

When do employees become entrepreneurs?

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Abstract

Entrepreneurs often get their ideas from working as employees in established firms. However, employees with ideas can also become intrapreneurs, or even managers of corporate spin-offs. This paper shows how innovation and entrepreneurship are influenced by company policies towards employees. Using a multi-task incentives model, we identify a trade-off between focussing employees on their assigned tasks, versus encouraging their exploration of new ideas. We show how the rate of innovation, and the organizational structure of new ventures (start-ups, spin-offs, internal ventures) depend on factors such as the entrepreneurial environment and the allocation of intellectual property rights.

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Where do entrepreneurs come from? Employees of established companies turn out to be one of the most important source for entrepreneurship. The semiconductor industry, for example, has an impressive genealogy, where, generation after generation, employees left their parent company to launch the next entrant.¹ In a sample of fast-growing private companies, Bhide (1994) finds that “71% of all founders had replicated or modified an idea encountered through previous employment.” Similarly, Cooper (1985) reports in a broad cross section of industries that 70% of all founders pursued opportunities closely related to their previous employment.

A popular response is that established firms are “stupid” to miss out on all these opportunities, although this hardly provides a systematic explanation to economists.² A central tenet of this paper is that the departure of employees to become entrepreneurs can be understood as a natural equilibrium outcome in the process of innovation. Clearly, it is also not the only possible equilibrium outcome. While some firms let their employees go, others develop their innovations internally, turning employees into intrapreneurs. 3M, for example, is famous for its norm of allowing employees to use 15% of their time to develop new ideas. The company also has an objective of generating 25% of its sales from products that are less than five years old (See Bartlett and Mohammed (1995)). Some firms also use their employees’ innovations to found spin-offs. Thermo-Electron is an example of a company that makes extensive use of spin-offs (See Allen (1998)). To get a more complete picture of the supply of entrepreneurs, we need to ask how companies handle employee innovations?

This paper examines the question of when employees become entrepreneurs from an economic theory perspective. It jointly addresses the two fundamental questions of when employees generate innovations, and whether they are developed inside or outside the firm. The analysis is based on four key ingredients:

1. *Employee-driven innovations:* Our analysis is concerned with employees working in a company’s main line of business, rather than employees specifically hired for R&D.³ As part of their regular activities, employees serendipitously obtain new ideas, that fall outside their assigned line of business. The attraction of exploring these ideas is that employees may identify innovations that generate economics rents, that they could never hope for by sticking to their assigned employment tasks. But while employees may view these ideas as opportunities,

¹The “traitorous eight” left Shockley Labs to create Fairchild Semiconductor, which itself saw its employees starting, among others, National Semiconductor, Intel, AMD and LSI Logic, which in turn became parents to Cypress, Zilog, Sierra Semiconductor and many other semiconductor companies.

²This “stupidity” notion has been popularized by Smith and Alexander (1999), who describe how Xerox “fumbled the future” by not capitalizing on some of its inventions for the personal computer, such as the mouse. Interestingly, Smith and Alexander put little emphasis on the fact that Xerox’s main line of business was photocopiers, which was highly successful and profitable firm during this period. Chesbrough (2003) provides a more thoughtful analysis of the Xerox experience.

³This distinction also exists in the law, which differentiates between employees that are hired to invest, and others.

the firm may view them as distractions, as employees exploring their ideas may lose focus on the core tasks that sustain the firms' existing lines of business.

Our model distinguishes between ideas, innovations and new ventures. As part of their regular employment activities, employees sometimes get new ideas. To turn them into innovations, they need to explore these ideas, assessing their technical and/or commercial viability. This exploration stage consists of so-called "skunkwork," where employees quietly focus on their own project, rather than on what the boss wants. While the original encounter with ideas is complementary to regular employment activities, the exploration of ideas is thus a substitute. We model the trade-off between focussing on the assigned employment tasks versus exploring new ideas as a multi-task problem. If an idea is found to be viable, we call it an innovation. At this point it requires resources to be developed into a new venture. Resources may be provided by the firm. Hence the employee becomes an intrapreneur. Or the employee develops the innovation with outside resources, such as venture capital, thus becoming an entrepreneur.

2. *Endogenous corporate strategy*: Strategic management scholars often argue that firms face a fundamental trade-off between exploitation and exploration. When they focus on exploiting incremental improvements in their core businesses, they often miss opportunities outside that core focus.⁴ In our model, firms can influence how much their employees focus on core tasks versus new ideas. In addition to setting monetary incentives, firms devise policies towards the development of employee innovations. They can either promote exploration by offering to develop innovations, or they can promote exploitation by blocking the development of innovations that fall outside their core focus.
3. *Differences in the entrepreneurial environment*: Economic geography scholars note that the supply of entrepreneurs differs widely across different environments. Saxenian (1994) credits the success of Silicon Valley largely to its fluidity in the labor market, and the ease of starting new companies. Empirically studies confirm that employment mobility and the rate of start-ups is significantly higher in Northern California than anywhere else.⁵ Our model parameterizes the entrepreneurial environment through the attractiveness of developing an innovation with outside resources. An important part of the analysis is to explain how this parameter affects the behavior of employees and firms. We first take the environment exogenously given, and then show how to endogenize it.
4. *Alternative regimes of intellectual property rights*: Legal scholars argue that

⁴See, for example, Burgelman and Sayles (1986), Christensen (1997), Henderson and Clark (1990), March and Olsen (1991), or Tushman and Anderson (1986).

⁵See Almeida and Kogut (1999), Gompers, Lerner and Scharfstein (2003) and Klepper and Sleeper (2002).

yet another important factor is the intellectual property regime. Gilson (1999) shows that Californian courts do not enforce non-compete clauses, even if voluntarily agreed upon. Hyde (1998) emphasizes a employee-friendly attitude of Californian courts with respect to trade secret laws. Our analysis considers two main regimes, where intellectual property rights either belong to the employee or to the firm. An extension considers imperfect intellectual property protection, where employees may go ahead even without formally owning the intellectual property.

Table 3 summarizes all the main results of the paper. The central tenet is that the rate of innovation, and the rate at which employees become entrepreneurs or intrapreneurs, depends critically on firm strategies, the entrepreneurial environment, and the intellectual property regime. We first show that as long as firms own the intellectual property rights, they prefer a strategy of exploitation. In order to focus employees on their core tasks, firms refuse to develop other innovations. In equilibrium, there is no exploration of new ideas.

If the employee owns the intellectual property rights, and the external environment is inhospitable to entrepreneurs, the same equilibrium occurs. However, as the entrepreneurial environment improves, exploring ideas becomes more tempting. An equilibrium occurs, where employees sometimes generate innovations, even though the firm does not support this. The employees always take their innovations outside, even though internal venturing would sometimes be more efficient. An interesting model prediction is that employees leave firms when they perceive weak prospects for the firm's core activities. Gompers, Lerner and Scharfstein (2003) provide empirical evidence that "spawning" rates increases when firms are facing a slow-down in their main lines of business.

If the entrepreneurial environment improves even further, firms can no longer stem the "entrepreneurial tide." They "go with the flow" by offering to develop their employees' innovations. Employees make efficient choices between becoming intrapreneurs or entrepreneurs. This equilibrium mirrors the experiences of many established companies at the height of the Internet boom. Rather than focussing on their "old economy" tasks, employees were much more interested in exploring their own "new economy" ideas. Firms responded to the growing number of departing employees by setting up a variety of internal venturing programs.⁶

Giving employees intellectual property rights thus increases the rate of innovation and start-ups. But that alone does not make it socially efficient. The model derives a fundamental trade-off between promoting innovation by giving rights to employees, versus protecting value generation in existing businesses by giving rights to firms.

⁶McKinsey, for example, instituted an incubator facility (called the McKinsey accelerator), to retain talented employees that wanted to pursue ventures unrelated to its core consulting business. Needless to say with the bursting of the Internet bubble, the activities of the accelerator severely slowed down.

We show that neither allocation of intellectual property rights achieves the first-best equilibrium, nor does either regime clearly dominate the other.

An extension of the model recognizes that intellectual property rights may be imperfect. Even if firms formally own the intellectual property rights, employees may still find ways around them. We show that as long as firms want to discourage exploration, they refuse to cooperate with departing employees. In equilibrium firms may even go after departing employees with costly lawsuits. This matches Jackson's (2000) account of how Intel treated its departing employees with great hostility, including hitting them with vengeful lawsuits. Also consistent with the model, Burgelman (2003) shows how during this period, Intel was committed to a focus strategy, at the expense of exploring new ideas. On the other hand, if firms are open to exploration, they can also coopt their employees' innovations by doing internal ventures or "spin-offs."⁷ This matches Chesbrough's (2003) description of how in the nineties Xerox implemented a corporate venturing program to make the best of its employee's innovations, sorting them into those best organized as internal ventures or spin-offs.

Our model provides a unified framework for analyzing the different ways in which ideas are turned into new venture. With this, it dispels two popular fallacies about the role of intellectual property rights. One fallacy is that intellectual property rights *pre-determine* how ideas are turned into ventures. That is, if firms have the rights, they develop innovations internally, and if employees have the rights, they start their own firms. Our results challenge this view: internal ventures may occur when employees have the intellectual property rights, and spin-offs may occur when firms have the rights. The second fallacy is that intellectual property rights are *irrelevant*. The Coase theorem does not apply here because the firm may commit to a corporate strategy that involves deliberate ex-post inefficiencies, and because the optimal strategy depends on the allocation of intellectual property rights.

A different reason why firms may be hostile to departing employees is if the new ventures cannibalize the firms' existing profits. Firms may respond to the threat of cannibalization in two distinct ways. One response is ex-ante prevention, discouraging the exploration of ideas in the first place. The other response is to strike deals with departing employees, to shelve those innovations that inefficiently cannibalize existing profits. We show that firms may resort to either of these two strategies, although they will never use them jointly.

A final extension of the model examines the interrelationship between firm strategies and the entrepreneurial environment. It suggests that there may be multiple equilibria with varying degrees of entrepreneurial activity. If few (many) employees become entrepreneurs, there are few (strong) incentives for others to invest developing the entrepreneurial infrastructure. Venture capitalists, for example, are unlikely

⁷We reserve the term "spin-off" to describe the case where an innovation is developed with outside resources, but with the cooperation of the old firm. For example, the old firm may grant access to the intellectual property, in return for an equity stake. We distinguish this from "start-ups," where the external ventures has no formal link to the old firm.

(likely) to locate in a location where there are few (many) entrepreneurs. But if the entrepreneurial infrastructure is weak (strong), employees face little (much) temptation to explore their ideas. Firms find it easy (difficult) to focus their employees, and few (many) employees become entrepreneurs, thus reinforcing the equilibrium. This line of reason agrees with the observation that some environments, like Silicon Valley, witness not only an active venture capital market, but also a constant flux of people leaving established firms to create new ones, whereas other environments, such as Japan or parts of Europe, witness both a weak venture capital market and few employees leaving established firms to become entrepreneurs.

This paper concerns the supply of entrepreneurship, which has received surprisingly little attention in the economics literature. Nonetheless, the paper builds on a diverse set of related literatures. First, there is a growing number of papers about the trade-off between internal versus external venturing. Pakes and Nitzan (1983) examine the efficient development decision when there is a potential for cannibalization. Anton and Yao (1994, 1995) look at the role of weak property rights. Gromb and Scharfstein (2001) consider the effect of a stigma of failure. Amador and Landier (2003) examine entrepreneurial optimism. Hellmann (2002) analyzes the value-added support of a strategic versus independent venture capitalist. And Cassiman and Ueda (2002) focus on the opportunity cost of committing to one venture, at the expense of all others. All these papers take the generation of ideas as given. Aghion and Tirole (1994, 1997), Anand and Galetovic (2000), and Gans and Stern (2000) consider models of incomplete contracts where a hold-up at the development stage may influence investment decisions at the innovation generation stage.

The current paper differs from all of the above in several important respects. It considers a larger set of development alternatives, explaining start-ups (with or without intellectual property rights), internal ventures, spin-offs, and even the shelving of an innovation. It uses a multi-task incentive framework to characterize the employee's incentive problem (Holmström and Milgrom, 1994). The analysis does not rely on incomplete contracts. And most importantly, this paper introduces corporate strategy into the analysis. This approach builds on the work by Rotemberg and Saloner (1994), who examine the benefits of narrow business strategy.

A few recent papers also discuss the importance of employee mobility for innovation. Rajan and Zingales (2002) examine how the threat of employee departures affects firm's hiring decisions. Lewis and Yao (2001) examine how firms can attract talented employees that value mobility. Hellmann and Perotti (2003) show how firms can be thought of as deliberate boundaries on the circulation of ideas, so that the role of firms is to prevent employees from appropriating each other's ideas. Lester and Talley (2000), Merges (1999) and Talley (1998) raise legal and normative issues of employee departures, weighing up a employee-friendly perspective that employees should be entitled to the fruits of their own creativity, against a firm-friendly perspective that employees should not develop their business ideas at the employers' expense. The paper is also related to the literature on internal resource allocation (Gertner,

Scharfstein and Stein, 1994). Finally, there is a separate literature on spin-offs, and how they affect employee incentives (Aron, 1991).

The remainder of the paper is structured as follows. Section 1 develops the basic model. Section 2 derives optimal firm policies under alternative intellectual property regimes. Section 3 examines the efficiency of the intellectual property regimes. Section 4 expands the analysis to imperfect intellectual property rights. Section 5 considers the problem of cannibalization. Section 6 explains multiple equilibria. It is followed by a brief conclusion. All proofs are in the appendix.

1 Model

Suppose there is a wealth-constrained employee, denoted by E , and a firm, denoted by F . At date 0 an employment contract is drafted. At date 1 the employee may serendipitously obtain a new idea. She has a choice about whether to explore the idea or to focus on her assigned employment task. If she explores her idea, she discovers at date 2 whether or not the idea is feasible. If it is feasible, the idea can be developed inside or outside the firm. All returns accrue at date 3. All parties are risk-neutral profit maximizers. There is no discounting.

As part of her regular job activities, the employee may serendipitously get a new idea, that falls outside the established line of business. When she gets such an idea, she can choose to ignore or explore it. We model this as a multi-task problem, where she can focus either on project A or B .

A denotes the assigned employment task, which may include a large variety of activities that improve the firm's current core businesses. If successful, the assigned task generates a value a , which is entirely captured by the firm. At date 1, the employee has a binary signal about the likelihood of success: either the prospects for the core task are "strong," so that success is certain; or they are "weak," so that the probability of success is given by $\phi < 1$.

B represents exploring a new idea. There are two stages to turning an idea into a successful venture: exploring the idea and developing the innovation. If the employee explores her idea at date 1, she finds out at date 2 whether it is feasible (which occurs with probability p) or not. If it is not feasible, all parties receive zero utility. If it is feasible, we call the idea an innovation. A development effort is then required to generate value from the innovation. The employee has a unique skill for - or understanding of - the innovation, so that she is indispensable for its development.⁸ The attraction of exploring an idea is that generating an innovation propels the employee into a unique position, where she might be able to extract some rents. This she cannot do by merely sticking to her assigned employment tasks.

If the idea is feasible at date 2, all parties observe the expected returns from

⁸This assumption eliminates the issue of whether the idea leads to the creation of one or two ventures. Anton and Yao (1994, 1995) provide an extensive analysis of this problem.

developing it. We denote these expected returns by $y(x)$ for an internal (external) development. The expected return y itself is random, with a distribution $\Omega(y)$. For simplicity, we let x be a constant. At date 1 the total expected returns from exploring an idea are given by $p\mu$ where

$$\mu \equiv \int_0^\infty \text{Max}[x, y]d\Omega(y).$$

At date 1, the employee can be in any of four distinct states:

States at Date 1	Weak core signal	Strong core signal
Employee has an idea	State 1	State 2
Employee has no idea	State 3	State 4

For simplicity, we assume that all four states are equally likely. In states 3 and 4, the employee can only pursue her core task. But in states 1 and 2, she has to choose between focusing on her assigned task (A) or exploring her idea (B). We can thus distinguish three levels of exploration:

No exploration (σ^-)	Employee never explores ideas
Healthy exploration (σ^*)	Employee explores ideas in state 1 but not in state 2
Excessive exploration (σ^+)	Employee explores ideas in state 1 and in state 2

As our vocabulary suggests, we assume that it is efficient to explore in state 1, where the prospects of the core are weak, but not in state 2, when the core prospects are strong. Formally,

$$\phi a < p\mu < a.$$

Since μ is increasing in x , this condition also defines the feasible range of x . The upper boundary is given by \bar{x} , where \bar{x} satisfies $p\mu(\bar{x}) = a$. The lower boundary is simply $x = 0$, provided that $\phi a < p\mu(x = 0)$, which we assume throughout.

An important part of the analysis is to examine the firm's commitments about developing employee innovations. Let D_y and D_x be dummies for whether an innovation is developed internally or externally. D_y and D_x may depend on y . And $D_y = D_x = 0$ means that the project is "shelved," i.e., not developed at all. To implement an innovation internally, the firm still needs the employee. This gives the employee some hold-up power. They bargain according to the Nash solution. The firm can pay her share of the internal development in a variety of ways, such as with an internal equity stake, or a transfer payment that can be thought of as a retention bonus.

We assume that all value realizations are verifiable, so that contracts can be made contingent on them. Specifically, if the employee generates no value in the core, nor any innovation, the firm may reward this with a transfer payment w_\emptyset . If she generates value in the core, but no innovation, the firm may reward this with w_A . And if she generates no value in the core, but an innovation, the firm may reward this with

a transfer w_B . (This would be in addition to the retention bonus from bargaining mentioned above.) In principle, the reward w_B may also depend on the signal y , or the development decision (D_y, D_x) . We will see that in equilibrium we always have $w_B = 0$, so that any such additional conditioning is not needed anyway. Since the employee is wealth constraint, all transfers are from the firm to the employee.

At the risk of repeating ourselves, we summarize the information structure of the game. At date 0, the firm and the employee have symmetric information. Conditional on their information, they write a complete contract. At date 1, the employee privately observes the state. She privately chooses whether to focus on the core task (A) or to explore her idea (B). At date 2, the employee's idea is revealed to be feasible or not. If feasible, both parties symmetrically observe the expected values x and y . All returns accrue at date 3 and are divided according to the contract.

There are two regimes of intellectual property rights: the employee-friendly regime (denoted by EIP) where innovations belong to the employee, and the firm-friendly regime (denoted by FIP) where innovations belong to the firm. For expositional convenience, we assume that the intellectual property regime is exogenously given. At the end of section 3 we discuss what happens when intellectual property rights can be transferred. Section 4 expands these regimes by looking at imperfect property rights (denoted by IIP).

Table 1 depicts the time line. Table 2 summarizes the key notation. Table 3 provides an overview of the main results. To remain tractable, the model abstracts from at least two empirically relevant issues. First, the model assumes that ex-ante all employees are the same, abstracting from issues of self-selection at the hiring stage. Second, it assumes that the expected values of an innovation are symmetrically known, excluding issues of disagreement or self-selection at the development stage. However, these omissions may also be viewed as a strength, in so far as the analysis does not rely on these additional complications.

2 Optimal firm policies

2.1 The employee-friendly regime

Suppose the employee has the intellectual property rights. She can always develop the innovation outside, if the firm chooses not develop it inside. No innovation is ever shelved. If the innovation is developed outside, the employee obtains x . This is also her outside option when bargaining with the firm over an internal venture. The Nash bargaining values are thus $x + \frac{y-x}{2}$ for the employee and $\frac{y-x}{2}$ for the firm. Naturally, internal ventures never occur for $y < x$.

Consider now the employee's utilities from choosing A or B . At date 1, her utility of focusing on her assigned task (A) is given by w_A in state 2 and $\phi w_A + (1-\phi)w_\emptyset$ in state 1. She compares this with the expected utility of exploring her idea (B). This

depends on the firm's development policy. It is useful define

$$\delta = \int_x^\infty (y - x) D_y(y) d\Omega(y)$$

δ measures the total benefit from a "cooperative" development policy, where the firm develops innovations inside, when it is efficient to do so. The expected utilities from exploring an idea are given by

$$b^E = px + p\frac{\delta}{2} + pw_B + (1 - p)w_\emptyset \text{ and } b^F = p\frac{\delta}{2} - pw_B - (1 - p)w_\emptyset.$$

And the employee's incentive constraints are given by $w_A \geq b^E$ in state 2 and $\phi w_A + (1 - \phi)w_\emptyset \geq b^E$ in state 1.

To derive the firm's optimal policy, we calculate the ex-ante utility for each of the three exploration levels. We denote the firm's ex-ante utilities by U_F^- , U_F^* and U_F^+ . It is easy to verify that the firm never wants to compensate failure, so that $w_\emptyset = 0$. We use this throughout the analysis.

Suppose now the firm wants to implement an equilibrium with no exploration (σ^-). The incentive compatibility constraints are given by $\phi w_A \geq b^E$ and $w_A \geq b^E$. The lowest value of w_A satisfying these constraints is $w_A^- = \frac{b^E}{\phi}$. U_F^- is found by

adding utilities across the four states, so that $U_F^- = \frac{2 + 2\phi}{4}(a - w_A^-)$. The effect of increasing w_B is to increase b^E , which in turn increases w_A^- . The firm therefore always prefers to set $w_B = 0$. Similarly, the effect of developing innovations internally (i.e., setting $D_y(y) = 1$) is to increase δ , which increases b^E and thus w_A^- . The firm therefore commits not to develop any of its employees innovations, setting $D_y(y) = 0 \forall y$.

To implement σ^* , the incentive compatibility constraints are given by $\phi w_A < b^E$ and $w_A \geq b^E$. $w_A^* = b^E$ is the lowest value of w_A to satisfy these constraints. Again, setting $w_B = 0$ ensures the lowest possible value of b^E . Using $w_A^* = b^E = p(x + \frac{\delta}{2})$, the firm's ex-ante utility is now given by $U_F^* = \frac{p\delta}{4} + \frac{2 + \phi}{4}(a - p(x + \frac{\delta}{2}))$. There are two effects to a policy of developing innovations internally. Increasing δ (by setting $D_y(y) = 1$) benefits the firm in state 1, where the employee actually explores her ideas. But it costs the firm in all other states, because a higher δ necessitates greater incentives for the core task (w_A^*). From $\frac{dU_F^*}{d\delta} = -\frac{1 + \phi p}{4} \frac{p}{2} < 0$, we recognize that the costs outweigh the benefits. It follows that $D_y(y) = 0$ is optimal for all y . The firm finds it optimal to refuse all internal development, even though it loses some profitable opportunities.⁹

⁹Because the firm is able to commit, there is no renegotiation. In the working paper version we show how this commitment can be derived from a credibility condition in a repeated game.

For σ^+ , the incentive compatibility constraints are given by $\phi w_A < b^E$ and $w_A < b^E$. Clearly $w_A^+ = 0$ and again $w_B = 0$. We have $U_F^+ = \frac{p\delta}{2} + \frac{1+\phi}{4}a$. From $\frac{dU_F^+}{d\delta} = \frac{p}{4} > 0$, we note that the optimal development policy is $D_y(y) = 1$ for all $y \geq x$. Once the firm is resigned to the fact that the employee explores all of her ideas, it no longer needs to provide incentives. The net benefits of cooperating through internal ventures are then given by $\delta = \int_x^\infty (y-x)d\Omega(y) = \mu - x$.

Proposition 1 (Optimal contracts for different exploration levels)

- To implement an equilibrium with no exploration (σ^-), the firm sets strong incentives for the core task ($w_A^- = \frac{px}{\phi}$), refuses to implement any internal ventures ($D_y = 0 \forall y$), and achieves an ex-ante utility of $U_F^- = \frac{2+2\phi}{4}(a - \frac{px}{\phi})$.
- To implement an equilibrium with healthy exploration (σ^*), the firm sets some incentives for the core task ($w_A^* = px$), refuses to implement any internal ventures ($D_y = 0 \forall y$), and achieves an ex-ante utility of $U_F^* = \frac{2+\phi}{4}(a - px)$.
- To implement an equilibrium with excessive exploration (σ^+), the firm provides no incentives for the core task ($w_A^+ = 0$), seizes all opportunities for internal ventures ($D_y = 1 \forall y \geq x$), and achieves an ex-ante utility of $U_F^+ = \frac{p\mu - x}{2} + \frac{1+\phi}{4}a$.

Proposition 1 shows that the firm has a fundamental choice between fighting or accommodating the employee's desire to explore her own ideas. To implement σ^- or σ^* , the firm has two levers. It can provide incentives for the core task (setting $w_A > 0$), and it can refuse to develop innovations internally (setting $D_y = 0$). By contrast, when implementing σ^+ , the firm is effectively resigned to accept all exploration. It no longer tries to set incentives for the core task, but makes the best of the innovations through internal ventures.

An interesting difference is that for σ^+ , employees become entrepreneurs if and only if they prefer it over becoming intrapreneurs. By contrast, for σ^* , it may be that employees become entrepreneurs, even though they would prefer to become intrapreneurs.

Another interesting difference concerns σ^- and σ^* . For σ^- , the firm has a policy of not developing innovation inside. In equilibrium this policy is never tested, since

the employee never explores her ideas . By contrast, under σ^* the firm's policy of not developing innovations inside is constantly tested in equilibrium.

So far we contrasted the three policies that the firm might pursue. We now explain when each of them is optimal. We focus on the external environment as a key determinant. The more hospitable the environment is to entrepreneurs, the higher the expected return for taking innovations outside. We capture this as a comparative static of x . Figure 1 illustrates how U_F^- , U_F^* and U_F^+ depend on x . In the appendix we show that $\frac{dU_F^-}{dx} < \frac{dU_F^*}{dx} < \frac{dU_F^+}{dx} < 0$. This says that higher returns for developing ideas outside (higher x), are most costly for the firm if it wants to prevent all exploration (σ^-), less costly if the firm tolerates a healthy amount of exploration (σ^*), and least costly if the firm accepts all exploration (σ^+).

To describe the firm's optimal policies, we define \hat{x}_- as the critical value of x , below which the firm prefers σ^- over σ^* , and above which the firm prefers σ^* over σ^- . Formally, we obtain \hat{x}_- from $U_F^*(\hat{x}_-) = U_F^-(\hat{x}_-)$. We also define \hat{x}_+ and \hat{x}_* analogously. In the appendix we show that there exists $\hat{\phi} \in (0, 1)$, so that $\phi < \hat{\phi} \Leftrightarrow \hat{x}_- < \hat{x}_+ < \hat{x}_*$ and $\phi > \hat{\phi} \Leftrightarrow \hat{x}_- > \hat{x}_+ > \hat{x}_*$. Unless specified otherwise, our exposition focuses on the case of $\phi < \hat{\phi}$, which is the more revealing case. (The appendix develops proofs for all values of ϕ .)

Proposition 2 (Optimal policies under EIP)

- For $x < \hat{x}_-$, the firm implements σ^- . In equilibrium there is no idea exploration, so employees never become entrepreneurs or intrapreneurs.
- For $\hat{x}_- < x < \hat{x}_+$, the firm implements σ^* . In equilibrium there is a healthy level of exploration. But the firm refuses to make any internal ventures. Employees with innovations always become entrepreneurs.
- For $x > \hat{x}_+$, the firm implements σ^+ . In equilibrium there is excessive exploration. The firm offers to do internal ventures. Employees with innovations become either entrepreneurs (for $y < x$), or intrapreneurs (for $y \geq x$).

Proposition 2 shows how the entrepreneurial environment influences both the employee's choices and the firm's optimal strategies. If the external environment is inhospitable to entrepreneurs (i.e., $x < \hat{x}_-$), it is easy for the firm to provide incentives that keep the employee focussed on her core tasks. In equilibrium, she does not explore her ideas and no innovations are generated. As the entrepreneurial environment improves ($\hat{x}_- < x < \hat{x}_+$), the temptation to explore ideas becomes stronger. The firm still rewards core tasks, and discourages exploration by refusing internal ventures. But these incentives work only if the core prospects are strong.

If the core prospects are weak, the employee explores her ideas. In equilibrium, her innovations are always developed outside, even if internal venturing is more efficient. If the entrepreneurial environment improves even further ($x > \hat{x}_*^+$), the firm can no longer “stem the entrepreneurial tide.” It decides to “go with the flow,” no longer attempting to curtail the employee’s drive for exploration, but making the best of it by agreeing to internal ventures.

The analysis for $\phi > \hat{\phi}$ is very similar. The main difference is that for $\phi > \hat{\phi}$, there is relatively little distinction between weak and strong prospects, so that the firm wants to implement the same outcome across these two states. This means implementing either σ^- (for $x < \hat{x}_-^+$) or σ^+ (for $x > \hat{x}_-^+$), but not σ^* . The model with $\phi > \hat{\phi}$ can be thus thought of as a special case of the model with $\phi < \hat{\phi}$ without the region σ^* .

The model has some intuitive comparative statics. In the appendix we show that the critical values of x are all increasing in a and $-p$. This means that a higher return to the core task (high a), or a lower return to idea exploration (low p) expand the range of parameters where σ^- is optimal. It also shrinks the range of parameters where σ^+ is optimal. The range where σ^* is optimal shrinks on the low end, but expands on the high end.

2.2 The firm-friendly regime

Suppose the firm holds the intellectual property rights. It can use them to shelve the project ($D_x = D_y = 0$). Alternatively, it can develop the innovation internally ($D_y = 1$) or through a spin-off ($D_x = 1$). Without intellectual property rights, the employee has no outside option. For an internal (external) development, the employee and the firm both get $\frac{y}{2}$ ($\frac{x}{2}$). The expected utilities from exploring an idea are given by $b^E = b^F = p\frac{\delta}{2}$ where $\delta = \int_0^\infty [yD_y(y) + xD_x(y)]d\Omega(y)$. Again, $w_\emptyset = w_B$ holds for the same reasons as before. In the appendix we rederive the optimal strategies.

Proposition 3 (Optimal policies under *FIP*)

If the firm has the intellectual property rights, it implements σ^- , setting $w_A^- = 0$ and refusing to develop innovations ($D_y(y) = D_x(y) = 0 \forall y$).

Proposition 3 is a strong and somewhat surprising result. The firm uses the intellectual property rights to shelve all the innovations. This discourages idea exploration in the first place. That is, the firm’s policy of shelving innovations helps to focus its employees on the core business. It is interesting to note that the optimal policy in the *FIP* model closely resembles the optimal policy with $x = 0$ in the *EIP* model. In either case the employee is essentially powerless, and therefore gets discouraged from exploring her own ideas.

3 Efficiency

Comparing proposition 2 and 3 we recognize that the allocation of intellectual property rights can have a dramatic effect both on the generation and development of innovations. One may be inclined to argue that the firm-friendly regime is inefficient, because it undermines innovation. However, to assess the efficiency of the two regimes, we also need to take into account the value lost on core tasks.

It is easy to verify that neither regime Pareto-dominates the other: the employee is always better off under *EIP*, and the firm is always better off under *FIP*. We focus on the standard efficiency criterion of maximizing the sum of utilities $U_F + U_E$. The first-best efficient outcome occurs when the employee explores in state 1, but focuses on the core task in all other states; and when innovations are developed inside if $y \geq x$ and outside if $y < x$. We immediately note that neither allocation of intellectual property rights ever achieves this first-best efficient outcome.

We proceed to compare the second-best social efficiencies of *EIP* and *FIP*. We focus on the net welfare gain of allocating the intellectual property rights to the employee, which we denote by $\Gamma = (U_E + U_F)_{EIP} - (U_E + U_F)_{FIP}$. Since the firm always implements σ^- in the *FIP* model, Γ depends mainly on the equilibrium in the *EIP* model. For σ^+ in the *EIP* model, we have $\Gamma^+ = \frac{p\mu}{2} + \frac{1+\phi}{4}a - \frac{2+2\phi}{4}a = \frac{p\mu}{2} - \frac{1+\phi}{4}a$. The fundamental trade-off is that *FIP* enables too little exploration, whereas *EIP* generates too much. Put differently, under *FIP* the firm focuses too much on generating value in the core, whereas under *EIP* there is too little focus on the core tasks. For σ^* in the *EIP* model, we have $\Gamma^* = \frac{px}{4} + \frac{2+\phi}{4}a - \frac{2+2\phi}{4}a = \frac{px}{4} - \frac{\phi}{4}a$. Here we encounter a slightly different efficiency trade-off. Again, *FIP* engenders too little exploration. But now the problem with *EIP* is development, namely that the firm has a socially inefficient policy of refusing internal ventures. Proposition 4 formally evaluates these efficiency trade-offs.

Proposition 4 (Efficiency comparisons)

- The first-best efficient equilibrium is never achieved
- If the firm implements σ^- under *EIP*, then $\Gamma^- = 0$.
- If the firm implements σ^* under *EIP*, then Γ^* is increasing in x , with $\Gamma^* < 0$ for $x < x_\Gamma^*$, and $\Gamma^* > 0$ for $x > x_\Gamma^*$, where x_Γ^* satisfies $\hat{x}_-^* < x_\Gamma^* \leq \hat{x}_+^*$.
- If the firm implements σ^+ under *EIP*, then Γ^+ is increasing in x , with $\Gamma^+ < 0$ for $x < x_\Gamma^+$, and $\Gamma^+ > 0$ for $x > x_\Gamma^+$, where x_Γ^+ satisfies $\hat{x}_-^+ \leq x_\Gamma^+ < \bar{x}$.

The two main insights from proposition 4 are first that neither regime achieves a first-best efficient outcome, and second that there is no clear second-best ranking between *EIP* and *FIP*. For some parameters one regime dominates, and for other parameters the other dominates. Within the σ^* region, lower values of x favor *FIP* whereas higher values of x favor *EIP*. Same for the σ^+ region.

So far we assumed that intellectual property rights cannot be transferred. In many cases, this is a reasonable assumption. Californian courts, for example, do not enforce non-compete clauses, irrespective of whether employees voluntarily agreed to them or not. Nonetheless let us briefly consider the case where intellectual property rights can be transferred. If the firm has the intellectual property rights, then it never transfers them to the employee in this model, because the employee has no wealth for trading. But if the employee has the intellectual property rights, and $\Gamma < 0$, then she would like to sell them to the firm. Proposition 4 shows that the employee would sell them for $x < x_F^*$ in an σ^* equilibrium, and for $x < x_F^+$ in an σ^+ equilibrium.

Clearly our analysis depends on the assumption that the employee is wealth constrained. If this is not the case then it is easy to show that the firm always implements the first-best outcome. The reason for this is that we have kept the model sufficiently simple. Without wealth constraints there are no other costs of providing incentive. To examine a non-trivial model without wealth constraints, we would have to further complicate the model by recognizing other incentive costs, presumably related to informational imperfections or risk-aversion. See Gibbons (1998) for an excellent survey of the vast literature on incentives and their costs.

4 Imperfect protection

4.1 The extended model

So far the model assumes that intellectual property protection is fully effective, so that if the firm owns the intellectual property rights, it can fully prevent the employee from developing the innovation. We now relax this assumption, recognizing that intellectual property protection is imperfect. For example, if intellectual property rights involve patents, the employee may be able to work around them. If they involve trade secrets, the employee may still develop her innovation, just without using the trade secrets. And if intellectual property is protected by non-compete clauses, the employee may be able to develop her innovation outside the clause's scope, such as waiting out the duration of the clause, or leaving its geographic scope.

We provide an extension of the model where intellectual property rights are imperfect. For this, we assume that the firm formally owns the intellectual property rights. As before, the firm and the employee can cooperate on developing the innovation outside, as a spin-off, and obtain a return x . But in addition, we now allow for the possibility that the employee may develop the innovation as a start-up. This means that the employee proceeds without the firm's cooperation, and without owning the

intellectual property rights. We assume that her expected returns from a start-up are given by λx , where $\lambda \in [0, 1]$ measures the degree to which the intellectual property rights are imperfect. For $\lambda = 0$, intellectual property rights are perfect, so that the employee cannot achieve any returns without them. In this case, the model is equivalent to the *FIP* model. For $\lambda = 1$, intellectual property rights are useless, since the employee can achieve the same returns with or without them. In this case, the model is equivalent to the *EIP* model.

The possibility of developing the innovation on her own improves the employee's bargaining power. For internal ventures the Nash bargaining values are given by $\lambda x + \frac{y - \lambda x}{2}$ for the employee and $\frac{y - \lambda x}{2}$ for the firm. The higher λ , the better (worse) off the employee (firm). Similarly, in case of a spin-off, the Nash bargaining values are given by $\lambda x + \frac{x - \lambda x}{2}$ for the employee and $\frac{x - \lambda x}{2}$ for the firm. The firm's value can be realized with an equity stake of $\frac{1 - \lambda}{2}\%$, that the firm gets in return for granting access to the intellectual property. In the appendix we derive the equilibria for this model.

Proposition 5 (Optimal policies under IIP)

- For $x < \text{Min}[\hat{x}_-, \hat{x}_+]$, the firm implements σ^- . There is no idea exploration.
- For $\hat{x}_- < x < \hat{x}_+$, the firm implements σ^* . There is a healthy level of exploration, but the firm refuses to cooperate on any development. In equilibrium, employees become entrepreneurs without the firm's cooperation or intellectual property rights.
- For $x > \text{Max}[\hat{x}_*, \hat{x}_-]$, the firm implements σ^+ . There is excessive exploration. The firm develops innovations either as internal ventures (for $y < x$), or as spin-offs (for $y \geq x$).
- The critical values \hat{x}_- , \hat{x}_* and \hat{x}_+ are decreasing in λ , as depicted in figure 2.

For low λ , the model behaves like the *FIP* model, where the firm finds it optimal to prevent all idea exploration. For high λ , the model is similar to the *EIP* model. Generally, the range where the firm prevents all exploration (σ^-) is decreasing in λ . And the range of excessive exploration (σ^+) is increasing in λ . Overall, we find that higher values of λ encourage innovation, as shown in figure 2.

We need to be careful, however, that in the *IIP* model σ^- , σ^* and σ^+ represent slightly different outcomes than before. For σ^+ , the firm cooperates on innovations. For $y < x$, this means internal ventures, just as in the *EIP* model. But for $y \geq x$,

the *IIP* model predicts spin-offs, compared to start-ups in the *EIP* model. For σ^* the firm refuses to cooperate on innovations. In equilibrium the employee develops all her innovations outside as start-ups. Unlike in the *EIP* model, however, these start-ups operate without intellectual property rights. Their returns are thus given by λx , rather than x .

The combination of propositions 2, 3 and 5 allows us to dispels two common fallacies about intellectual property rights. The first fallacy is that intellectual property rights pre-determine development, in the sense that one would always get internal development if the firm has the rights, and external development if the employee has the rights. Our results challenge this preconception. We can get internal ventures in the *EIP* model where the employee has the rights, and spin-offs in the *IIP* model where the firm has the rights. The second fallacy is that intellectual property rights are irrelevant. The Coase theorem fails in this model because the firm commits to a corporate strategy of making decisions that, although ex-ante optimal, may lead to inefficient ex-post development.

4.2 Lawsuits

A notion closely related to imperfect intellectual property rights is ambiguous intellectual property rights. Laws are not always entirely clear, and courts are not perfectly predictable. If the allocation of intellectual property rights is ambiguous, either party can try to resolve the ambiguity by taking the case to court. Prior to any trial, the two parties may also try to settle, thereby saving legal costs. We now provide a simple model of this.

At date 2, the employee and the firm decide whether to cooperate. We focus on spin-offs as the cooperative outcome, although the case of internal ventures is analogous. If the employee does not cooperate, the firm can threaten with a lawsuit. The parties either settle before trial. Or they go to court, in which case they each incur legal costs k . Let λ now be the probability that the employee wins the trial. If she wins, she can continue with her start-up and earn x . With probability $1 - \lambda$, however, she loses. In this case we assume that the firm shelves the innovation. The appendix shows that this assumption is without loss of generality.

Since the employee is wealth constrained, her legal costs have to be paid with a contingency fee \tilde{k} that satisfies $\lambda\tilde{k} = k$. For $\tilde{k} > x \Leftrightarrow \lambda < \frac{k}{x}$, she cannot afford a trial, and concedes defeat. We now focus on the case where $\lambda x > k$. If there is a lawsuit, the expected utilities are given by $\lambda x - k$ for the employee and $-k$ for the firm. This defines the outside options for a pre-trial settlement. The Nash values for the settlement are given by $\lambda x - k + \frac{x - (\lambda x - 2k)}{2} = \lambda x + \frac{x - \lambda x}{2}$ for the employee and $-k + \frac{x - (\lambda x - 2k)}{2} = \frac{x - \lambda x}{2}$ for the firm. Naturally, these settlement values also define the Nash values for the spin-off agreement. And we recognize that these

are the same values as in the *IIP* model above.

Consider now how the firm views lawsuits under the three optimal strategies. For σ^- , the firm wants to minimize the returns to exploration. This is best achieved by a policy of always going to court. This minimizes the returns to exploration, given by $b^E = p(\lambda x - k)$. In equilibrium, the firm never has to take anyone to court, since employees never explore their ideas. For σ^* , the returns to exploration are given by $b^E = p(\lambda x - k) + \frac{\delta}{2}$ and $-k + \frac{\delta}{2}$. We get $\delta = 0$ if the firm always takes the employee to court, and $\delta = \mu - (\lambda x - 2k)$ if the firm cooperates on the development of the innovation. Going to court is costly, since in equilibrium the firm actually has to incur legal costs. However, going to courts also improves ex-ante incentives. As before we find that $\frac{dU_F^*}{d\delta} < 0$, so that the benefits of going to court outweigh the costs. For σ^+ , the firm is resigned to accepting exploration. It makes the best of the employee's innovations by developing them as internal ventures or spin-offs. The threat of a lawsuit constitutes a bargaining threat, that is never exercised in equilibrium. We summarize these findings as follows.

Proposition 6 (Lawsuits)

- For σ^- , the firm uses the threats of lawsuits to deter idea exploration. No lawsuits occur equilibrium.
- For σ^* , the firms takes all departing employees to court. The deterrence benefit outweighs the cost of lawsuits that actually occur in equilibrium.
- For σ^+ , the firm uses the threat of lawsuits when bargaining over the division of rents from internal ventures and spin-offs. No lawsuits occur equilibrium.

5 Cannibalization

So far the innovation generates value on its own, but does not affect any of firm's existing profits. One reason that firms might want to limit idea explorations is that innovations may cannibalize their existing profits. How does a firm deal with this cannibalization? One approach is to provide ex-ante incentives that discourage the employee from generating cannibalizing innovations. A very different approach is that after the employee has generated a cannibalizing innovation, the firm strikes a deal to shelve the innovation. We now examine when it is that the firm addresses cannibalization through prevention (the ex-ante solution) or shelving (the ex-post solution).

We stay in the *IIP* model, remembering that the *EIP* and *FIP* can be viewed as special cases. Denote the loss from cannibalization by $c > 0$, where c is an exogenous

constant. This assumes that cannibalization is an inevitably consequence of the innovation that cannot be mitigated by developing it inside. Below we show how to relax this assumption.

Consider first the ex-post effect of cannibalization. Suppose the employee has found a cannibalizing innovation. The question is whether to develop or shelve it? If $c < \text{Max}[x, y]$, cannibalization is sufficiently small that developing the innovation is more efficient than shelving it. The Nash values are given by $\lambda x + \frac{\text{Max}[x, y] - \lambda x}{2}$ for the employee and $-c + \frac{\text{Max}[x, y] - \lambda x}{2}$ for the firm.¹⁰ The firm simply bears the burden of cannibalization. If $c > \text{Max}[x, y]$, shelving the innovation is more efficient than developing it. The Nash values are now given by $\lambda x + \frac{c - \lambda x}{2}$ for the employee and $-c + \frac{c - \lambda x}{2}$ for the firm. Ironically, the employee benefits most from cannibalization when the effect is so large, that the firm wants to prevent it.

To examine the ex-ante effect of cannibalization, we need to examine how the firm adopts its optimal strategy to prevent cannibalization in the first place. In the appendix we rederive the firm's optimal strategies. We obtain the following result.

Proposition 7 (Optimal responses to cannibalization)

- The firm prevents cannibalization by choosing more often strategies that prevent idea exploration. The critical boundaries in figure 2 are all increasing in c .
- For σ^* , the firm refuses to respond with ex-post shelving.
- For σ^+ , the firm does not rely on ex-ante prevention, but responds ex-post by shelving innovations whenever $\text{Max}[x, y] > c$.

The most interesting aspect of Proposition 7 is how the ex-ante and ex-post responses interact. Naturally, the firm adapts its ex-ante optimal policies to the threat of cannibalization. The greater c , the more the firm discourages exploration, as reflected by the rightward shift of the the boundaries in figure 2.¹¹ For the ex-post response, there is a fundamental difference between the σ^* and the σ^+ strategy. For σ^* , the firm prevents cannibalization by discouraging idea exploration. But in equilibrium, the employee still generates innovations, some of which ought to be shelved. Yet the firm never strikes a deal with an innovative employee, so as not to reward the

¹⁰This assumes that in case of disagreement, the employee always develops the innovation outside. In the appendix we show that this is without loss of generality.

¹¹In the appendix we show that for very large values of c , it is sometimes possible that the boundaries locally shift the other way.

exploration of ideas. That is, to preserve the effectiveness of its ex-ante response, the firm refuses to use the ex-post response. For the σ^+ strategy, this preference inverts. The firm is resigned to excessive exploration, and no longer relies on an ex-ante response. Instead, it uses the ex-post approach of striking a deal with the employee whenever shelving is efficient.

Our discussion focuses on the case where the innovation cannibalizes the firm's core profits. Innovations could also generate complementarities for the firm's core business. Complementarities are the opposite of cannibalization. In our model we can describe a net complementarity with $c < 0$. Naturally, shelving is never an issue. And from proposition 7 we see that greater complementarities shift the boundaries in figure 2 to the left. Complementarities thus encourage exploration.

So far c is an exogenous constant. The extent of cannibalization may also depend on whether an innovation is developed internally or outside. Internalizing the venture might give the firm better control, allowing it to endogenously reduce the cannibalization to $\tilde{c} (< c)$. This does not change the essential workings of the model. The endogenous mitigation simply causes an upward shift in the distribution of y , from y to $y + c - \tilde{c}$. This increases the attractiveness of internal ventures over spin-offs.

6 Multiple equilibria

Our analysis establishes that employees are more likely to leave their employment if they expect to find outside resource providers, such as venture capitalists.¹² But the availability and quality of outside resources is likely to be higher if there are many employees leaving to found start-ups. This suggests that x might be an endogenous variable.

Let V be the demand for resource providers, such as venture capitalists.¹³ V depends on the number of employees becoming entrepreneurs, and therefore on corporate strategy. For the *EIP* model, figure 3 shows the demand for venture capital V , as a function of x . An interesting aspect about the demand is that it may be non-monotonic in x . The probability of an innovation is $\frac{p}{2}$ for σ^+ , compared to $\frac{p}{4}$ for σ^* and 0 for σ^- . But this measures the innovation rate, not the rate of external venturing. The probability that the employee becomes an entrepreneur is $\frac{p\Omega(x)}{2}$ under σ^+ , compared to $\frac{p}{4}$ under σ^* . It follows that whenever $\Omega(\hat{x}_*^+) < \frac{1}{2}$, V has a discontinuous drop at \hat{x}_*^+ .

Next consider the supply of venture capital. A potential entrant has to decide on

¹²Cooper (1985) notes that most entrepreneurs do not change their geographic location when starting their own businesses.

¹³We can also think of other resource providers, such as a local government that is considering investments in its entrepreneurial infrastructure, say by offering incubator facilities, or providing fiscal incentives.

whether to expand into a new geographical area, or whether to acquire expertise in a new technological area. For simplicity we assume that there is only one potential venture capitalist, who's net benefit of investing is given by a standard concave function $z(x)$.¹⁴ He faces a private cost of offering better quality, given by a standard convex function $Z(x)$. The venture capitalist thus maximizes $Vz(x) - Z(x)$ w.r.t. x . The optimal choice $x(V)$ constitutes the supply of venture capital. This is an increasing function of V , as depicted in Figure 3.

Proposition 8 (Multiple equilibria)

Suppose x depends on the supply decisions of a venture capitalist.

- In the *EIP* model, there may be multiple equilibria, in any of the three regions σ^- , σ^* and σ^+ .
- In the *FIP* model, the unique equilibrium is σ^- at $x = 0$.

For the *FIP* model, employees never become entrepreneurs. Thus $V = 0$, and $x = 0$ becomes the unique equilibrium. By contrast, figure 3 shows how there can be multiple equilibria in the *EIP* model. If $x = 0$, employees are not interested in start-ups and the firm finds it optimal to choose the σ^- strategy. The lack of start-ups ensures that x remains low, since venture capitalists see no entrepreneurial activity to peek their interest. The economy is thus trapped in a self-fulfilling low entrepreneurship equilibrium. In contrast, if x is sufficiently large, employees are keen to explore their ideas and found new ventures, and firms retreat to the σ^+ strategy. The high start-up rate provides incentives for venture capitalists to invest, and the economy finds itself in a self-fulfilling high innovation equilibrium.

We thus identify a fundamental complementarity between the willingness of employees to become entrepreneurs, and the willingness of financiers to develop a venture capital industry. This is consistent with cross-country differences in entrepreneurship levels. In the US employees seem quite willing to leave their employer to start new businesses. And there is an active venture capital industry that finances those departing employees. In Japan and Germany, by contrast, long-term employment is much more prevalent, and few employees want to leave their jobs. At the same time, these countries have a much smaller venture capital industry. Consistent with our analysis, Becker and Hellmann (2003) report how German venture capitalists lament the lack of capable managers who are willing to leave established firms to become entrepreneurs. Even within the US, there seem to be significant regional differences in this respect. Our analysis suggests that employee-friendly intellectual property

¹⁴The model can easily be generalized to the case where there are several resource providers. See also Amador and Landier (2003).

rights are a necessary condition for a high entrepreneurship equilibrium. This is consistent with Gilson (1999) and Hyde (1998) on why California has higher levels of entrepreneurship. Naturally, our analysis only hopes to identify two among several important complementary factors that enable a high level of entrepreneurial activity. Miller et. al. (2000) provide a more comprehensive discussion of the complementarities that promote high levels of entrepreneurship.

7 Conclusion

This paper addresses the supply of entrepreneurs, which is a wide open research question in economics. It starts with the observation that many entrepreneurs receive their ideas while working for firms in related industries. It builds a model of when an employee wants to become an entrepreneur. A critical step of the analysis is to recognize that firms may respond to their employees' innovations in a variety of ways. Some firms want to prevent their employees from leaving, whereas others coopt them through internal ventures or spin-offs. The paper provides a unified framework for understanding the various ways by which innovations are turned into new ventures, such as internal ventures, spin-offs and start-ups, with or without intellectual property rights. The analysis highlights the importance of intellectual property rights and the entrepreneurial environment.

8 Appendix

8.1 Proof of Proposition 2

Remember that $U_F^- = \frac{2+2\phi}{4}(a - \frac{px}{\phi})$, $U_F^* = \frac{2+\phi}{4}(a - px)$ and $U_F^+ = \frac{p\mu - x}{2} + \frac{1+\phi}{4}a$. For all proofs, it is useful to use the following notation:

$$\begin{aligned}\Upsilon_-^*(x) &\equiv U_F^* - U_F^- = \frac{p}{4}[\frac{2-\phi^2}{\phi}x - \phi\frac{a}{p}] \\ \Upsilon_-^+(x) &\equiv U_F^+ - U_F^- = \frac{p}{4}[\mu + \frac{2+\phi}{\phi}x - (1+\phi)\frac{a}{p}] \\ \Upsilon_*^+(x) &\equiv U_F^+ - U_F^* = \frac{p}{4}[\mu + (1+\phi)x - \frac{a}{p}]\end{aligned}$$

Note that \hat{x}_-^* is defined from $\Upsilon_-^*(\hat{x}_-^*) = 0$, \hat{x}_-^+ is defined from $\Upsilon_-^+(\hat{x}_-^+) = 0$, and \hat{x}_*^+ is defined from $\Upsilon_*^+(\hat{x}_*^+) = 0$. For \hat{x}_-^* we obtain an explicit solution, namely $\hat{x}_-^* = \frac{\phi^2}{2-\phi^2}\frac{a}{p}$.

Now note that

$$\frac{dU_F^-}{dx} = -\frac{2+2\phi}{4}\frac{p}{\phi} < \frac{dU_F^*}{dx} = -\frac{2+\phi}{4}p < \frac{dU_F^+}{dx} = -\frac{1-\Omega(x)}{4}p < 0$$

It follows that if $U_F^+ > U_F^*$ at \hat{x}_-^* , then $\hat{x}_-^* < \hat{x}_-^+ < \hat{x}_*^+$. But if $U_F^+ < U_F^*$ at \hat{x}_-^* , then $\hat{x}_-^* > \hat{x}_-^+ > \hat{x}_*^+$. We thus focus on the condition $U_F^+(\hat{x}_-^*) > U_F^*(\hat{x}_-^*) \Leftrightarrow \Upsilon_*^+(\hat{x}_-^*) > 0$. Substituting $\hat{x}_-^* = \frac{\phi^2}{2-\phi^2}\frac{a}{p}$ we obtain after transformations $\Upsilon_*^+(\hat{x}_-^*) = \frac{p}{4}[\mu(\hat{x}_-^*) + \frac{2\phi^2 + \phi^3 - 2a}{2-\phi^2}\frac{a}{p}]$. We have $\frac{d\Upsilon_*^+(\hat{x}_-^*)}{d\phi} = \frac{p}{4}[\Omega(\hat{x}_-^*)\frac{d\hat{x}_-^*}{d\phi} + \frac{d}{d\phi}(\frac{2\phi^2 + \phi^3 - 2a}{2-\phi^2}\frac{a}{p})]$ $= \frac{p}{4}[\Omega(\hat{x}_-^*)\frac{4\phi}{(2-\phi^2)^2}\frac{a}{p} + \frac{\phi(4+6\phi-\phi^3)}{(2-\phi^2)^2}\frac{a}{p}] > 0$. At $\phi = 0$ we have $\hat{x}_-^* = 0$ and thus $\Upsilon_*^+(\hat{x}_-^*) = \frac{p}{4}[\mu - \frac{a}{p}] < 0$. At $\phi = 1$ we have $\hat{x}_-^* = \frac{a}{p}$ and thus $\Upsilon_*^+(\hat{x}_-^*) = \frac{p}{4}[\mu(\frac{a}{p}) + \frac{a}{p}] > 0$. We have thus shown that $\Upsilon_*^+(\hat{x}_-^*)$ is strictly increasing in ϕ , with $\Upsilon_*^+(\hat{x}_-^*) < 0$ at $\phi = 0$, and $\Upsilon_*^+(\hat{x}_-^*) > 0$ at $\phi = 1$. It follows that there exists $\hat{\phi} \in (0, 1)$, so that for all $\phi < \hat{\phi}$ we have $\Upsilon_*^+(\hat{x}_-^*) < 0$, and for all $\phi > \hat{\phi}$ we have $\Upsilon_*^+(\hat{x}_-^*) > 0$. The critical value $\hat{\phi}$ is defined by the non-linear equation $\mu(\frac{\phi^2}{2-\phi^2}\frac{a}{p}) = \frac{2-2\phi^2-\phi^3}{2-\phi^2}\frac{a}{p}$. There is no general analytical solution. In the proof of proposition 4 we provide some numerical examples.

We next examine when the critical values lie in the feasible range. For the lower boundary, we note that at $x = 0$ we have $U_F^- = \frac{2+2\phi}{4}a$, $U_F^* = \frac{2+\phi}{4}a$ and $U_F^+ =$

$\frac{p\mu}{2} + \frac{1+\phi}{4}a$. Clearly, $U_F^- - U_F^* > 0$. Moreover, $U_F^- - U_F^+ = \frac{p}{4}[(1+\phi)a - \mu] > 0$. Thus U_F^- is always optimal at $x = 0$, implying $\hat{x}_-^* > 0$ for $\phi < \hat{\phi}$ and $\hat{x}_-^+ > 0$ for $\phi > \hat{\phi}$. Thus, the relevant critical values are always above the lower bound of the feasible range.

Concerning the upper bound, for $\phi < \hat{\phi}$ we check that $\hat{x}_*^+ < \bar{x}$. We note that \hat{x}_*^+ satisfies $\mu(\hat{x}_*^+) + (1+\phi)\hat{x}_*^+ - \frac{a}{p} = 0$, whereas \bar{x} satisfies $\mu(\bar{x}) - \frac{a}{p} = 0$. Thus $\mu(\hat{x}_*^+) - \mu(\bar{x}) = -(1+\phi)\hat{x}_*^+ < 0$ and thus $\hat{x}_*^+ < \bar{x}$. For $\phi > \hat{\phi}$, we now show that the upper boundary is typically satisfied, except for some extreme parameters. If the condition $\hat{x}_-^+ < \bar{x}$ holds, then the firm finds it optimal to implement σ^- for $x < \hat{x}_-^+$ and σ^+ for $x > \hat{x}_-^+$. But for $\hat{x}_-^+ > \bar{x}$, the firm finds it optimal to implement σ^- for all x . To examine the condition $\hat{x}_-^+ < \bar{x}$, we note that at $\phi = \hat{\phi}$ we have $\hat{x}_-^* = \hat{x}_-^+ = \hat{x}_*^+$, and thus $\hat{x}_-^+ = \hat{x}_*^+ < \bar{x}$, as shown above. For higher values of ϕ , we note that if $\Upsilon_-^+(\bar{x}) > 0$ then $\hat{x}_-^+ < \bar{x}$, but if $\Upsilon_-^+(\bar{x}) < 0$ then $\hat{x}_-^+ > \bar{x}$. Using $\mu(\bar{x}) = \frac{a}{p}$, we obtain after transformations $\Upsilon_-^+(\bar{x}) = \frac{p}{4}[\frac{2+\phi}{\phi}\bar{x} - \phi\mu(\bar{x})]$. This is decreasing in ϕ . Consider the highest value $\phi = 1$, then $\Upsilon_-^+(\bar{x}, \phi = 1) = \frac{p}{4}[3\bar{x} - \mu(\bar{x})]$. If $3\bar{x} - \mu(\bar{x}) > 0$, then $\Upsilon_-^+(\bar{x}) > 0$ for all ϕ , and $\hat{x}_-^+ < \bar{x}$. But for $3\bar{x} - \mu(\bar{x}) < 0$, there exists $\tilde{\phi} (> \hat{\phi})$ satisfying $\frac{2+\tilde{\phi}}{\tilde{\phi}}\bar{x} - \tilde{\phi}\mu(\bar{x}) = 0$, so that $\Upsilon_-^+(\bar{x}) > 0 \Leftrightarrow \hat{x}_-^+ < \bar{x}$ for $\phi < \tilde{\phi}$, but $\Upsilon_-^+(\bar{x}) < 0 \Leftrightarrow \hat{x}_-^+ > \bar{x}$ for $\phi > \tilde{\phi}$.

For the comparative statics, we immediately see that $\hat{x}_-^* = \frac{\phi^2}{2-\phi^2}\frac{a}{p}$ is increasing in a and $-p$. To see the same for \hat{x}_*^+ , remember that it is defined from $\Upsilon_*^+(\hat{x}_*^+) = 0$. We note that $\frac{d\Upsilon_*^+}{dx} = \frac{p(1+\phi-\Omega)}{4} > 0$. From $\frac{d\Upsilon_*^+}{da} = -\frac{1}{4} < 0$, we get $\frac{d\hat{x}_*^+}{da} = -\frac{d\Upsilon_*^+}{da}/\frac{d\Upsilon_*^+}{dx} > 0$. Similarly, from $\frac{d\Upsilon_*^+}{dp} = \frac{\mu}{4} + \frac{(1+\phi)x}{4} > 0$ we get $\frac{d\hat{x}_*^+}{dp} < 0$. And for \hat{x}_-^+ , we use $\frac{d\Upsilon_-^+}{dx} = \frac{p}{4}\frac{2+\phi}{\phi} - \frac{p}{4}\Omega > 0$. From $\frac{d\Upsilon_-^+}{da} = -\frac{1+\phi}{4}a < 0$ we get $\frac{d\hat{x}_-^+}{da} > 0$. And from $\frac{d\Upsilon_-^+}{dp} = \frac{\mu}{4} + \frac{(2+\phi)x}{4\phi} > 0$ we get $\frac{d\hat{x}_-^+}{dp} < 0$.

8.2 Proof of Proposition 3

For σ^- , we have $w_A^- = \frac{b^E}{\phi}$ and $U_F^- = \frac{2+2\phi}{4}(a - w_A^-)$. The effect of developing innovations internally or externally is to increase b^E , which increases w_A^- . Thus $D_y(y) = D_x(y) = 0 \forall y$. This implies $w_A^- = 0$ and $U_F^- = \frac{2+2\phi}{4}a$. For σ^* , we

have $w_A^* = b^E$. Using $U_F^* = \frac{1}{4}b^F + \frac{2+\phi}{4}(a - b^E)$ we get $\frac{dU_F^*}{d\delta} = -\frac{1+\phi p}{4} < 0$. The incentive cost of developing innovations outweighs their direct benefit, so that shelving is optimal, i.e., $D_y(y) = D_x(y) = 0 \forall y$. Thus $w_A^* = 0$ and $U_F^* = \frac{2+\phi}{4}a$. It is immediate that σ^* is always dominated by σ^- . For σ^+ , it is easy to see the firm always makes the best of all innovations, so that $D_y(y) = 1$ for $y \geq x$ and $D_x(y) = 1$ for $y < x$. This implies $\delta = \mu$ and thus $b^E = b^F = \frac{\mu}{2}$. With $w_A^+ = 0$ we obtain $U_F^+ = \frac{p\mu}{4} + \frac{1+\phi}{4}a$. To see that σ^+ is also dominated by σ^- , we note that $U_F^+ < U_F^- \Leftrightarrow \frac{p\mu}{4} < \frac{1+\phi}{4}a \Leftrightarrow p\mu < (1+\phi)a$, which follows from $p\mu < a$.

8.3 Proof of Proposition 4

To see that Γ^* and Γ^+ are increasing in x , simply note that $\frac{d\Gamma^*}{dx} = \frac{p}{4} > 0$ and $\frac{d\Gamma^+}{dx} = \frac{p\Omega(x)}{2} > 0$. We focus first on the case of $\phi < \hat{\phi}$ and begin by examining the range where the firm implements σ^* , i.e., $x \in [\hat{x}_-, \hat{x}_+]$. To consider the lower boundary of this region, we simply evaluate $\Gamma^* = \frac{px - \phi a}{4}$ at $\hat{x}_- = \frac{\phi^2 a}{2 - \phi^2 p}$. We obtain $\Gamma^* = \frac{1}{4}[p\frac{\phi^2 a}{2 - \phi^2 p} - \phi a] = \frac{a\phi\phi + \phi^2 - 2}{4} < 0$. This says that *FIP* is more efficient for x sufficiently close to \hat{x}_- . Naturally, we want to know whether *FIP* is more efficient over the entire range $[\hat{x}_-, \hat{x}_+]$, or whether *EIP* becomes more efficient for higher values of x . For this, we define x_Γ^* so that $\Gamma^* = 0$, i.e., $x_\Gamma^* = \frac{\phi a}{p}$. We want to know whether $x_\Gamma^* > \hat{x}_+$, in which case *FIP* is more efficient over the entire range $[\hat{x}_-, \hat{x}_+]$, or whether $x_\Gamma^* < \hat{x}_+$, in which case *FIP* is more efficient over the lower range $[\hat{x}_-, x_\Gamma^*]$ and *EIP* is more efficient over the upper range $[x_\Gamma^*, \hat{x}_+]$. For this, we remember that Υ_*^+ is increasing in x . It follows that whenever $\Upsilon_*^+ > 0$ at x_Γ^* , then $x_\Gamma^* > \hat{x}_+$. And whenever $\Upsilon_*^+ < 0$ at x_Γ^* then $x_\Gamma^* < \hat{x}_+$. Evaluating Υ_*^+ at x_Γ^* , we note that $\Upsilon_*^+(x_\Gamma^*) = \frac{p}{4}[\mu(x_\Gamma^*) + (1+\phi)\frac{\phi a}{p} - \frac{a}{p}]$. Using $\frac{d\mu}{dx_\Gamma^*} > 0$ and $\frac{dx_\Gamma^*}{d\phi} > 0$, we find that $\frac{d\Upsilon_*^+(x_\Gamma^*)}{d\phi} > 0$. At $\phi = 0$ we have $\Upsilon_*^+(x_\Gamma^*) = \frac{p}{4}[\mu(0) - \frac{a}{p}] < 0$. This says that for low values of ϕ , we have $x_\Gamma^* < \hat{x}_+$. However, for higher values of ϕ , we can get the opposite relationship, i.e., $x_\Gamma^* > \hat{x}_+$. To see this, we note that we always have $x_\Gamma^* > \hat{x}_-$, which follows from $\frac{\phi a}{p} > \frac{\phi^2 a}{2 - \phi^2 p} \Leftrightarrow 2 > \phi^2 + \phi$. From proposition 2, we know that at $\phi = \hat{\phi}$ we have $\hat{x}_- = \hat{x}_+$. Thus $x_\Gamma^* > \hat{x}_+$ for ϕ sufficiently close to $\hat{\phi}$. We have thus shown that both $x_\Gamma^* < \hat{x}_+$ and $x_\Gamma^* > \hat{x}_+$ are possible outcomes of the model. Thus either *FIP* is more efficient over the entire range $x \in [\hat{x}_-, \hat{x}_+]$, or *FIP*

is more efficient for a lower range $[\widehat{x}_-, x_\Gamma^*]$ and *EIP* is more efficient for an upper range $[x_\Gamma^*, \widehat{x}_*^+]$.

Next, we examine the range where the firm implements σ^+ , i.e., $x \in [\widehat{x}_*^+, \bar{x}]$. For the upper boundary, remember that \bar{x} is defined so that $p\mu(\bar{x}) = a$. Evaluating Γ^+ at \bar{x} , we obtain $\Gamma^+ = \frac{p\mu(\bar{x})}{2} - \frac{1+\phi}{4}a = \frac{a}{2} - \frac{1+\phi}{4}a > 0$. It follows that near \bar{x} , *EIP* is always better. Again we define x_Γ^+ so that $\Gamma^+ = 0$, and ask whether *EIP* is more efficient over the entire range $[\widehat{x}_*^+, \bar{x}]$, or whether *FIP* is more efficient over the lower range $[\widehat{x}_*^+, x_\Gamma^+]$ and *EIP* more efficient over the upper range $[x_\Gamma^+, \bar{x}]$. Note that the latter case requires $x_\Gamma^+ > \widehat{x}_*^+$.

To compare x_Γ^+ and \widehat{x}_*^+ , we evaluate Υ_*^+ at x_Γ^+ . If $\Upsilon_*^+(x_\Gamma^+) > 0$, then $x_\Gamma^+ > \widehat{x}_*^+$. And if $\Upsilon_*^+(x_\Gamma^+) < 0$, then $x_\Gamma^+ < \widehat{x}_*^+$. We note that x_Γ^+ satisfies $\mu(x_\Gamma^+) = \frac{1+\phi}{2} \frac{a}{p}$. We

use this in $\Upsilon_*^+(x_\Gamma^+) = \frac{p}{4}[(1+\phi)x_\Gamma^+ - \frac{1-\phi}{2} \frac{a}{p}]$. Using $\frac{dx_\Gamma^+}{d\phi} = \frac{1}{2} \frac{a}{p} \frac{1}{\Omega(x_\Gamma^+)} > 0$, we note

that $\frac{d\Upsilon_*^+(x_\Gamma^+)}{d\phi} > 0$. Evaluating $\Upsilon_*^+(x_\Gamma^+)$ at the lowest ϕ , i.e., $\phi = 0$, we get $\Upsilon_*^+ = \frac{p}{4}[x_\Gamma^+ - \frac{1}{2} \frac{a}{p}]$. But at $\phi = 0$ we also have $\mu(x_\Gamma^+) = \frac{1}{2} \frac{a}{p}$. Thus $\Upsilon_*^+ = \frac{p}{4}[x_\Gamma^+ - \mu(x_\Gamma^+)] < 0$.

For sufficiently low ϕ we thus note that $x_\Gamma^+ < \widehat{x}_*^+$, so that *EIP* more efficient over the entire range $[\widehat{x}_*^+, \bar{x}]$. Again, we also examine whether for higher values of ϕ , it is possible that $x_\Gamma^+ > \widehat{x}_*^+$, so that *FIP* more efficient for the lower and *EIP* more efficient for the upper range. To show that $x_\Gamma^+ > \widehat{x}_*^+$ is indeed possible for higher values of ϕ , we focus on $\phi = \widehat{\phi}$. Naturally, the same results holds for ϕ sufficiently close to $\widehat{\phi}$.

Our aim is thus to show that it is possible that $x_\Gamma^+ > \widehat{x}_*^+$ at $\phi = \widehat{\phi}$. Anticipating the last part of the proof (where we examine the case of $\phi > \widehat{\phi}$), we show the slightly more general result that both $x_\Gamma^+ > \widehat{x}_*^+$ and $x_\Gamma^+ < \widehat{x}_*^+$ are possible at $\phi = \widehat{\phi}$. For this we establish that both $\Gamma^+(\widehat{x}_*^+) < 0$ (implying $x_\Gamma^+ > \widehat{x}_*^+$) and $\Gamma^+(\widehat{x}_*^+) > 0$ (implying

$x_\Gamma^+ < \widehat{x}_*^+$) are possible. At $\widehat{\phi}$ we have $\widehat{x}_*^+ = \widehat{x}_-^+ = \widehat{x}_-^* = \frac{\widehat{\phi}^2}{2 - \widehat{\phi}^2} \frac{a}{p} \equiv \widehat{x}$ and $\Upsilon_-^*(\widehat{x}, \widehat{\phi}) =$

$\Upsilon_-^+(\widehat{x}, \widehat{\phi}) = \Upsilon_*^+(\widehat{x}, \widehat{\phi}) = 0$. Using $\Upsilon_-^+(\widehat{x}, \widehat{\phi}) = \frac{p}{4}[\mu(\widehat{x}) + \frac{2+\widehat{\phi}}{\widehat{\phi}} \widehat{x} - (1+\widehat{\phi}) \frac{a}{p}] = 0$ and

$\widehat{x} = \frac{\widehat{\phi}^2}{2 - \widehat{\phi}^2} \frac{a}{p}$ we get after transformations $\mu(\widehat{x}) = [\frac{2 - 2\widehat{\phi}^2 - \widehat{\phi}^3}{2 - \widehat{\phi}^2}] \frac{a}{p}$. We can use this

to obtain $\Gamma^+(\widehat{x}, \widehat{\phi}) = \frac{p}{4}[\mu(\widehat{x}) - \frac{1+\widehat{\phi}}{2} \frac{a}{p}] = \frac{2 - 2\widehat{\phi} - 3\widehat{\phi}^2 - \widehat{\phi}^3}{4 - 2\widehat{\phi}^2} \frac{a}{4}$. This can be positive

or negative depending on the value of $\widehat{\phi}$. $\widehat{\phi}$ is determined by the non-linear equation

$\mu(\hat{x}) = \left[\frac{2 - 2\hat{\phi}^2 - \hat{\phi}^3}{2 - \hat{\phi}^2} \right] \frac{a}{p}$. This depends on μ , and thus on the distribution $\Omega(y)$, so

that no general analytical solution exists. Thankfully, to show that $\Gamma^+(\hat{x}, \hat{\phi})$ may be positive or negative, it is enough to construct two simple numerical examples. The calculations for this numerical example were performed in Excel, and are available from the author upon request. For $\Omega(y)$ we use the uniform distribution over $[0, 1]$.

Standard calculations show that $\mu = \frac{1 + x^2}{2}$. After transformation, the nonlinear

equation becomes $1 - 2 \frac{2 - 2\hat{\phi}^2 - \hat{\phi}^3}{2 - \hat{\phi}^2} \frac{a}{p} + \left(\frac{\hat{\phi}^2}{2 - \hat{\phi}^2} \frac{a}{p} \right)^2 = 0$. Using $a = \frac{1}{5}$ and $p = \frac{1}{3}$

we obtain $\hat{\phi} = 0.4495$, $\hat{x} = 0.0674$ and $\Gamma^+(\hat{x}, \hat{\phi}) = 0.0056 > 0$. And using $a = \frac{1}{5}$ and

$p = \frac{1}{4}$ we obtain $\hat{\phi} = 0.6025$, $\hat{x} = 0.1774$ and $\Gamma^+(\hat{x}, \hat{\phi}) = -0.0078 < 0$. In either case

we also verified that $\hat{\phi}a < p\mu(\hat{x}) < a$.

We finally turn to the analysis of $\phi > \hat{\phi}$. The region of interest is $[\hat{x}_-^+, \bar{x}]$, where the firm implements σ^+ under *EIP*. For the upper boundary, the proof of why *EIP* is more efficient near \bar{x} is the same as before. For the lower boundary, we examine whether $x_\Gamma^+ < \hat{x}_-^+$ and/or $x_\Gamma^+ > \hat{x}_-^+$ are possible. But our numerical example already established that both of these are possible at $\phi = \hat{\phi}$, and therefore also in a neighborhood of $\hat{\phi}$. We thus conclude that either $x_\Gamma^+ < \hat{x}_-^+$, so that *EIP* is more efficient over the entire range $[\hat{x}_-^+, \bar{x}]$, or $x_\Gamma^+ > \hat{x}_-^+$, so that *FIP* is more efficient for the lower range $[\hat{x}_-^+, x_\Gamma^+]$, and *EIP* is more efficient for the upper range $[x_\Gamma^+, \bar{x}]$.

8.4 Proof of Proposition 5

As before we have $w_\emptyset = w_B = 0$, so that $b^E = p\lambda x + p\frac{\delta}{2}$ and $b^F = p\frac{\delta}{2}$, where

$\delta = \int_0^\infty [(y - \lambda x)D_y(y) + (x - \lambda x)D_x(y)]d\Omega(y)$. For σ^- , we have $w_A^- = \frac{b^E}{\phi}$. To

discourage exploration, the firm sets $D_y(y) = D_x(y) = 0 \forall y$, which yields $b^E = p\lambda x$.

It follows that $U_F^- = \frac{2 + 2\phi}{4} \left(a - \frac{p\lambda x}{\phi} \right)$. For σ^* , the firm has to trade-off the benefits

of cooperation against the cost of encouraging more exploration. Cooperation means doing internal ventures ($D_y = 1$) or spin-offs ($D_x = 1$), both of which increases δ . The

firm's ex-ante utility is given by $U_F^* = \frac{1}{4}b^F + \frac{2 + \phi}{4}(a - b^E)$. The effect of increasing

cooperation is given by $\frac{dU_F^*}{d\delta} = -\frac{1 + \phi p}{4} \frac{p}{2} < 0$. Again we find that the firm prefers not

to cooperate, i.e., $D_y(y) = D_x(y) = 0 \forall y$. Thus $w_A^* = p\lambda x$ and $U_F^* = \frac{2 + \phi}{4}(a - p\lambda x)$.

Finally, for σ^+ , cooperation is clearly beneficial, so that $D_y(y) = 1$ for $y \geq x$ and

$D_x(y) = 1$ for $y < x$. We get $\delta = \mu - \lambda x$, $b^E = \lambda x + \frac{\mu - \lambda x}{2}$, and $b^F = \frac{\mu - \lambda x}{2}$ so that $U_F^+ = \frac{p(\mu - \lambda x)}{4} + \frac{1 + \phi}{4}a$.

Again, we find that $\frac{dU_F^+}{dx} = \frac{p\Omega - \lambda}{2} > \frac{dU_F^*}{dx} = -\frac{2 + \phi}{4}p\lambda > \frac{dU_F^-}{dx} = -\frac{2 + 2\phi p\lambda}{4\phi}$. We now show that \hat{x}_-^* , \hat{x}_-^+ and \hat{x}_*^+ are all decreasing in λ . From $\Upsilon_-^* = U_F^* - U_F^- = 0$ we obtain after simple transformations $\hat{x}_-^* = \frac{\phi^2}{2 - \phi^2} \frac{a}{p\lambda}$, which is decreasing in λ . \hat{x}_-^+ is defined by $\Upsilon_-^+ = U_F^+ - U_F^- = 0$. Simple transformations show that \hat{x}_-^+ satisfies $\mu(\hat{x}_-^+) + \frac{2 + \phi}{\phi} \lambda \hat{x}_-^+ - (1 + \phi) \frac{a}{p} = 0$. Totally differentiating this w.r.t. \hat{x}_-^+

and λ , we get $\frac{d\hat{x}_-^+}{d\lambda} = \frac{-\frac{2 + \phi}{\phi} \hat{x}_-^+}{\Omega(\hat{x}_-^+) + \frac{2 + \phi}{\phi} \lambda} < 0$. \hat{x}_*^+ is defined by $\Upsilon_*^+ = U_F^+ - U_F^* = 0$.

Simple transformations show that \hat{x}_*^+ satisfies $\mu(\hat{x}_*^+) + (1 + \phi) \lambda \hat{x}_*^+ - \frac{a}{p} = 0$. Totally differentiating, we get $\frac{d\hat{x}_*^+}{d\lambda} = -\frac{(1 + \phi) \hat{x}_*^+}{\Omega(\hat{x}_*^+) + (1 + \phi) \lambda} < 0$.

As in proposition 2, we note that if $U_F^+ > U_F^*$ at \hat{x}_-^* , then $\hat{x}_-^* < \hat{x}_-^+ < \hat{x}_*^+$. But if $U_F^+ < U_F^*$ at \hat{x}_-^* , then $\hat{x}_-^* > \hat{x}_-^+ > \hat{x}_*^+$. We thus focus on evaluating $\Upsilon_*^+ = U_F^+ - U_F^*$ at \hat{x}_-^* . We note that $\Upsilon_*^+ = \frac{p}{4} [\mu + (1 + \phi) \lambda x - \frac{a}{p}]$. Substituting $\hat{x}_-^* = \frac{\phi^2}{2 - \phi^2} \frac{a}{\lambda p}$ we obtain after transformations $\Upsilon_*^+(\hat{x}_-^*) = \frac{p}{4} [\mu(\hat{x}_-^*) + \frac{2\phi^2 + \phi^3 - 2a}{2 - \phi^2} \frac{a}{p}]$. This is almost exactly the same expression as in proposition 2, the only difference being that $\mu(\hat{x}_-^*)$ depends on λ . The critical value $\hat{\phi}$ is defined by the non-linear equation $\mu(\frac{\hat{\phi}^2}{2 - \hat{\phi}^2} \frac{a}{\lambda p}) =$

$\frac{2 - 2\hat{\phi}^2 - \hat{\phi}^3}{2 - \hat{\phi}^2} \frac{a}{p}$, which now depends on λ . For $\lambda \rightarrow 0$, we get $\hat{\phi} \rightarrow 0$.

The biggest difference to proposition 2 pertains to when the critical values lie within the feasible range. Again, the lower boundary is never binding. This follows from the fact that \hat{x}_-^* , \hat{x}_-^+ and \hat{x}_*^+ are all decreasing in λ , and that we already established in proposition 2 (where $\lambda = 1$) that the lower boundary is never binding. For the upper boundary, we also know from proposition 2 that for $\lambda = 1$, $\hat{x}_-^* < \hat{x}_-^+ < \hat{x}_*^+ < \bar{x}$. We thus focus on $\lambda \rightarrow 0$. \hat{x}_*^+ satisfies $\mu(\hat{x}_*^+) + (1 + \phi) \lambda \hat{x}_*^+ - \frac{a}{p} = 0$. Using $\mu(\bar{x}) = \frac{a}{p}$, we get $\mu(\hat{x}_*^+) - \mu(\bar{x}) = -(1 + \phi) \lambda \hat{x}_*^+$. At $\lambda = 0$, we get $\hat{x}_*^+ = \bar{x}$.

Next, \hat{x}_-^+ satisfies $\mu(\hat{x}_-^+) + \frac{2 + \phi}{\phi} \lambda \hat{x}_-^+ - (1 + \phi) \frac{a}{p} = 0$. At $\lambda = 0$, this reduces to

$\mu(\widehat{x}_-^+) - (1 + \phi)\frac{a}{p} = 0$, so that $\widehat{x}_-^+ > \bar{x}$. And for $\widehat{x}_-^* = \frac{\phi^2}{2 - \phi^2} \frac{a}{p\lambda}$, we note that $\widehat{x}_-^* \rightarrow \infty$ as $\lambda \rightarrow 0$. We use all of this to construct figure 4, which provides a graphical overview of \widehat{x}_-^* , \widehat{x}_-^+ , \widehat{x}_*^+ and \bar{x} , as a function of λ . Note also that the intersection of \widehat{x}_-^* , \widehat{x}_-^+ , \widehat{x}_*^+ corresponds to $\phi = \widehat{\phi}$, where $\widehat{\phi}$ depends on λ as noted above.

8.5 Proof of Proposition 6

For the model with lawsuits, we only need to show why there is no loss of generality to assume that the firm always shelves an innovation after winning a lawsuit. Developing the innovation instead would mean that both parties get $\frac{x}{2}$ (the employee has no more outside option). For σ^- and σ^+ , this would only increase b^E and thus undermine the firm's objectives. For σ^+ , developing the innovation instead does not affect the returns. To see this, note that the outside options at the settlement stage would then be given by $\lambda x + (1 - \lambda)\frac{x}{2} - k$ for the employee and $(1 - \lambda)\frac{x}{2} - k$ for the firm. And the Nash values for the settlement would be $\lambda x + (1 - \lambda)\frac{x}{2} - k + \frac{2k}{2} = \lambda x + \frac{x - \lambda x}{2}$ for the employee and $(1 - \lambda)\frac{x}{2} - k + \frac{2k}{2} = \frac{x - \lambda x}{2}$ for the firm. We see that this is the same as before.

8.6 Proof of Proposition 7

In the main text we noted that our specification of outside options assumes that in case of disagreement, the employee always develops the innovation outside. We briefly show that this is without loss of generality. For $\lambda x < c < \text{Max}[x, y]$, in case of disagreement, the two parties could instead renegotiate to shelve the innovation. In a renegotiation after disagreement, the employee would get $\lambda x + \frac{c - \lambda x}{2}$ and the firm would get $-c + \frac{c - \lambda x}{2}$. The gains from developing the venture would now be given by $\text{Max}[x, y] - c$. The Nash values are thus given by $\lambda x + \frac{c - \lambda x}{2} + \frac{\text{Max}[x, y] - c}{2} = \lambda x + \frac{\text{Max}[x, y] - \lambda x}{2}$ for the employee, and $-c + \frac{c - \lambda x}{2} + \frac{\text{Max}[x, y] - c}{2} = -c + \frac{\text{Max}[x, y] - \lambda x}{2}$ for the firm. This is the same as without renegotiation. Thus renegotiation after disagreement does not matter.

Consider now σ^+ . The firm is resigned to excessive exploration, but makes the best of her innovations. The expected returns from exploration are $b^E = p\lambda x + p\frac{\delta}{2}$ and $b^F = -pc + p\frac{\delta}{2}$, where δ depends on whether $c < x$ or $c > x$. For $c < x$, the firm always prefers to develop the innovation, and $\delta = \mu - \lambda x$, as before. But

for $c > x$, the firm wants to shelve the innovation whenever $y < c$. This implies $\delta = \int_0^c (c - \lambda x) d\Omega(y) + \int_c^\infty (y - \lambda x) d\Omega(y) = C + \mu - \lambda x$, where $C \equiv (c - x)\Omega(c) > 0$ measures the expected benefit from a policy of shelving all innovations with $y < c$. Conveniently writing $C = 0$ for $c < x$, the firm's ex-ante utility from σ^+ is given by $U_F^+ = \frac{p}{2}(-c + \frac{C + \mu - \lambda x}{2}) + \frac{1 + \phi}{4}a$. Consider next σ^* . As before, we get $\frac{dU_F^*}{d\delta} = -\frac{1 + \phi p}{4} \frac{p}{2} < 0$, so that it is optimal to set $\delta = 0$. Using $w_A^* = b^E = p\lambda x$, the firm's ex-ante utility from σ^* is given by $U_F^* = -\frac{p}{4}c + \frac{2 + \phi}{4}(a - p\lambda x)$. For σ^- , the firm also maintains a policy of never bargaining, so that $w_A^- = \frac{b^E}{\phi} = \frac{p\lambda x}{\phi}$ and $U_F^- = \frac{2 + 2\phi}{4}(a - \frac{p\lambda x}{\phi})$ as before.

We now show that, provided c not too large, the critical values \hat{x}_- , \hat{x}_- and \hat{x}_* are increasing in c . We have $\hat{x}_- = \frac{\phi}{(2 - \phi^2)\lambda}(\frac{a}{p} + c)$, so that \hat{x}_- is always increasing in c . Consider next \hat{x}_* , which satisfies $\mu - c + C + (1 + \phi)\lambda\hat{x}_* - \frac{a}{p} = 0$. Totally differentiating we get $\frac{d\hat{x}_*}{dc} = \frac{1}{\Omega(\hat{x}_*) + (1 + \phi)\lambda}$ for $c < \hat{x}_*$, which is always positive. For $c > \hat{x}_*$ we get $\frac{d\hat{x}_*}{dc} = \frac{1 - \Omega(c) - (c - \hat{x}_*)\Omega'(c)}{\Omega(\hat{x}_*) - \Omega(c) + (1 + \phi)\lambda}$ which is always positive for c sufficiently close to \hat{x}_* . For even higher values of c , however, it may be that $\frac{d\hat{x}_*}{dc}$ is negative, such as if $\Omega'(c)$ is locally particularly large. Finally, consider \hat{x}_- , which satisfies $\mu - 2c + C + \frac{2 + \phi}{\phi}\lambda\hat{x}_- - (1 + \phi)\frac{a}{p} = 0$. Totally differentiating we get $\frac{d\hat{x}_-}{dc} = \frac{2}{\Omega(\hat{x}_-) + \frac{2 + \phi}{\phi}\lambda} > 0$ for $c < \hat{x}_-$, which is always positive. For $c > \hat{x}_-$ we get $\frac{d\hat{x}_-}{dc} = \frac{2 - \Omega(c) - (c - \hat{x}_-)\Omega'(c)}{\Omega(\hat{x}_-) - \Omega(c) + \frac{2 + \phi}{\phi}\lambda}$ which is again positive for c sufficiently close to \hat{x}_- . However, $\frac{d\hat{x}_-}{dc}$ can also be negative for even larger c , such as if $\Omega'(c)$ is locally particularly large.

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Table 1: Time line

- Date 0 (Contracting stage): Firm sets optimal strategy, including development and compensation policy
- Date 1 (Employee's choice of action): Employee privately observes state (has idea or not, core prospects good or bad) and privately chooses either to pursue her assigned core task, or to explore her new idea.
- Date 2 (Firm's choice of development) If the employee has generated an innovation, there is choice of shelving it, developing it internally or developing it externally. Developing it conveys some hold-up power to the employee.
- Date 3 (Return realization stage): All returns are realized and divided according to contracts.

Table 2: Key notation

A	Employee's choice to focus on core task
a	Returns to core task
B	Employee's choice to explore new idea
b^E, b^F	Expected returns from choosing B
c	Cannibalization value
D_y, D_x	Dummies of developing an innovation internally or externally
δ	Benefits from a cooperative development policy
E	Employee
EIP	Regime where intellectual property rights belong to employee
F	Firm
FIP	Regime where intellectual property rights belong to firm
ϕ	Probability of success if prospects in the core are bad
Γ	Welfare gain of giving intellectual property rights to the employee rather than the firm
IIP	Regime where intellectual property rights formally belong to firm, but are imperfect
k	Cost per party of going to court
λ	Fraction of returns achieved without intellectual property rights (for IIP model)
μ	Expected value of an innovation, if developed efficiently
$\Omega(y)$	Distribution of y
p	Probability that idea is feasible
σ^-	Strategy where employee does no exploration
σ^*	Strategy where employee has healthy level of exploration (only state 1)
σ^+	Strategy where employee has excessive level of exploration (state 1 and 2)
U_F, U_E	Ex-ante utility of firm and employee
w_A, w_B, w_\emptyset	Compensation for generating value in the core (A), an innovation (B), or nothing (\emptyset)
x	Returns external venture (start-up or spin-off)
y	Returns to internal venture

Table 3: Overview of Results

	Low x ($x < \hat{x}_-^*$)	Medium x ($\hat{x}_-^* < x < \hat{x}_+^*$)	High x ($x > \hat{x}_+^*$)
<i>EIP</i> : Exploration level	None (σ^-)	Healthy (σ^*)	Excessive (σ^+)
<i>EIP</i> : Core incentives	High ($w_A^- = \frac{px}{\phi}$)	Intermediate ($w_A^* = px$)	None ($w_A^+ = 0$)
<i>EIP</i> : Firm development policy	Refuse internal ventures	Refuse internal ventures	Do internal ventures (for $y \geq x$)
<i>EIP</i> : Type of external ventures	None	Voluntary ($y < x$) and involuntary ($y \geq x$)	Voluntary ($y < x$)
<i>EIP</i> : Start-up rate	0	$\frac{p}{4}$	$\frac{p\Omega(x)}{2}$
<i>FIP</i> : Exploration level	None (σ^-)	None (σ^-)	None (σ^-)
<i>FIP</i> : Core incentives	None ($w_A =^- 0$)	None ($w_A =^- 0$)	None ($w_A =^- 0$)
<i>FIP</i> : Development policy	Shelve all innovations	Shelve all innovations	Shelve all innovations
Welfare Comparison	$EIP = FIP$	Lower x : $EIP < FIP$ Higher x : $EIP > FIP$	Lower x : $EIP < FIP$ Higher x : $EIP > FIP$
<i>IIP</i> : Exploration level	None (σ^-)	Healthy (σ^*)	Excessive (σ^+)
<i>IIP</i> : Firm development policy	Refuse int. vent. and spin-offs	Refuse int. vent. and spin-offs	Embrace int. vent. and spin-offs
<i>IIP</i> : Type of external ventures	None	Start-ups without <i>IP</i> (for all y)	Spin-offs (for $y < x$)
Threat of Lawsuits	Used to prevent exploration Not executed in equilibrium	Used to prevent exploration Executed in equilibrium	Used for bargaining Not executed in equilibrium
Cannibalization	Strong ex-ante prevention No ex-post shelving needed	Some ex-ante prevention Ex-post shelving refused in equilibrium	No ex-ante prevention Ex-post shelving welcome
Multiple equilibria	Always equil. for <i>EIP</i> and <i>FIP</i>	Possible equil. for <i>EIP</i> , not <i>FIP</i>	Possible equil. for <i>EIP</i> , not <i>FIP</i>

Figure 1

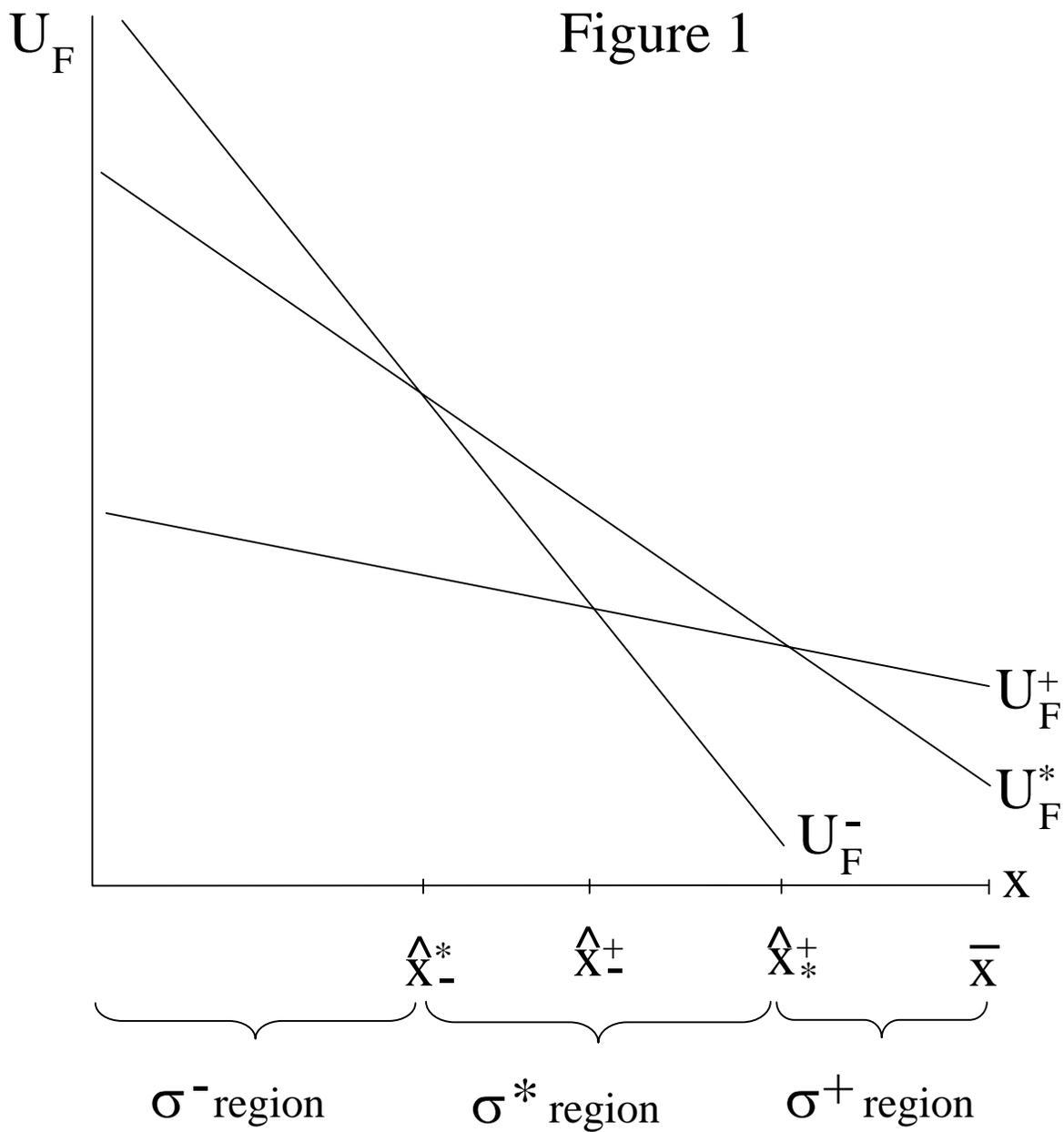


Figure 2

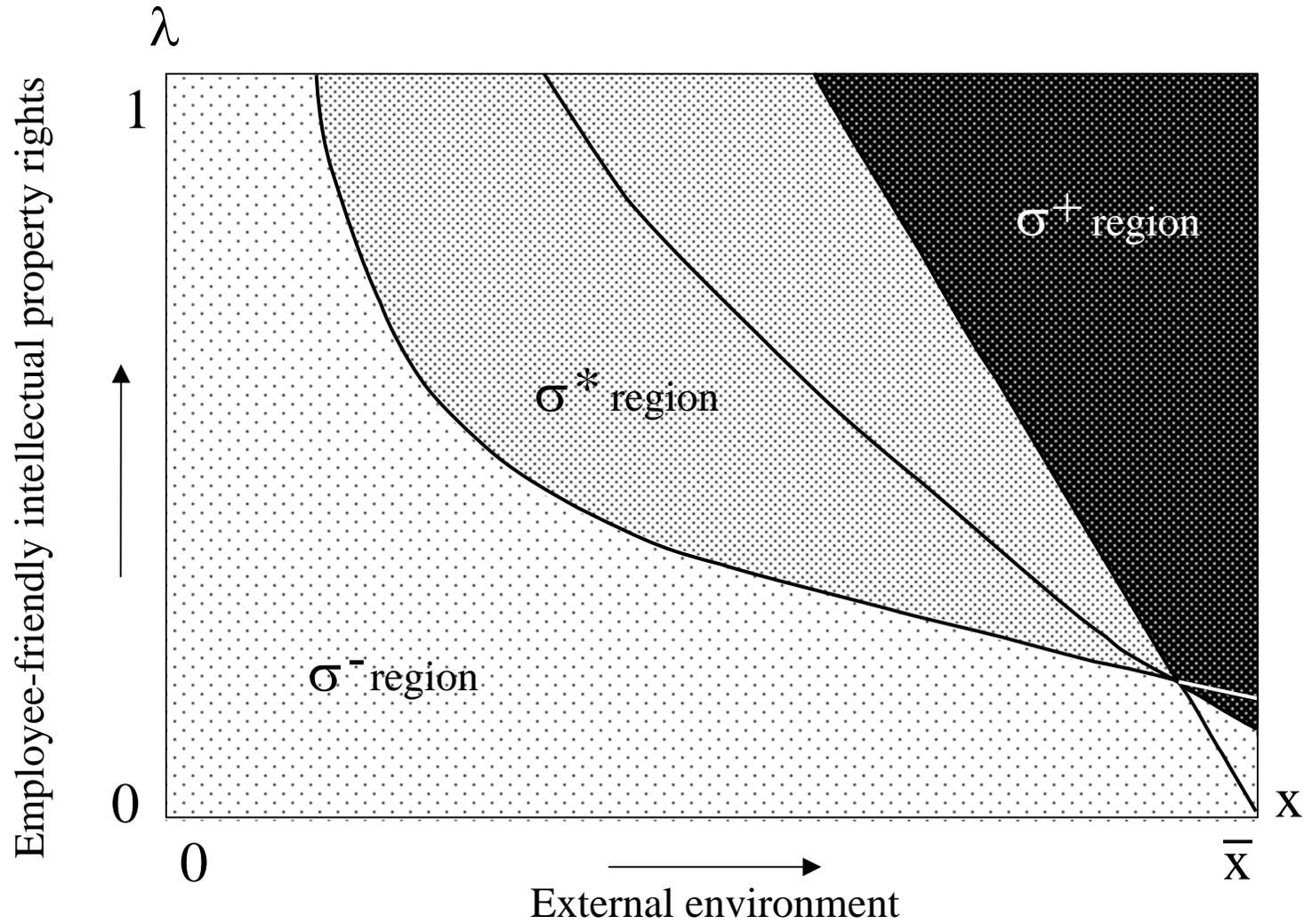


Figure 3

