)\alpha_e}{1 - \alpha_f - \beta_L\alpha_e}$, there exists a cutoff $\tilde{L} \geq 0$, such that for $L > \tilde{L}$, the likelihood of downstream departure by β_H -type of employee is increasing in L .*

An increase in the level of support, L , makes internal exploration more attractive for both employee types. Thus, the cutoff $\Delta_s^I(L, v, \beta, \theta_1^*)$ is increasing in L and the cutoff $\Delta_c^I(L, v, \beta, \theta_1^*)$ is decreasing in L , reducing the range of ideas explored outside the firm. The likelihood of downstream disagreement depends on the firm's ability to distinguish between the employee's types.

Proposition 5 states that if a high-type employee is sufficiently likely (that is, $\theta \geq \frac{(\beta_H - \beta_L)\alpha_e}{1 - \alpha_f - \beta_L\alpha_e}$), then identifying the employee's type is not an issue, since the firm always finds it optimal to make a generous offer in the downstream. However, for $\theta < \frac{(\beta_H - \beta_L)\alpha_e}{1 - \alpha_f - \beta_L\alpha_e}$, the firm may choose to make a low price offer if the idea is weakly related to its existing products.

Recall that disagreements can only occur over high-value ideas. Given low levels of support, a high-type employee leaves the firm at the exploration stage, whereby the firm is able to perfectly screen out the employee's type over a wide range of ideas exhibiting weak externalities, $\Delta \in (\Delta_s^I(L, v, \beta_H), \Delta_c^I(L, v, \beta_H))$. However, as the level of support increases, internal exploration becomes more attractive to the high types. As a result, disagreements occur for moderate complements and substitutes; that is, in cases where $\Delta \in (\Delta_s^d(v, \theta_I), \Delta_s^I(L, v, \beta_H))$ and $\Delta \in (\Delta_c^I(L, v, \beta_H), \Delta_c^d(v, \theta_I))$. These disagreements occur because the low likelihood of a high type and the moderate externality of these ideas induce low offers by the firm in the negotiation subgame.

Proposition 5 suggests that firms with higher levels of support may experience more exploration activity within the firm by existing employees, but this may also render the firm more susceptible to losing innovations in their development stage. Thus, increasing the level of support that the firm offers may play a significant role in changing the timing of existing employees' departures, but may fail to eliminate such departures. This observation is consistent with anecdotal evidence from highly innovative firms, such as Google, that are known both for their generous

exploration support policies – and for a relatively large number of employee departures to pursue new ventures.

It is important to point out that the analysis in this section highlights the impact that the level of support has on the departure by existing employees (intensive margin effect). In this respect, our analysis abstracts from the possibility that the firm’s exploration support may also impact the type of new employees that the firm is able to hire (extensive margin effect). The extensive margin effect can be analyzed in the context of our model by introducing an additional stage, in which workers make an occupational choice between the firm and alternative (self-)employment opportunities. If high entrepreneurship types are associated with significantly higher outside options, an increase in L , which makes employment within the firm more attractive, is also likely to increase the share of β_H -type of employees within the firm (i.e., an increase in θ).¹⁶ This increase in θ would impact the likelihood of external exploration and development. In particular, the extensive margin effect tends to increase external exploration since employees of the β_H type are more likely to explore externally. This goes contrary to the intensive margin effect. An increase in θ would also impact the likelihood of downstream disagreements. On the one hand, an increase in θ tends to increase the likelihood of downstream departures as it increases the share of β_H -type employees in the downstream. On the other hand, by Proposition 1, a higher likelihood of β_H types in the downstream negotiations induces more generous downstream offers by the firm, which tends to decrease the likelihood of downstream departures. As a result, the overall extensive margin effect on the likelihood of downstream disagreements is ambiguous.¹⁷

¹⁶One way to illustrate this effect more formally, is to model the employee’s outside opportunity H as a draw from a distribution $G(H|\lambda_\beta)$, where higher λ_β causes the distribution to lean more heavily towards low values of H . This can be captured by a decreasing reverse hazard rate ($\frac{\partial}{\partial \lambda_\beta} \left(\frac{g(H|\lambda_\beta)}{G(H|\lambda_\beta)} \right) < 0$) Then, if λ_{β_L} is significantly higher than λ_{β_H} , the β_H -type will have sufficiently higher outside option (in probabilistic terms), making him less likely to enter the firm for any level of support L . Consequently, the firm’s belief of facing a β_H -type employee (θ) will increase in L , as a higher L would attract employees with higher outside options H , who in turn are more likely to correspond to the β_H -type.

¹⁷Ultimately, whether overall departure by employees increases or decreases is an empirical question. One way to disentangle the intensive and extensive margin effects empirically is to consider the differential impact of the firm’s exploration support on existing and new employees.

4.4 Optimal Support for Exploration

Having identified the characteristics of ideas explored and/or developed inside and outside of the firm, and the corresponding timing of an employee's departure, we now turn our focus to the firm's choice of exploration support. At the time of choosing its support, the firm has incomplete information about the characteristics of the ideas that are likely to emerge. Hence, the firm's decision is based on its prior beliefs about the likely characteristics of new ideas and about the distribution of employees' types.

Our focus in this subsection is to examine policy variables that could impact the firm's willingness to offer support. Among the policy variables of interest are the firm's relative bargaining position vis-à-vis employees, captured by γ , and the parameters α_f and α_e , capturing relative market strengths and development capabilities for the firm and employees respectively. These variables are impacted by a variety of legal and institutional factors and affect the outcomes of negotiations over internal handling of innovations. Some of these factors include the allocation and strength of property rights as determined by local laws and by firm-specific legal frameworks and policies, the indispensability of the employee's expertise in the development process, and institutional structures that help determine the firm's and the employee's shares of the realized surplus.

Let $\pi_f^R(v_i, \Delta, \beta, L)$ denote the firm's downstream payoff following a β -type employee's decision to keep an idea with characteristics (v_i, Δ) inside the firm. If the employee explores the idea, then $\pi_f^R(v_i, \Delta, \beta, \theta_1^*, L) = p(L)\pi_f^N(v_i, \Delta, \beta, \theta_1^*)$, where $\pi_f^N(v_i, \Delta, \beta, \theta_1^*)$ denotes the firm's expected payoff from the negotiation subgame conditional on a β -type employee. If the employee instead chooses to ignore the idea, then $\pi_f^R(v_i, \Delta, \beta, L) = 0$. The firm's payoff from external exploration is given by $\pi_f^E(v_i, \Delta) = p_0\Delta\mathbf{1}(v_i = v)$. We recall from Propositions 2 and 4 that the firm retains ideas with externality $\Delta \notin (\Delta_s^I(L, v_i, \beta, \theta_1^*), \Delta_c^I(L, v_i, \beta, \theta_1^*))$, where we have $\Delta_s^I(L, 0, \beta, \theta_1^*) = \Delta_c^I(L, 0, \beta, \theta_1^*) = 0$ for low-profit ideas (since they are always retained within the firm).

Let $S_f(v_i, \Delta, \beta, L) = \pi_f^R(v_i, \Delta, \beta, L) - \pi_f^E(v_i, \Delta)$ denote the firm's retention surplus. Then, the firm's expected profit from offering a level of support L at the outset of the game is given by

$$\begin{aligned} \Pi_f(L) = & E_{v_i, \Delta, \beta} [S_f(v_i, \Delta, \beta, L) | \Delta \notin (\Delta_s^I(L, v_i, \beta, \theta_i^*), \Delta_c^I(L, v_i, \beta, \theta_i^*))] \\ & + E_{v_i, \Delta} [\pi_f^E(v_i, \Delta)] - L. \end{aligned} \quad (3)$$

Hence, the firm's expected payoff consists of the expected externality that an idea would impose on the firm, captured by $E_{v_i, \beta} [\pi_f^E(v_i, \Delta)]$, plus the additional surplus generated from retaining ideas with strong externalities within the firm. The impact of the level of support L on the firm's profit is given by

$$\begin{aligned} \frac{d\Pi_f(L)}{dL} = & E_{v_i, \Delta, \beta} \left[\frac{\partial S_f(v_i, \Delta, \beta, L)}{\partial L} \Big|_{\Delta \notin (\Delta_s^I, \Delta_c^I)} \right] - 1 \\ & + \psi E_\beta \left[S_f(v, \Delta_s^I, \beta, L) f(\Delta_s^I | v) \frac{\partial \Delta_s^I}{\partial L} \Big|_v \right] \\ & - \psi E_\beta \left[S_f(v, \Delta_c^I, \beta, L) f(\Delta_c^I | v) \frac{\partial \Delta_c^I}{\partial L} \Big|_v \right] \end{aligned} \quad (4)$$

The level of support has a twofold effect on the firm's profit. The first term in equation (4) captures the *productivity effect* of L via its impact on the likelihood of successful exploration, $p(L)$. The last two terms capture the *retention effect* of L (that is, its effect on the employee's incentives) via its impact on the cutoffs $\Delta_s^I(L, v, \beta, \theta_i^*)$ and $\Delta_c^I(L, v, \beta, \theta_i^*)$. The retention effect has a (weakly) positive sign as higher support tends to increase the range of ideas explored internally by both types.

For analytical purposes, we maintain the following technical assumptions on the retention effect.

Assumption 1

- a) For $j = \{s, c\}$, $\Delta_j^I(0, v, \beta_H) \in (\underline{\Delta}, \bar{\Delta})$.
- b) For $j = \{s, c\}$, $\frac{d[S_f(v, \Delta_j^I, \beta, L) f(\Delta_j^I | v)]}{dL} \leq 0$ and $\Delta_j^I(L, v, \beta_L, \theta_i^*) \neq 0$.

Assumption 1 provides sufficient conditions for the retention effect to be monotonically decreasing in L . The first condition states that even at the lowest exploration support (i.e., $L = 0$), the employee chooses internal exploration with positive probability (i.e., $\Pr(\Delta \notin (\Delta_s^I(0, v, \beta_H), \Delta_c^I(0, v, \beta_H))) > 0$). If this condition is

violated, the employee will choose only external exploration for low values of L and only internal exploration for high values of L , causing the retention effect to be zero for very high and low support levels and positive for intermediate levels. This would result in non-monotonicity of the retention effect and local convexity of the objective function.¹⁸ The first condition is satisfied as long as the distribution of the externality parameter Δ has sufficiently wide support. The second condition guarantees that the retention effect is always diminishing in the firm's level of support.¹⁹ Together, the two conditions ensure the strict concavity of the objective function and the uniqueness of the optimal solution, obtained from the firm's first order condition in equation (4). Given the optimal solution L^* , we explore the impact of increasing the firm's relative bargaining position as captured by the parameters $\sigma \in \{\gamma, \alpha_f, 1 - \alpha_e\}$. Thus, higher σ correspond to stronger bargaining position for the firm. The following Proposition characterizes these comparative statics.

Proposition 6 $L^*(\sigma)$ is increasing in σ .

An improvement in the firm's appropriability in the negotiation subgame, either through an increase γ and α_f or a decrease in α_e , has two effects. First, it increases the firm's downstream retention profit $\pi_f^R(v_i, \Delta, \beta, \theta_I^*, L^*, \sigma)$ from internally explored ideas, captured by the direct effect of exploration support on $S_f(v, \Delta_j^I, \beta, L, \sigma)$ (i.e. $\frac{\partial S_f(v, \Delta_j^I, \beta, L, \sigma)}{\partial \sigma} > 0$). This effect induces the firm to increase its support. Second, the level of support also impacts the employee's willingness to explore ideas within the firm, which affects the retention cut-offs $\Delta_j^I(L^*, v_i, \beta, \theta_I^*, \sigma)$. Implicit differentiation of equation (2) results in the following impact of σ on the retention cut-offs.

¹⁸Relaxing Assumption 1(a) may give rise to two local maxima: one corresponding to only the low type exploring internally and another corresponding to both types exploring internally with positive probability. While the comparative statics of the local maxima conform to the properties described in Proposition 6, the global maximum may exhibit a discontinuous jump as the firm's exploration support switches from one local maximum to another. In particular, given a low prior probability θ , the firm may find it optimal to attract internal exploration by both types for low levels of appropriability, but may opt to attract only the low type for high levels of appropriability. This is due to the fact that it becomes increasingly costly to induce internal exploration by the high type.

¹⁹A sufficient condition that satisfies 1(b) is a synergy parameter g that is sufficiently close to 1 and a distribution on Δ that satisfies $f_\Delta(\Delta|v) \leq (\geq) 0$ for substitutes (complements) (e.g., the uniform distribution). This ensures that the firm's surplus from retaining ideas in-house is diminishing rapidly as the exploration cut-offs Δ_j^I move closer to 0 in response to increasing exploration support.

Lemma 1 $\Delta_s^I(L, v_i, \beta, \theta_1^*, \sigma)$ is decreasing σ , whereas $\Delta_c^I(L, v_i, \beta, \theta_1^*, \sigma)$ is increasing in σ .

Thus, increasing the firm's bargaining position has an adverse retention effect as it reduces the employee's payoff from internal exploration. As a result, the employee requires a higher level of support to mitigate his reduced incentives for internal exploration. This negative retention effect causes the firm to further increase its level of support in order to encourage internal exploration and reap the benefit of higher appropriability.

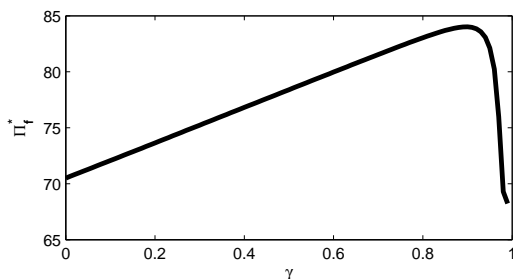
While the increase in the firm's bargaining position through higher γ and α_f and lower α_e causes the firm to offer more exploration support, it may have an adverse effect on the firm's ex-ante profitability. To see this, let $\Pi_f(L^*, \sigma)$ denote the firm's optimal ex-ante profit. Then, by the envelope theorem, the impact of changing σ is given by

$$\begin{aligned} \frac{d\Pi_f(L^*, \sigma)}{d\sigma} &= E_{v_i, \Delta, \beta} \left[\frac{\partial S_f(v_i, \Delta, \beta, L^*, \sigma)}{\partial \sigma} \Big|_{\Delta \notin (\Delta_s^I, \Delta_c^I)} \right] \\ &\quad + \psi E_\beta \left[S_f(v, \Delta_s^I, \beta, L^*, \sigma) f(\Delta_s^I | v) \frac{\partial \Delta_s^I}{\partial \sigma} \Big|_v \right] \\ &\quad - \psi E_\beta \left[S_f(v, \Delta_c^I, \beta, L^*, \sigma) f(\Delta_c^I | v) \frac{\partial \Delta_c^I}{\partial \sigma} \Big|_v \right] \end{aligned} \quad (5)$$

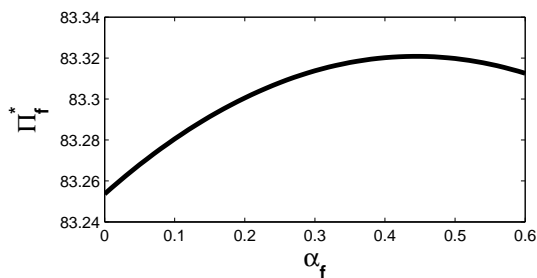
The first term denotes the direct effect of increasing σ on the firm's downstream retention profit $\pi_f^R(v_i, \Delta, \beta, \theta_1^*, L^*, \sigma)$, which is always positive. Thus, the direct effect tends to increase the firm's profit. The last two terms denote the strategic effect of increasing σ on the employee's retention, which is always negative. By Lemma 1, strengthening the firm's bargaining position makes the employee less willing to explore internally, which has a negative effect on the firm's profitability.

Note that the direct effect is diminishing in the firm's appropriability since the region of ideas explored internally is decreasing in the firm's bargaining power (i.e., $\Delta \notin (\Delta_s^I, \Delta_c^I)$ shrinks). This suggests that the strategic effect may dominate the direct effect for relatively high values of γ and α_f and low values of α_e . The following example illustrates this point.

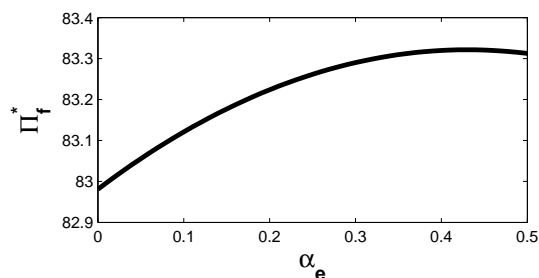
Example 1 In the following example, $v = 5$, $\psi = 0.7$, $\beta_L = 0.1$, $\beta_H = 0.5$, and $\theta = 0.7$. The externality parameter is a draw from a uniform distribution $U \sim [\underline{\Delta}, 0]$



(a) Expected profit as a function of γ



(b) Expected profit as a function of α_f



(c) Expected profit as a function of α_e

Figure 2: Firm's expected profit as a function of γ , α_f , and α_e .

with prob. λ_{v_i} and $U \sim [0, \bar{\Delta}]$ with probability $1 - \lambda_{v_i}$, where $\underline{\Delta} = -80$, $\bar{\Delta} = 400$, $\lambda_0 = 0.8$ and $\lambda_v = 0.3$. The probability of a successful exploration outside the firm is $p_o = 1 - e^{-1}$. The effect of L on the employee is captured by $p(L) = 1 - e^{-1-0.05L}$ and the employee's base pay is $w = 0.2$. Efficiencies from joint-development are captured by $g_c = 1.1$ (complements) and $g_s = .9$ (substitutes). For Figures 2a and 2b $\alpha_e = 0.4$. For Figures 2a and 2c $\alpha_f = 0.5$. For Figures 2b and 2c $\gamma = 0.80$. The figure illustrates the effects of increasing γ , α_f and α_e on the firm's profitability. As can be seen, the firm's profit is non-monotonic.

Example 1 illustrates that a firm may find it optimal to maintain weak appropriability over the ideas explored in-house. This suggests that laws strengthening firms' claims over ideas emerging from their employees might actually hurt profitability by making it more difficult to induce internal exploration. Instead, a highly innovative firm may favor a more balanced allocation of property rights that weaken the firm's bargaining position in the downstream, but provide powerful retention incentives for employees. This finding can help explain why certain innovation-focused institutions, such as academia, have adopted a flat organi-

zational structure, giving employees significant autonomy and control over their ideas.

5 Conclusions

We show that employees who leave their employment to pursue new ventures tend to develop products that are weakly related to their former employers' lines of business. While increasing the level of support for innovation can induce the internal exploration of a wider range of ideas, such policies may also increase employee turnover in downstream development stages.

When choosing its optimal level of support, the firm in our model balances the benefits of inducing higher levels of exploration in-house with the cost of supporting this exploration activity. We showed that as the firm's relative bargaining position vis-à-vis an employee strengthens, its chosen level of support increases, but its ex-ante expected profits may decrease. This suggests that the firm may favor balanced policies that enable employees to retain some control over their internally explored ideas.

Future work can incorporate a mechanism-design framework, where the firm is able to structure roles for employees in order to make the discovery of certain innovations more likely (e.g., innovations that are more complementary to the firm's existing line of products). Another direction is to consider the firm's incentives for committing ex-ante to a development strategy in order to affect the employee's exploration choice. One may also consider a competitive landscape where outside investors, as well as other firms, are competing for attracting new ideas and their development by the firm's employees, and a framework where employees choose a subset of ideas to pursue from a larger set of ideas.

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Appendix

Proof of Proposition 1. We consider the case of $v_i = 0$ and $v_i = v$ separately.

1. Let $v_i = 0$. Then, the employee's outside option is common knowledge and equal to $\pi_e^E(0, \beta) = 0$. Thus, disagreements do not arise in equilibrium and the efficient outcome is implemented. Joint development of the idea is efficient if and only if $\pi^J = \max\{g\Delta, 0\} \geq \max\{\Delta, 0\} + w = \pi_f^o + w$ or $\Delta > \frac{w}{g_c - 1} > 0$. In this case, if negotiations favor the firm, then it makes an offer of w . Otherwise, if negotiations favor the employee, then he makes an offer of π_f^o . For $\Delta \in \left(0, \frac{w}{g_c - 1}\right]$, the efficient outcome is for the firm to develop independently and for the employee to focus on the core task resulting in Δ for the firm and w for the employee. For $\Delta \leq 0$, the efficient outcome is shelving resulting in payoffs of 0 for the firm and w for the employee.

2. Next, we consider the case of $v_i = v$. The employee makes a take-it-or-leave-it offer of π_f^o with probability $(1 - \gamma)$, which is subsequently accepted by the firm. If, instead, negotiations favor the firm, occurring with probability γ , the firm has two options:

i) Offer $\beta_H \alpha_e v$, which is accepted with probability 1, resulting in an expected payoff of $\pi^J - \beta_H \alpha_e v$ for the firm; or ii) Offer $\beta_L \alpha_e v$, which is accepted with probability θ_I , resulting in an expected payoff of $(1 - \theta_I)(\pi^J - \beta_L \alpha_e v) + \theta_I \pi_f^o$ for the firm. It is optimal for the firm to offer $\beta_H \alpha_e v$ if and only if its expected payoff from doing so exceeds its expected payoff from offering $\beta_L \alpha_e v$. That is,

$$\pi^J \geq \pi_f^o + \beta_L \alpha_e v + \frac{(\beta_H - \beta_L) \alpha_e v}{\theta_I} \quad (\text{A-1})$$

For $\Delta \geq 0$, it is straightforward to check that the above inequality is satisfied if and only if $\Delta \geq \frac{\theta_I(\alpha_f + \beta_L \alpha_e - 1) + (\beta_H - \beta_L) \alpha_e}{\theta_I(g_c - 1)} v$. Then, we can define $\Delta_c^d(v, \theta_I) \equiv \max \left\{ \frac{\theta_I(\alpha_f + \beta_L \alpha_e - 1) + (\beta_H - \beta_L) \alpha_e}{\theta_I(g_c - 1)} v, 0 \right\}$. Clearly, $\Delta_c^d(v, \theta_I)$ is non-increasing in θ_I . Further, $\Delta_c^d(v, \theta_I) > 0$ if and only if $\theta_I < \frac{(\beta_H - \beta_L) \alpha_e}{1 - \alpha_f - \beta_L \alpha_e}$.

For $\Delta \leq 0$, there are two cases to consider:

- $\Delta \geq -\frac{1}{g_s} v$, in which case equation (A-1) is satisfied if and only if

$$\Delta \leq -\frac{\theta_I(\alpha_f + \beta_L \alpha_e - 1) + (\beta_H - \beta_L) \alpha_e}{\theta_I(1 - g_s)} v \equiv \Delta_1(v, \theta_I).$$

- $\Delta < -\frac{1}{g_s}v$, in which case equation (A-1) is satisfied if and only if

$$\Delta \leq -\frac{\theta_I (\alpha_f + \beta_L \alpha_e) + (\beta_H - \beta_L) \alpha_e}{\theta_I} v \equiv \Delta_2(v, \theta_I).$$

Combining the above inequalities, it can be verified that given $\Delta < 0$, equation (A-1) is satisfied for $\Delta \leq \max \{\Delta_1(v, \theta_I), \Delta_2(v, \theta_I)\}$. Therefore, $\Delta_s^d(v, \theta_I) \equiv \min \{\max \{\Delta_1(v, \theta_I), \Delta_2(v, \theta_I)\}, 0\}$. It can be readily verified that $\Delta_s^d(v, \theta_I)$ is non-decreasing in θ_I and that $\Delta_s^d(v, \theta_I) < 0$ if and only if $\theta_I < \frac{(\beta_H - \beta_L) \alpha_e}{1 - \alpha_f - \beta_L \alpha_e}$. ■

Proof of Corollary 1. We consider $v_i = 0$ and $v_i = v$ separately.

1. Consider $v_i = 0$. From the proof of Proposition 1, we know that joint development takes place if $\Delta > \frac{w}{g_c - 1}$. In this case, the firm makes a take-it-or-leave-it offer of w to the employee with probability γ and the employee makes a take-it-or-leave-it offer to the firm of π_f^o with probability $(1 - \gamma)$. For $\Delta \leq \frac{w}{g_c - 1}$, the employee focuses on the core task and the firm develops independently whenever optimal. Therefore,

$$\pi_e^N(0, \Delta, \beta, \theta_I) = \begin{cases} w & \text{if } \Delta \leq \frac{w}{g_c - 1} \\ \gamma w + (1 - \gamma)(\pi^J - \pi_f^o) & \text{if } \Delta > \frac{w}{g_c - 1} \end{cases}$$

$$\pi_f^N(0, \Delta, \theta_I) = \begin{cases} \max\{0, \Delta\} & \text{if } \Delta \leq \frac{w}{g_c - 1} \\ \gamma(\pi^J - w) + (1 - \gamma)\pi_f^o & \text{if } \Delta > \frac{w}{g_c - 1} \end{cases}$$

Therefore, $\frac{d\pi_e^N(0, \Delta, \beta, \theta_I)}{d\Delta} = 0$ for $\Delta \leq \frac{w}{g_c - 1}$ and $\frac{d\pi_e^N(0, \Delta, \beta, \theta_I)}{d\Delta} = (1 - \gamma)(g_c - 1) > 0$ for $\Delta > \frac{w}{g_c - 1}$. For the firm, $\frac{d\pi_f^N(0, \Delta, \theta_I)}{d\Delta} = 0$ for $\Delta \leq 0$, and

$$\frac{d\pi_f^N(0, \Delta, \theta_I)}{d\Delta} = \begin{cases} 1 & \text{if } \Delta \in \left(0, \frac{w}{g_c - 1}\right] \\ \gamma g_c + (1 - \gamma) & \text{if } \Delta > \frac{w}{g_c - 1} \end{cases} > 0$$

2. Consider $v_i = v$. In this case, the employee has a credible option of developing independently resulting in π_e^o , while the firm's outside option is π_f^o . In the agreement region $\Delta \notin (\Delta_s^d(v, \theta_I), \Delta_c^d(v, \theta_I))$, the firm makes a take-it-or-leave-it offer of $\beta_H \alpha_e v$, which is accepted with probability 1 by the employee. In the disagreement region, $\Delta \in (\Delta_s^d(v, \theta_I), \Delta_c^d(v, \theta_I))$, the firm makes a take-it-or-leave-it offer of $\beta_L \alpha_e v$,

which is accepted by the low type and rejected by the high type. Let $\tilde{\pi}_e^o$ be defined as

$$\tilde{\pi}_e^o(v, \beta_H) = \alpha_e \beta_H v \quad (\text{A-2})$$

$$\tilde{\pi}_e^o(v, \beta_L) = \begin{cases} \beta_H \alpha_e v & \text{if } \Delta \notin (\Delta_s^d(v, \theta_I), \Delta_c^d(v, \theta_I)) \\ \beta_L \alpha_e v & \text{if otherwise} \end{cases} \quad (\text{A-3})$$

Then the employee's expected payoff from the negotiation stage is given by

$$\pi_e^N(v, \Delta, \beta, \theta_I) = \gamma \tilde{\pi}_e^o + (1 - \gamma)(\pi^J - \pi_f^o) \quad (\text{A-4})$$

Thus,

$$\frac{d\pi_e^N(v, \Delta, \beta, \theta_I)}{d\Delta} = \begin{cases} -(1 - \gamma) & \text{if } \Delta < -\frac{1}{g_s}v \\ -(1 - \gamma)(1 - g_s) & \text{if } -\frac{1}{g_s}v < \Delta < 0 \\ (1 - \gamma)(g_c - 1) & \text{if } \Delta > 0 \end{cases}$$

The firm's expected payoff is given by

$$\pi_f^N(v, \Delta, \theta_I) = \begin{cases} (1 - \gamma)\pi_f^o + \gamma(\pi^J - \beta_H \alpha_e v) & \text{if } \Delta \notin (\Delta_s^d(v, \theta_I), \Delta_c^d(v, \theta_I)) \\ (1 - \gamma)\pi_f^o + \gamma[\theta_I \pi_f^o + (1 - \theta_I)(\pi^J - \beta_L \alpha_e v)] & \text{otherwise} \end{cases}$$

Since both π_f^o and π^J are increasing in Δ , it follows that $\frac{d\pi_f^N(v, \Delta, \theta_I)}{d\Delta} > 0$. ■

Proof of Proposition 2. Consider $v_i = 0$. From the proof of Corollary 1, the employee's expected payoff from internal exploration is given by

$$\pi_e^I(0, \Delta, \beta, \theta_I) = \begin{cases} w & \text{if } \Delta \leq \frac{w}{g_c - 1} \\ p(L)[\pi_e^N(0, \Delta, \beta, \theta_I) - w] + w & \text{if } \Delta > \frac{w}{g_c - 1} \end{cases}$$

The employee's payoff from focusing on his core task is $\pi_e^D = w$, and his payoff from external exploration is $\pi_e^E(0, \beta) = 0$. Given that $\pi_e^N(0, \Delta, \beta, \theta_I) > w$ for $\Delta > \frac{w}{g_c - 1}$, the result follows immediately. ■

Proof of Proposition 3. Consider $v_i = v$. The employee's payoff from internal exploration is $\pi_e^I = p(L)[\pi_e^N(v, \Delta, \beta, \theta_I) - w] + w$, where $\pi_e^N(v, \Delta, \beta, \theta_I)$ is given by equation (A-4). Since $\pi_e^N(v, \Delta, \beta, \theta_I) > w$, payoff from internal exploration exceeds the payoff from pursuing the core task and the employee chooses between internal

and external exploration. Moreover, from the proof of Corollary 1, we have

$$\frac{d\pi_e^N(v, \Delta, \beta, \theta_I)}{d\Delta} = \begin{cases} -(1 - \gamma) & \text{if } \Delta < -\frac{1}{g_s}v \\ -(1 - \gamma)(1 - g_s) & \text{if } -\frac{1}{g_s}v < \Delta < 0 \\ (1 - \gamma)(g_c - 1) & \text{if } \Delta > 0 \end{cases}$$

Thus, $\frac{d\pi_e^I}{d\Delta} < 0$ for $\Delta < 0$ and $\frac{d\pi_e^I}{d\Delta} > 0$ for $\Delta > 0$. Then, if $\pi_e^I(v, 0, \beta, \theta_I, L) \geq \pi_e^E(v, \beta)$, the payoff from internal exploration always exceeds the payoff from external exploration, and $\Delta_s^I = \Delta_c^I = 0$. Otherwise, Δ_s^I and Δ_c^I are defined as the solutions of equation (2). Note that since $\frac{d\pi_e^I}{d\Delta} < 0$ for $\Delta < 0$, Δ_s^I is unique and $\pi_e^I(v, \Delta, \beta, \theta_I, L) > \pi_e^E(v, \beta)$ for $\Delta < \Delta_s^I$. By the same token, since $\frac{d\pi_e^I}{d\Delta} > 0$ for $\Delta > 0$, Δ_c^I is unique and $\pi_e^I(v, \Delta, \beta, \theta_I, L) > \pi_e^E(v, \beta)$ for $\Delta > \Delta_c^I$.

To establish Properties (1) and (2), let $\Delta_j^I \neq 0$. It then follows that $D(v, \Delta_j^I, \beta, \theta_I, L) \equiv \pi_e^I(v, \Delta_j^I, \beta, \theta_I, L) - \pi_e^E(v, \beta) = 0$. Then, by Implicit Function theorem, we have $d\Delta_j^I/dL = -\frac{p'(L)(\pi_e^N - w)}{p(L)\partial\pi_e^N/\partial\Delta}$. The numerator is positive due to $p'(L) > 0$ and $\pi_e^N > w$. The denominator is positive for complements and negative for substitutes. Therefore, $\frac{d\Delta_s^I}{dL} > 0$ and $\frac{d\Delta_c^I}{dL} < 0$.

For Properties (3) and (4), note that $\pi_e^N(v, \Delta, \beta_H)$, as given by equation (A-4), is not a function of θ_I , establishing Property (3). To establish Property (4), recall from Proposition 1 that $\Delta_s^d(v, \theta_I)$ ($\Delta_c^d(v, \theta_I)$) is increasing (decreasing) in θ_I . This implies that $\frac{d\Delta_s^I(L, v, \beta_L, \theta_I)}{d\theta_I} = -\frac{p(L)\partial\pi_e^N/\partial\theta_I}{p(L)\partial\pi_e^N/\partial\Delta} \geq (\leq) 0$ for substitutes (complements).

For Properties (5) and (6), note that $D(v, \Delta, \beta, \theta_I, L) = 0$ can be written as

$$p(L)(1 - \gamma)(\pi^J - \pi_e^o) + (1 - p(L))w = p_o\beta v - p(L)\gamma\tilde{\pi}_e^o(v, \beta)$$

where $\tilde{\pi}_e^o(v, \beta)$ is defined by equations (A-2) and (A-3). Note that for $p_o\beta v \leq p(L)\gamma\tilde{\pi}_e^o(v, \beta)$, $\Delta_j^I(L, v, \beta, \theta_I) = 0$. Therefore, we consider the case of $p_o\beta v > p(L)\gamma\tilde{\pi}_e^o(v, \beta)$ for at least one of the types. In this case, it is sufficient to show that the right-hand side is increasing in β . This is straightforward to establish since $\beta_H(p_o - p(L)\gamma\alpha_e)v > \beta_L(p_o - p(L)\gamma\alpha_e)v$. ■

Proof of Proposition 4. By Proposition 3, we have that $\Delta_j^I(L, v, \beta_H)$ is independent of θ_I . We also have that $\Delta_c(L, v, \beta_L, \theta_I) \leq \Delta_c(L, v, \beta_H)$ and $\Delta_s(L, v, \beta_L, \theta_I) \geq$

$\Delta_s(L, v, \beta_H)$ for all θ_I . This implies that both employee types choose internal exploration for $\Delta \notin (\Delta_s^I(L, v, \beta_H), \Delta_c^I(L, v, \beta_H))$. By Bayes' Rule, this implies that the equilibrium belief is $\theta_I^* = \theta$. For $\Delta \in (\Delta_s^I(L, v, \beta_H), \Delta_c^I(L, v, \beta_H))$ the high type always explores externally. Thus, the low type is the only one that may have strict incentives to explore inside the firm.

Given $\theta_I = 0$, the low type would choose internal exploration provided $\Delta \notin (\Delta_s^I(L, v, \beta_L, 0), \Delta_c^I(L, v, \beta_L, 0))$. By Proposition 3, $\Delta_s^I(L, v, \beta_L, \theta_I)$ is non-decreasing in θ_I and $\Delta_c^I(L, v, \beta_L, \theta_I)$ is non-increasing in θ_I , indicating that the incentives for internal exploration are weakly increasing in θ_I . Therefore, $\theta_I^* = 0$ is the unique equilibrium belief that can be supported over regions $\Delta \in (\Delta_s^I(L, v, \beta_H), \Delta_s^I(L, v, \beta_L, 0)]$ and $\Delta \in [\Delta_c^I(L, v, \beta_L, 0), \Delta_c^I(L, v, \beta_H))$.

For $\Delta \in (\Delta_s^I(L, v, \beta_L, 0), \Delta_c^I(L, v, \beta_L, 0))$, the only possible equilibrium is for both types to explore externally. To see this, note that any belief θ_I that results in internal exploration by the low type in the region $\Delta \notin (\Delta_s(L, v, \beta_L, \theta_I), \Delta_c(L, v, \beta_L, \theta_I))$ cannot be supported as an equilibrium — in equilibrium, Bayes' Rule requires $\theta_I = 0$, a contradiction. An off-equilibrium belief $\theta_I^* = 0$ in this region guarantees no deviation incentives by the low type. ■

Proof of Proposition 5.

Let $F(\cdot|v_i)$ denote the conditional distribution of Δ for a given realization of v_i . Then the probability of internal exploration is given by

$$P(L) = \left[(1 - \psi) \left(1 - F \left(\frac{w}{g_c - 1} \middle| 0 \right) \right) \right] + \psi \sum_{\beta} \Pr(\beta) \left[1 - \left(F(\Delta_c^I(L, v, \beta, \theta_I^*)|v) - F(\Delta_s^I(L, v, \beta, \theta_I^*)|v) \right) \right].$$

From Proposition 3, $\frac{\partial \Delta_s^I(L, v, \beta, \theta_I^*)}{\partial L} \geq 0$ and $\frac{\partial \Delta_c^I(L, v, \beta, \theta_I^*)}{\partial L} \leq 0$. Thus,

$$\frac{dP}{dL} = \psi \sum_{\beta} \Pr(\beta) \left[f(\Delta_s^I|v) \frac{\partial \Delta_s^I}{\partial L} - f(\Delta_c^I|v) \frac{\partial \Delta_c^I}{\partial L} \right] \geq 0$$

Next, we consider the likelihood of downstream disagreements. Notice that a necessary condition for disagreements to occur is $\Delta \notin (\Delta_s^I(L, v, \beta_H), \Delta_c^I(L, v, \beta_H))$ because otherwise the high type explores externally and the negotiations never fail. By Proposition 4, $\theta_I^* = \theta$ in this region. Proposition 1 then implies that downstream

disagreements are not possible for $\theta_1^* = \theta \geq \frac{(\beta_H - \beta_L)\alpha_e}{1 - \alpha_f - \beta_L\alpha_e}$ since it then holds that $\Delta_s^d(v, \theta_1^*) = \Delta_c^d(v, \theta_1^*) = 0$. For $\theta_1^* = \theta < \frac{(\beta_H - \beta_L)\alpha_e}{1 - \alpha_f - \beta_L\alpha_e}$, $\Delta_s^d(v, \theta) < 0$ and $\Delta_c^d(v, \theta) > 0$. Downstream disagreements occur if and only if $\Delta \in (\Delta_s^d(v, \theta), \Delta_s^I(L, v, \beta_H, \theta)) \cup (\Delta_c^I(L, v, \beta_H, \theta), \Delta_c^d(v, \theta))$. By Proposition 3, $\Delta_s^I(L, v, \beta_H)$ is increasing in L and $\Delta_c^I(L, v, \beta_H)$ is decreasing in L . Therefore, there exists $\tilde{L} \geq 0$ such that the region of downstream disagreements is non-empty and increasing in L . ■

Proof of Proposition 6. $L^*(\gamma, \alpha_e, \alpha_f)$ is defined as the solution of $\frac{d\Pi_f(L^*)}{dL} = 0$, where $\frac{d\Pi_f(L)}{dL}$ is defined by equation (4). By Implicit function theorem, it is sufficient to establish $\frac{d^2\Pi_f(L^*)}{dLd\sigma} > 0$.

$$\begin{aligned} \frac{d^2\Pi_f(L)}{dLd\sigma} &= E_{v_i, \Delta, \beta} \left[\frac{\partial S_f(v_i, \Delta, \beta, L)}{\partial L \partial \sigma} \Big|_{\Delta \notin (\Delta_s^I, \Delta_c^I)} \right] \\ &+ \psi E_\beta \left[\frac{\partial S_f(v, \Delta_s^I, \beta, L)}{\partial \sigma} f(\Delta_s^I|v) \frac{\partial \Delta_s^I}{\partial L} - \frac{\partial S_f(v, \Delta_c^I, \beta, L)}{\partial \sigma} f(\Delta_c^I|v) \frac{\partial \Delta_c^I}{\partial L} \Big|_v \right] \\ &+ \psi E_\beta \left[\frac{d[S_f(v, \Delta_s^I, \beta, L) f(\Delta_s^I|v)]}{dL} \frac{\partial \Delta_s^I}{\partial \sigma} + S_f(v, \Delta_s^I, \beta, L) f(\Delta_s^I|v) \frac{\partial^2 \Delta_s^I}{\partial L \partial \sigma} \Big|_v \right] \\ &- \psi E_\beta \left[\frac{d[S_f(v, \Delta_c^I, \beta, L) f(\Delta_c^I|v)]}{dL} \frac{\partial \Delta_c^I}{\partial \sigma} - S_f(v, \Delta_c^I, \beta, L) f(\Delta_c^I|v) \frac{\partial^2 \Delta_c^I}{\partial L \partial \sigma} \Big|_v \right] \end{aligned}$$

where we use that fact that for $j = \{s, c\}$,

$$\begin{aligned} &\frac{\partial [S_f(v, \Delta_j^I, \beta, L) f(\Delta_j^I|v)]}{\partial L} + \frac{\partial [S_f(v, \Delta_j^I, \beta, L) f(\Delta_j^I|v)]}{\partial \Delta} \frac{\partial \Delta_j^I}{\partial L} \\ &= \frac{d[S_f(v, \Delta_j^I, \beta, L) f(\Delta_j^I|v)]}{dL}. \end{aligned}$$

Recall from Proposition 3 that $\frac{\partial \Delta_s^I}{\partial L} \geq 0$ and $\frac{\partial \Delta_c^I}{\partial L} \leq 0$. Given Assumption 1, we have that $\frac{d[S_f(v, \Delta_j^I, \beta, L) f(\Delta_j^I|v)]}{dL} \leq 0$ for $j = \{s, c\}$. We proceed in sequence to establish the signs of the remaining variables:

- $\frac{\partial S_f(v_i, \Delta, \beta, L)}{\partial L \partial \sigma} = p'(L) \frac{\partial \pi_f^N(v_i, \Delta, \beta, \theta_1^*)}{\partial \sigma}$, where it can be readily established that $\frac{\partial \pi_f^N(v_i, \Delta, \beta, \theta_1^*)}{\partial \gamma} > 0$, $\frac{\partial \pi_f^N(v_i, \Delta, \beta, \theta_1^*)}{\partial \alpha_f} > 0$ and $\frac{\partial \pi_f^N(v_i, \Delta, \beta, \theta_1^*)}{\partial \alpha_e} < 0$

- $\frac{\partial S_f(v, \Delta_j^I, \beta, L)}{\partial \sigma} = p(L) \frac{\partial \pi_f^N(v, \Delta, \beta, \theta_1^*)}{\partial \sigma}$.
- $\frac{\partial \Delta_j^I}{\partial \sigma} = -\frac{\partial D / \partial \sigma}{\partial D / \partial \Delta}$ for $\Delta_s^I \in [\underline{\Delta}, 0)$ and $\Delta_c^I \in [0, \bar{\Delta})$ where $D(v, \Delta, \beta, \theta_1^*, L) \equiv \pi_e^I(v, \Delta, \beta, \theta_1^*, L) - \pi_e^E(v, \beta)$. Given $\pi_e^I(v, \Delta, \beta, \theta_1^*, L) = p(L)(\pi_e^N(v, \Delta, \beta, \theta_1^*) - w) + w$, we have $\frac{\partial \Delta_j^I}{\partial \sigma} = -\frac{\partial \pi_e^N / \partial \sigma}{\partial \pi_e^N / \partial \Delta}$. It is straightforward to establish that $\frac{\partial \pi_e^N(v, \Delta, \beta, \theta_1^*)}{\partial \gamma} < 0$, $\frac{\partial \pi_e^N(v, \Delta, \beta, \theta_1^*)}{\partial \alpha_f} < 0$ and $\frac{\partial \pi_e^N(v, \Delta, \beta, \theta_1^*)}{\partial \alpha_e} > 0$. Moreover, from Corollary 1, $\frac{\partial \pi_e^N(v, \Delta, \beta, \theta_1^*)}{\partial \Delta} > 0$ for complements and $\frac{\partial \pi_e^N(v, \Delta, \beta, \theta_1^*)}{\partial \Delta} < 0$ for substitutes. Therefore, $\frac{\partial \Delta_c^I}{\partial \gamma} > 0$, $\frac{\partial \Delta_s^I}{\partial \gamma} < 0$, $\frac{\partial \Delta_c^I}{\partial \alpha_f} > 0$, $\frac{\partial \Delta_s^I}{\partial \alpha_f} < 0$, $\frac{\partial \Delta_c^I}{\partial \alpha_e} < 0$, and $\frac{\partial \Delta_s^I}{\partial \alpha_e} > 0$.
- $\frac{\partial^2 \Delta_j^I}{\partial L \partial \sigma} = \frac{\partial}{\partial L} \left[-\frac{\partial \pi_e^N / \partial \sigma}{\partial \pi_e^N / \partial \Delta} \right] = 0$, since π_e^N is not a function of L .

Given the signs of the variables above, it is straightforward to establish that $\frac{d^2 \Pi_f(L^*)}{dL d\sigma} > 0$. ■

Proof of Lemma 1. This proof is contained in Proof of Proposition 6. ■

Notation Table

α_e, α_f	profit eroding effect of competition
$\beta \in \{\beta_H, \beta_L\}$	employee's entrepreneurial ability
$\{D, I\} \in R$	employee's choice given R : Drop the idea vs. Internal exploration
Δ	externality imposed by the idea
e	research employee
E, R	employee's choice: External exploration vs. Remain with firm
f	firm
$g \in \{g_c, g_s\}$	synergies from joint development
γ	probability that firm makes an offer in negotiation stage
L	level of exploration support offered by the firm
ψ	probability that $v_i = v$
θ	firm's prior belief that $\beta = \beta_H$
θ_I	firm's posterior belief that $\beta = \beta_H$
$v_i \in \{0, v\}$	stand alone valuation of the idea
w	competitive wage
p_o	likelihood of successful exploration if idea is pursued outside the firm
$p(L)$	likelihood of successful exploration if idea is pursued inside the firm
$\pi_e^o(\cdot), \pi_f^o(\cdot)$	expected payoffs from independent development after internal exploration
π_e^D	employee's payoff from dropping the idea
$\pi_e^E(\cdot), \pi_f^E(\cdot)$	expected payoffs from external exploration
$\pi_e^I(\cdot), \pi_f^I(\cdot)$	expected payoffs from internal exploration
$\pi^J(\cdot)$	surplus from internal (joint) handling of an explored idea

Table 1: A summary of the notation.