Human Capital Investment, Entrepreneurship and New Firm Creation

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Abstract

This paper studies the role of established firms on the creation of entrepreneurs, new firms and venture capitalists (VCs). We argue that established firms' investment in their employees' human capital leads to the creation of entrepreneurs, which in turn, drives the creation of VCs. Similarly, the availability of VCs increases the willingness of established firms to invest in employee human capital, which drives the emergence of entrepreneurs from established firms. Hence the creation of entrepreneurs and VCs is determined jointly and endogenously in equilibrium. We show the existence of multiple equilibria with varying degree of entrepreneur and VC creation. Our results help understand the variation in the amount of entrepreneurship activity and VC financing across regions, as well as regional clustering of entrepreneurial *established* firms, entrepreneurial *new* firms and VCs. In addition, our analysis shows how investment in employee human capital can improve employee motivation, encourage innovation and increase growth. Our paper also generates a number of new and testable empirical predictions.

1 Introduction

Established firms represent an important source of entrepreneurs and new entrepreneurial ventures in the economy. Bhide (1994) finds that 71% of entrepreneurs found their ventures by replicating or modifying an idea they encountered at their previous employment. Firms started by a former employee of an established firm are often referred to as spin-outs.[1] Spin-outs are one of the most important source of entrepreneurial start-ups especially in high-tech and human capital intensive sectors (Garvin 1983). Consider the disk drive industry as an example. Christensen (1993) documents that spin-outs were the most important source of new firm creation in this industry in the period 1976-1989. In addition, spin-outs represented the majority of the start-ups that were successful at generating revenue and made up for 99.4 percent of the total revenues generated by the start-up group. Many of the early start-ups in the industry were IBM spin-outs, including Century Data, Memorex, Pertec and Storage Technology Corporation. This industry experienced a very high rate of entry by start-up firms and an extremely rapid rate of innovation from 1956 to 1997.

More evidence on the role of existing firms on the creation of entrepreneurs and new entrepreneurial firms comes from a recent paper by Gompers, Lerner and Scharfstein (2005). This paper documents that public firms located in Silicon Valley and Massachusetts contribute to the creation of new entrepreneurial ventures by training, educating and preparing their employees for entrepreneurship. Anecdotal evidence also suggests that companies like GE and McKinsey encourage their employees to be entrepreneurial and start their own businesses. A former employee of GE reports that "GE taught him how to seize opportunities, take risks and make mistakes". The same employee also says "GE is among the best incubators of talent and has a great culture of encouraging entrepreneurship". Similarly, a former McKinsey employee sees his former employer as an "idea lab and opportunity shop". (BusinessWeek, March 2006). These evidence raise interesting questions: Why do established firms invest in employee human capital and promote entrepreneurship if it results in the departure of their valuable employees who leave their firm to become an entrepreneur? What factors affect established firms' willingness to encourage entrepreneurship and to supply entrepreneurs to the economy?

In our model, established firms' investment in their employees' human capital leads to the creation of

[1] New firms created by an established firm from one of its divisions is referred to as spin-offs whereas independent start-ups created by the employee(s) of an established firm are referred to as spin-outs. Established firms usually take an equity position in a spin-off transaction. In spin-outs there is no equity link between the parent company and the start-up.

entrepreneurs in the economy, which, in turn, drives the creation of VCs. Similarly, the availability of VC financing increases the willingness of established firms to invest in employee human capital and facilitates the creation of entrepreneurs. Hence, the creation of VC-backed new firms and VCs is determined jointly and endogenously in equilibrium. In addition, our analysis shows how investment in employee human capital can improve employee motivation, enhance innovation incentives and benefit firms.

We argue that the emergence of entrepreneurs out of established firms is a byproduct of these firms' effort to motivate innovation and to improve firm profitability. In our set-up, there is an established firm with the objective of motivating its employees to generate firm specific innovations and to increase firm profitability. The firm can make a human capital investment which enhances the entrepreneurial potential of its employees. Human capital investment is costly for the firm since it increases the likelihood that (some) employees of the firm will generate a non firm specific innovation, which falls outside the core business of the firm and leave the firm to found their own ventures. Hence, the firm bears the cost of losing its employees, who are irreplaceable or very costly to replace in the short run. However, the firm benefits from the human capital investment since it can increase the ex ante probability with which the employees of the firm generate firm specific innovations. This is because human capital investment strengthens employee incentives to exert higher effort, which translates into higher likelihood of not only non firm specific innovations but also firm specific innovations.

There are two different channels why human capital investment improves employee incentives to innovate: The first is that employees anticipate that the investment in their human capital increases the likelihood that they may obtain a new business idea and capture greater rents from founding their own ventures rather than working for the firm and, as a result, exert higher effort ex-ante. The second channel is that it relaxes the firm's resource constraint and reduces competition among the employees for the firm's limited resources and affects employee incentives positively. Although a higher effort level translates into a higher likelihood of the employees leaving the firm, it nevertheless can be beneficial for the firm since it also results in a higher probability for the employees to generate firm specific innovations which are implemented within the firm. Under certain conditions, the beneficial effect of human capital investment in terms of higher likelihood of firm specific innovations dominates the expected cost of losing (some) employees and the firm finds it optimal to invest in employee human capital and encourage entrepreneurship. An alternative interpretation of the firm's human capital investment is that the higher likelihood of losing some of its employees is the price (risk) that the firm must pay for improving the ex-ante motivation

and quality of remaining employees, who turn out to generate firm specific innovations and stay with the firm. In other words, without the risk of losing some employees, there is no (or very little) firm specific innovation.

Our analysis establishes an interesting interaction between firms' human capital investment and the creation of venture capitalists. Becoming a VC is more desirable and profitable when established firms supply more entrepreneurs to the economy. Similarly and perhaps counterintuitively, it becomes more attractive for firms to invest in employee human capital, and as a result, to supply more entrepreneurs to the economy when the availability of VC financing improves. The intuition behind this externality is that having access to VC financing increases the payoff from new ventures and makes it more attractive for employees to exert effort, generate a business idea and found their own start-ups. This increases ex ante incentives (effort level) of the employees, some of whom the firm will be able to retain. As a result, easier availability of VC financing has a positive affect on the likelihood of firm specific innovations and hence established firms' willingness to invest in employee human capital. A similar line of reasoning suggests that the firms' investment in employee human capital increases the availability of VC financing. Investment in employee human capital increases the future supply of entrepreneurs in the economy, which in turn, increases the willingness of the would-be VC investors to become a VC due to the anticipation of the increase in the supply of entrepreneurs. An interesting implication of this interaction between firms' investment in employee human capital and VC creation is not only the regional clustering of *new* entrepreneurial firms and VCs, but also the clustering of *established* entrepreneurial firms, *new* entrepreneurial start-ups and VCs, an empirical result documented by Gompers, Lerner and Scharfstein (2005).

Our paper also illustrates the benefits and the costs of motivating entrepreneurship and encouraging innovation in organizations. A recent survey documents that 78% of the 540 CEOs surveyed reports that "stimulating innovation, creativity, and enabling entrepreneurship" is a vital task for their organizations.[2] Our analysis shows that one way for organizations to enable entrepreneurship is to invest in the human capital of their employees and to encourage them to generate innovative ideas even if there is some likelihood that they will not be within the core business of the organization. Human capital investment is beneficial for organizations because it improves employee motivation with a positive effect on the likelihood that employees generate firm specific innovative ideas.

[2] CEO Challenge 2004: Perspectives and Analysis, The Conference Board, Report 1353.

Our multiple equilibrium model helps explain the variation in entrepreneurial activity across regions and industries. The high entrepreneurship equilibrium in our model describes the co-existence of entrepreneurial public firms and the relative abundance of VC financing in Silicon Valley. Gompers, Lerner and Scharfstein (2005) document that the most active public firms in terms of entrepreneurial "spawning" are located in Silicon Valley and Massachusetts, regions characterized by the most developed VC industry. An interesting result of our paper is that established firms can benefit from the development of an active VC industry even if this implies losing (some of) their employees who collaborate with VCs to set up their own start-ups. This happens as long as having access to VC financing improves effort incentives of all employees some of whom end up generating firm specific innovations. Hence, in our model, development of an active VC industry and established firms' willingness to encourage entrepreneurship are complementary to each other. Our low entrepreneurship equilibrium where established firms do not invest in employee human capital and there is no (or little) creation of entrepreneurs and VCs can explain relatively low levels of entrepreneurial firm creation, low employee mobility and the lack of VC financing in Western Europe and Japan.

There are other papers in the literature analyzing entrepreneurship activity in equilibrium. Gromb and Scharfstein (2002) shows the existence of multiple equilibria with different levels of entrepreneurship activity by comparing the organization of new ventures in start-ups and in established firms. Landier (2002) considers an equilibrium model of entrepreneurship where the market's perception of entrepreneurial failure affects the willingness of a failed entrepreneur to start a new venture and the amount of entrepreneurial activity. Our paper contributes to this literature by endogenizing the creation of entrepreneurs and VCs.

The remainder of this paper is organized as follows. Section 2 describes the basic model with a review of the critical assumptions. In section 3, we analyze the model and derive firm profits with and without the investment in employee human capital. Section 4 extends the basic model by assuming that the firm has two employees and faces a resource constrained. Section 5 presents extensions of the model and evaluates the robustness of the results. Section 6 presents empirical predictions of our model and section 7 concludes. The proofs are presented in the appendix.

2 The Model

Consider a three-period model ($t = 0, 1, 2$) with no discounting. The model economy has three types of agents; a firm, employees and an investor with a potential to become a VC, referred to as the would-be VC investor. All agents are risk neutral. The firm has an employee. The employee is wealth constrained and ex ante monetary transfers between the firm, the employee and the investor are not feasible.

At $t = 0$, the firm decides whether or not to make a human capital investment in its employee. This investment increases the entrepreneurial potential of the employee by enhancing his prospects of generating an innovative idea which falls outside the core business of the firm.[3]

At $t = 1$, if the firm makes the human capital investment at $t = 0$, the employee acquires an entrepreneurial skill. If the firm does not make the investment, the employee does not have the technology to acquire the entrepreneurial skill and he is assumed to have a firm specific skill. The would-be VC investor can turn into a VC by making an investment at a personal cost of $K \geq 0$. This investment enables him to acquire all the skills, knowledge and capital to finance future entrepreneurs with a project idea. At $t = 1$, the investor, observing whether the firm makes the human capital investment in its employee at $t = 0$ makes his decision to become a VC or not by incurring the personal cost of K.

At $t = 2$, the employee exerts an unobservable effort p which determines the success probability of generating an innovative idea. There are two types of innovative ideas; firm specific and non firm specific ideas. The type of the idea generated depends on whether the firm invests in employee human capita and the employee acquires the entrepreneurial skill. If the firm does not invest in employee human capital, the employee generates a firm specific innovation with probability p_i, which has the greatest value, if implemented and commercialized within the firm. If the firm invests in employee human capital and the employee acquires the entrepreneurial skill, he generates a firm specific innovation only with probability $p_i(1 - \theta)$ with $0 < \theta < 1$,which has the highest value if implemented within the firm. With probability $p_i\theta$, the employee generates a non firm-specific innovation which falls outside the core business of the firm. The firm does not have the expertise to implement this innovation. The employee leaves the firm and commercializes the non firm specific innovation with a Venture Capitalist (VC) provided that there is a VC available in the economy.[4] If there is no availability of VC financing, then the employee's innovation

[3]The firm's investment in entrepreneurship can be interpreted in a variety of ways such as training the employees, encouraging them to be more entrepreneurial, creative and experimental, introducing them to venture capitalists, etc.

[4]Our results are robust to introducing the option for the employees to obtain a non firm specific idea and to leave the firm when they have the firm specific skill as well, as long as the probability of generating a non firm specific innovation is

generates a payoff of zero. This assumption that the employee's non firm specific innovation generates a zero payoff without a VC is a normalization and made for analytical simplification. This assumption captures the fact that the innovation generates a greater value with the involvement of a VC, due to the value adding role of the VC.

At $t = 3$, whether the employee has an innovation or not and the type of the innovation is realized. If the employee has a firm specific innovation, implementation of the innovation requires the participation of both the employee who generated the innovation and the firm. The firm and the employee bargain over the allocation of the surplus to be realized from implementing the innovation. If the employee has a non firm specific innovation, implementation of the innovation requires the participation of the employee and the VC. In this case, the employee leaves the firm and starts his own venture with the collaboration of the VC.

At $t = 4$ innovation value is realized and all the parties receive their surplus. Firm specific innovations generate a payoff of x and non firm specific innovations generate a payoff of y with, $x \geq 0$ and $y \geq 0$.

2.1 Discussion of the assumptions

Following the incomplete contracting literature of Grossman and Hart (1986) and Hart and Moore (1990), we assume that once the employee has a firm specific innovation, he bargains with the firm to determine his surplus from implementing the innovation. Thus, we rule out ex-ante equity contracts. This assumption is easily justified by noting that the employee has the ability to withdraw his human capital from the implementation phase of the innovation once he generates an innovation. Similarly, the firm can withdraw the resources necessary for the implementation of the innovation. In other words, commercializing a firm specific innovation is possible only when both the firm and the employee participate in the implementation phase of the innovation. If at least one of the parties withdraws his involvement, the innovation generates a payoff of zero. Hence, each party's bargaining power comes from his ability to withdraw his involvement from the implementation phase of the innovation. Similarly, if the employee generates a non firm specific innovation, he bargains with the VC over surplus allocation. Note that we make this assumption because it provides analytical simplicity in Section 4 where we analyze the model with multiple employees. In appendix A, we analyze the main model of our paper where the firm and the employee can commit to the long term contracts written at the outset of the game and we prove that the main results of the paper are

greater with the entrepreneurial skill than with the firm specific skill.

robust to the introduction of equity contracts.

The second important assumption of the model is that once an employee generates a non firm specific innovation, he leaves the firm and implements his innovation with the VC. We rule out initially any agreements between the employee and the firm on sharing the future revenues from the employees' new venture. Section 5 extends our analysis to the case where the firm can extract a proportion of the employee's payoff from his entrepreneurial venture if the employee leaves the firm and collaborates with the VC. This extension offers a rationale for established firms' investment in entrepreneurial start-ups, known as Corporate Venture Investment. It also provides additional results which help explain why many firms allow employee mobility and let their employees go and set up their own businesses without requiring any contractual agreements to receive a share of the future revenues from their employees' start-ups.

We rule out any contractual agreement between the firm and the VC on sharing the future revenues from the employee's new venture. This assumption is realistic considering the fact that when the firm makes the investment in its employee, it does not even know the identity of the future VC and hence it is impossible to enter into an agreement with the VC on the allocation of the surplus from the future start-up.

Our analysis assumes that if an employee leaves the firm to set up his own venture, the firm can not replace the employee with a new one from the general labor pool. We can relax this assumption by allowing the firm to hire new employees if one of the current employees departs. Our results continue to hold as long as the surplus that the firm and the new employee can generate is lower than the surplus generated by the firm and the original employee. This assumption is realistic considering that new employees need time and training to acquire firm specific skills to generate value. In addition, it is possible that the firm and the original employee can create a higher surplus due to relationship specific nature of the investment.

We also rule out any ex-ante transfers between the firm and the employee. The limited wealth constraint of the employees prevents transfers from the employee to the firm. The usual motivation for ruling out transfer payments to the employees is that these transfer payments would attract fraudulent employees (Rajan (1992)).

3 Model Analysis

Solving the model backwards, we first consider the case where the firm does not make the human capital investment in its employee. Subsequently, we analyze the case where the firm makes the human capital investment. We then compare the firm's expected profit from each strategy and derive the firm's optimal human capital investment decision and the resulting level of VC creation.

3.1 The firm does not invest in employee human capital

This section analyzes the subgame where the firm does not invest in employee human capital. The employee, with the firm specific skill, exerts effort p, at a cost of $\frac{k}{2}p^2$; where k is the cost of exerting effort, with $k > 1$.[5] Note that with the firm specific skill it is possible to generate only firm specific innovations. If the employee has a firm specific innovation, the innovation needs the firm's resources and employee's effort, human capital and involvement to generate a payoff. Assuming Nash bargaining between the employee and the firm where both parties have the same bargaining power, they split the total surplus x from commercializing the innovation equally and hence each party obtains $\frac{x}{2}$[6].

The employee, anticipating his expected share of the surplus from bargaining with the firm determines his level of effort p^F by maximizing his expected profit, π_E^F, given by

$$\max_{p^F} \;\; \pi_E^F \equiv p^F \frac{x}{2} - \frac{k}{2}(p^F)^2. \tag{1}$$

The firm's expected profit, π_F^F, is given by

$$\pi_F^F \equiv p^F \frac{x}{2}. \tag{2}$$

Solving the first order condition of (1) for p^F yields the level of employee effort p_1^{F*} given by

$$p^{F*} = \frac{x}{2k}. \tag{3}$$

Plugging (3) into (2) and (1) yields the expected profit of the firm, π_F^{F*} and the employee, π_E^{F*} given by

$$\pi_F^{F*} = \frac{x^2}{4k}, \tag{4}$$

$$\pi_E^{F*} = \frac{x^2}{8k}. \tag{5}$$

[5]Innovation can be broadly interpreted as any idea, project or concept which improves firm profitability.

[6]The results of the paper go through where the parties have different levels of bargaining power as well.

As expected, the equilibrium level of effort, the expected profits of the firm and of the employees are an increasing function of the project payoff, x, and a decreasing function of the cost of exerting effort, k.

Note that in this subgame, since the employee never obtains a non firm specific innovation, he never leaves the firm and hence, the firm supplies no entrepreneurs to the economy. Moreover, since the economy will have no entrepreneurs, there will not be any VC creation either. Note that the results that without the firm's human capital investment, the employee never obtains a non firm specific innovation and does not leave the firm, and there is no VC creation are the due to the normalization assumption that the probability that the employee generates a non firm specific innovation without the human capital investment is zero. This assumption is made only for analytical simplicity. What is important for our analysis is that the probability of the employee obtaining a non firm specific innovation and the likelihood of VC creation are higher with the firm's human capital investment than without it.

3.2 Investment in employee human capital

This section analyzes the subgame where the firm invests in employee human capital. After the firm's human capital investment, the employee acquires the entrepreneurial skill and exerts effort p^E. With probability $p^E\theta$ he generates a non firm specific innovation and leaves the firm to commercialize his innovation with the venture capitalist (VC). With probability $p^E(1-\theta)$, he generates a firm specific innovation which has the highest value, if implemented within the firm. In this case, he stays with the firm and implements the innovation with the firm.

3.2.1 Venture Capitalist

If the firm invests in its employees' human capital, and introduces the option for the employee to become an entrepreneur, the employee may obtain a non firm specific innovation which can be implemented with the collaboration of the VC. Hence, the would-be VC investor's decision to become a VC depends on whether the firm invests in employee human capital. The investor, observing the investment decision of the firm, makes his decision to become a VC or not by incurring the personal investment cost of K.

The employee determines his level of effort p^E by maximizing his expected profit, π_E^E, given by:

$$\max_{p_1^E} \pi_E^E \equiv p^E(1-\theta)\frac{x}{2} + p^E\theta\frac{y}{2} - \frac{k}{2}(p^E)^2. \tag{6}$$

The expected profit of the employee given in (6) is conditional on the availability of VC financing if the employee generates a non firm-specific innovation. We assume that the investor's participation constraint

from becoming a VC is satisfied and he recoups at least K from turning into a VC in the remainder of the analysis. In the characterization of the equilibrium, we will make sure that the his participation constrained is indeed satisfied.

If the employee acquires the entrepreneurial skill, this implies that with probability $p^E(1-\theta)$, he obtains a firm specific innovation. In this case, his compensation from implementing the innovation with the firm will be $\frac{x}{2}$. With probability $p^E\theta$, the employee generates a non firm-specific innovation and leaves the firm. In this case, the total payoff that he can generate with the collaboration of the VC is y. We assume that the VC and the employee share the total surplus equally and each party obtains $\frac{y}{2}$.[7]

The firm's expected profit π_F^E is given by

$$\pi_F^E \equiv p^E(1-\theta)\frac{x}{2}. \tag{7}$$

Comparison of (7) with (2) reveals the potential costs and benefits of the human capital investment. Although there is no direct monetary cost, human capital investment is costly for the firm as it increases the likelihood that the firm loses its employees who may leave the firm with probability $p^E\theta$.[8] In other words, human capital investment dilutes the core business of the firm by introducing some likelihood that the employee obtain a non firm specific innovation and leave the firm. However, the firm can benefit from the investment because it affects incentives positively for two different reasons. The first is that the employee, anticipating that he may leave the firm and found his own start-up, may have stronger incentives to exert effort, resulting in a higher level of effort. Formally, this can be seen by noting that the employee generates a firm specific innovation with probability p^F without the human capital investment, and with probability $p^E(1-\theta)$ with the human capital investment. Even though the probability of firm specific innovations is diluted by $1-\theta$ with the human capital investment, it is still possible that $p^E(1-\theta) > p^F$ if the positive effect of the human capital investment on incentives is sufficiently strong, that is, p^E is sufficiently larger than p^F.

[7] Even division of surplus between the employee and the VC is not important for our results in any way. Our results go through where the revenue sharing rule between the VC and the employee is such that the VC breaks even and his participation constraint is binding in equilibrium.

[8] Note that it is straightforward to introduce a monetary cost of making the human capital investment. Our model captures this cost implicitly since if the firm makes the investment and the employees acquire the entrepreneurial skill, the probability of obtaining a firm specific innovation reduces to $p\theta$ from p. Hence, θ can be interpreted as a measure of the cost of the investment.

The investor's expected payoff π_{VC}^{E} from becoming a VC is given by

$$\pi_{VC}^{E} \equiv p^{E}\theta\frac{y}{2} - K.$$

Solving the first order condition of (6) for p^{E} yields the level of employee effort p^{E*} given by

$$p^{E*} = \frac{(1-\theta)x + \theta y}{2k}. \tag{8}$$

Comparing (8) with (3) reveals that $p^{E*} \geq p^{F*}$ for $y \geq x$.

Conditional on the VC's participation constraint being satisfied, that is,

$$p^{E*}\theta\frac{y}{2} - K \geq 0. \tag{9}$$

the equilibrium level of firm, employee and VC expected profits are given by

$$\pi_{F}^{E*} = \frac{(1-\theta)\left((1-\theta)x + \theta y\right)x}{4k}, \tag{10}$$

$$\pi_{E}^{E*} = \frac{((1-\theta)x + \theta y)^{2}}{8k}, \tag{11}$$

$$\pi_{VC}^{E*} = \frac{\theta((1-\theta)x + \theta y)y}{4k} - K. \tag{12}$$

The following lemma shows the positive impact of human capital investment on employee effort and firm profits.

Lemma 1 *Conditional on the VC's participation constraint being satisfied, $p^{E*} \geq p^{F*}$ if and only if $y \geq x$. Firm expected profit with the human capital investment is greater than that without the investment, that is, $\pi_{F}^{E*} \geq \pi_{F}^{F*}$ for $y \geq y_1 \equiv x\frac{2-\theta}{1-\theta}$.*

Lemma 1 shows that employee effort is higher when the firm invests in employee human capital provided that the potential payoff that the employee will obtain from his venture, y is sufficiently high. Since the firm's expected profit is a function of employee effort, the firm benefits from human capital investment despite the possibility of losing the employee. Note that $p^{E*}(1-\theta) \geq p^{F*}$ for $y \geq y_1$, implying that the human capital investment not only leads to non firm specific innovations and departure of the employees, but also increases the probability of a firm specific innovation and improves firm profitability. Hence, the firm can use the human capital investment as a tool to increase growth and profitability. Another way to interpret this result is that even though human capital investment leads to departure of some employees (measured by $p^{E*}\theta$) , it can be still beneficial for the firm because it improves the motivation and quality

of the remaining employees (i.e., $p^{E*}(1-\theta) \geq p^{F*}$) and increases firm profits, compared to the case where the firm does not invest in employee human capital.

The firm decides whether to invest in employee human capital by comparing its expected profits with the human capital investment given by (10) to those without the investment given by (4). The following proposition summarizes the firm's optimal investment decision.

Proposition 1 *High entrepreneurship equilibrium with VC creation: The firm invests in employee human capital for $y \geq Y_1^*$ where*

$$Y_1^* \equiv \begin{cases} Y_1 \equiv \frac{(2-\theta)x}{1-\theta} & \text{if } K \leq K_1 \equiv \frac{\theta(2-\theta)x^2}{4(1-\theta)^2 k}; \\ Y_2 \equiv \frac{-(1-\theta)x+\sqrt{\left((1-\theta)^2x^2+16Kk\right)}}{2\theta} & \text{if } K > K_1. \end{cases}$$

Low (no) entrepreneurship equilibrium with no VC creation: The firm does not invest in employee human capital and there is no VC creation for $y < Y_1^*$. Furthermore, $Y_1 \leq Y_2$ if $K > K_1$.

Figure 1 describes the firm's optimal strategy as a function of parameter values. The firm is willing to invest in employee human capital only at sufficiently high values of y, that is, when $y \geq Y_1^*$. There are two conditions for the firm to be willing to invest in employee human capital. The first condition is that y should be sufficiently high that the investor's expected profits from becoming a VC given by (12) are greater than 0, and hence he is willing to turn into a VC by incurring the cost K. Remember that the VC's future expected profits are directly proportional to y. If y is not high enough to induce the investor to turn into a VC, then the human capital investment cannot motivate the employee since the employee's chances of starting his own company is conditional on being able to collaborate with a VC. Hence, if y is not sufficiently high to lead to VC creation, the firm does not invest in employee human capital. The second condition is that y should be sufficiently high that the firm benefits from the investment despite losing its employee with some probability (or losing a percentage of its employees). Formally, the ex-ante likelihood of firm specific innovations (or equivalently, the fraction of employees with firm specific innovations), reflected by $p^E(1-\theta)$ should be sufficiently high that the firm benefits from the investment. These two conditions are satisfied by the requirement that $y \geq Y_1^*$. At lower values of K, that is, when $K \leq K_1$, the condition $y > Y_1$ is necessary for the firm to benefit from human capital investment. Note that the threshold level Y_1 is independent of K since the VC's participation constraint does not bind at lower values of K. As K increases, the firm needs a more favorable entrepreneurial environment (higher y) not only to be able to benefit from the human capital investment but also to facilitate the creation of

VCs. Hence, the threshold level for y increases, that is, $Y_1 \leq Y_2$, to induce the firm to invest in employee human capital. In addition, Y_2 is an increasing function of K, implying that as K increases, it becomes more difficult to induce the entry of the VCs, and hence, the firm needs a higher value of y to be willing to encourage entrepreneurship. Note that when $y \geq Y_1^*$,the employee is better off as well with the human capital investment and he is willing to acquire the entrepreneurial skill.

The following lemma summarizes the impact of an improvement in the entrepreneurial environment and the value adding ability of the VC reflected by y on employee effort and firm profits, conditional on the firm making the human capital investment and the employee acquiring the entrepreneurial skill.

Lemma 2 *Employee effort p^{E*} and the expected profits of the firm π_F^{E*} and the employee profits π_E^{E*} increase in y.*

An entrepreneur friendly environment and a more able VC (high y) increase the employee's future expected profits. As a result, the employee exerts higher effort as y increases, leading to a higher probability of both firm specific and non-firm specific innovation. Since firm expected profit is directly proportional to the probability of a firm specific innovation, the firm benefits from an increase in y as well.

It is interesting to examine the impact of θ on firm profits. An increase in θ increases the probability of employee departure, hurting the firm ex-post. However, there is a second, positive effect of θ on employee incentives. An increase in θ improves employee incentives if y is sufficiently high and the following lemma shows that when θ is sufficiently low, firm profits can increase in θ at sufficiently high values of y. This result shows that firms can benefit from greater employee mobility even of it means that they face a higher likelihood of losing their employees. Encouraging entrepreneurship and employee mobility improve employee incentives and prove to be beneficial for the firm as long as there is some probability that employees with enhanced incentives generate firm specific innovations. An alternative interpretation is that human capital investment of the firm leads to the loss of some employees, but it may still increase firm value by increasing the likelihood that the remaining employees obtain a firm specific innovation.

Lemma 3 *For $\theta \leq \frac{2k-x}{4k-x}$, the expected profits of the firm π_F^{E*} is increasing in θ for $y > y_2 \equiv \frac{2(1-\theta)x}{1-2\theta}$.*

Given that the firm invests in employee human capital and the employee acquires the entrepreneurial skill, the following lemma shows how the creation of the VCs is affected by the fundamentals of our model economy.

Lemma 4 *The expected profits of the VC, that is,* $\pi_{VC}^{E*} = \frac{\theta((1-\theta)x+\theta y)y}{4k} - K$ *increases in* y *and* θ*, and decreases in* k *and* K*.*

Lemma 4 implies that it becomes more desirable for the investor to become a VC as the favorability of the entrepreneurial environment measured by y improves. The expected profits of the VC increase in θ implying that as the supply of future entrepreneurs in the economy increases, it becomes more desirable to become a VC. Since θ and hence the probability of the employee turning into an entrepreneur is positive only when the firm invests in employee human capital, this result shows that the firm's willingness to invest in employee human capital facilitates the creation of VCs.

Note that, given that the firm invests in employee human capital and the employee acquires the entrepreneurial skill, the rate at which the firm supplies entrepreneurs to the economy is given by $e^{E*} \equiv p^{E*}\theta = \frac{\theta((1-\theta)x+\theta y)}{2k}$. The following lemma shows how entrepreneurship creation is affected by certain parameters of our model.

Lemma 5 $\frac{\partial e^{E*}}{\partial y} > 0, \frac{\partial e^{E*}}{\partial k} < 0.$

The rate of entrepreneurship creation e^{E*} increases in y, reflecting the positive impact of the value adding potential of the VC and the favorability of the entrepreneurial environment on the amount of entrepreneurship activity. In addition, $\frac{\partial e^{E*}}{\partial k} < 0$ implies that the rate of entrepreneurship creation increases as the productivity or the skill level of the employees increases, that is, as k goes down. Note that since a low level of k implies a high level of effort and productivity we can interpret k as measuring the productivity of the employees

4 Analysis with two employees

In this section we investigate the firm's willingness to invest in employee human capital when the firm has two employees and faces a resource constrained. We will show that having two employees and the resource constraint of the firm provide another reason why the firm benefits from investing in employee human capital. The intuition is as follows. The resource constraint of the firm affects employee incentives to exert effort negatively because of each employee's anticipation that his innovation will receive a lower amount of resources for implementation when there is competing employee with a firm specific innovation. The firm's human capital investment reduces the negative effect of the resource constraint on incentives since it leads

to the departure of some employees of the firm, leaving the remaining employees with less competition for the firm's resources, with a positive effect on incentives to generate firm specific innovations.

As in the previous sections, we will first analyze the case where the firm does not invest in employee human capital. Second, we will analyze the case where the firm invests in employee human capital and then derive the firm's optimal human capital investment decision and the resulting amount of VC creation.

4.1 The firm does not invest in employee human capital

Without the human capital investment, employee i has the firm specific skill, and exerts effort p_i, at a cost of $\frac{k}{2}p_i^2$; $i = 1, 2$. As before we assume that with the firm specific skill it is possible to generate only firm specific innovations. We also assume that the firm has limited amount of resources in the following sense: Each firm specific innovation generates a revenue of x if it receives the entire amount of the resources of the firm. However, if both employees are successful, then each employee's innovation is implemented at a reduced scale and generates a payoff of $\frac{x}{2}$. [9]If only one of the employees has been successful in generating an innovation, his innovation receives the entire amount of the resources available. In this case, the innovation generates a payoff of x.

After observing whether the employees have an innovation or not, the employees and the firm bargain to determine the allocation of the surplus from the implementation of the innovation. The payoffs from bargaining between the firm and the employees depend on whether only one or both employees have an innovation. There are four different states of the world: 1)state SS: both employees have an innovation; 2) state SF: employee 1 has an innovation, employee 2 does not; 3) state FS: employee 1 does not have an innovation, employee 2 has; 4) state FF: neither employee has an innovation.

4.1.1 State SS

The employees share the limited resources of the firm to implement their innovations and each innovation generates a payoff of $\frac{x}{2}$. Assuming that both the firm and the employees have the same bargaining power, each employee obtains $\frac{x}{4}$, and the firm obtains a payoff of $\frac{x}{2}$.

[9]See Rotemberg and Saloner (1994) for a similar assumption which generates competition between the employees of a firm.

4.1.2 State SF (and FS)

In state SF (FS) only the first (second) employee has an innovation. Hence, the firm and employee 1 (2) share the total surplus of x equally and each party obtains $\frac{x}{2}$.

4.1.3 State FF

Both employees fail. All parties receive zero payoffs.

Employee $i, i = 1, 2$, anticipating his expected share of the surplus from bargaining with the firm in the different states of the world and given the effort level, p_j^{FF}, chosen by employee j, determines his level of effort p_i^{FF} by maximizing his expected profit, π_{Ei}^{FF}, given by

$$\max_{p_i^{FF}} \ \pi_{E_i}^{FF} \equiv p_i^{FF} p_j^{FF} (\frac{1}{2} \times \frac{x}{2}) + p_i^{FF}(1 - p_j^{FF})\frac{x}{2} - \frac{k}{2}(p_i^{FF})^2; i, j = 1, 2, i \neq j. \tag{13}$$

Note that the first term in (13) corresponds to the case where both employees are successful in generating an innovation and each employee obtains a payoff of $\frac{x}{4}$. The second term corresponds to the case where employee 1 is successful and employee 2 fails and employee 1 receives a payoff of $\frac{x}{2}$ from the implementation of his innovation.

The firm's expected profit, π_F^{FF}, is given by

$$\pi_F^{FF} \equiv p_i^{FF} p_j^{FF} (\frac{x}{4} + \frac{x}{4}) + p_i^{FF}(1 - p_j^{FF})\frac{x}{2} + p_j^{FF}(1 - p_i^{FF})\frac{x}{2}. \tag{14}$$

The first order condition of (13) is given by

$$p_i^{FF}(p_j^{FF}) = \frac{1}{4} x \frac{2 - p_j^{FF}}{k}. \tag{15}$$

Note that the first order condition (15) implies that effort level exerted by employee i is decreasing in employee j's effort level. This is due to the fact that the employees compete for the firm's limited resources in the state where both of them have an innovation. In state SS, each employee's innovation receives only half of the total resources of the firm and generates a payoff of $\frac{x}{2}$ rather than x.

Lemma 6 *The Nash-equilibrium level of employee effort is given by*

$$p_1^{FF*} = p_2^{FF*} = \frac{2x}{x + 4k}.^{10} \tag{16}$$

[10] We assume throughout the paper that $x < 2k$ to avoid corner solutions.

The corresponding level of expected profits for the firm and the employees are given by

$$\pi_F^{FF*} = \frac{8x^2k}{(x+4k)^2}, \tag{17}$$

$$\pi_{E1}^{FF*} = \pi_{E2}^{FF*} = \frac{2x^2k}{(x+4k)^2}. \tag{18}$$

The resource constraint of the firm has a negative effect on employee effort. It is straightforward to show that employee effort when the firm has two employees is strictly lower than that when the firm has only one employee, that is, $p_1^{FF*} < p^{F*}$.

Note that in this subgame, since the employees never obtain a non firm specific innovation, they do not leave the firm and hence, the firm supplies no entrepreneurs to the economy. Moreover, since the economy will have no entrepreneurs, there will not be any VC creation either.

4.1.4 The firm invests in employee human capital

This section analyzes the subgame where the firm invests in employee human capital and both employees acquire the entrepreneurial skill. After acquiring the entrepreneurial skill, employee i exerts effort p_i^{EE} to maximize his expected profits π_i^{EE}, given by:

$$\max_{p_i^{EE}} \pi_i^{EE} \equiv p_i^{EE}(1-\theta)[p_j^{EE}(1-\theta)\frac{x}{4} + p_j^{EE}\theta\frac{x}{2} + (1-p_j^{EE})\frac{x}{2}] + p_i^{EE}\theta\frac{y}{2} - \frac{k}{2}(p_i^{EE})^2, i,j = 1,2, i \neq j. \tag{19}$$

Employee i obtains a firm specific innovation with probability $p_i^{EE}(1-\theta)$. His payoff from implementing the innovation depends on whether employee j obtains an innovation and the type of employee j's innovation. With probability $p_j^{EE}(1-\theta)$, employee j also obtains a firm specific innovation and both employees obtain a payoff of $\frac{x}{4}$, as indicated by the first term in parenthesis in (19) after the term $p_j^{EE}(1-\theta)$. With probability $p_j^{EE}\theta$, employee j obtains a non firm specific innovation and leaves the firm. In this case, employee i receives the entire amount of firm resources and obtains a payoff of $\frac{x}{2}$ from implementing his innovation. With probability $(1-p_j^{EE})$, employee j fails to obtain an innovation and employee i again receives all the resources of the firm and obtains a payoff of $\frac{x}{2}$. Finally, with probability $p_i^{EE}\theta$, employee i obtains a non firm specific innovation, leaves the firm and obtains a payoff of $\frac{y}{2}$, by setting up his new firm with the VC.

The first order condition of (19) with respect to p_i^{EE} is given by

$$p_i^{EE}(p_j^{EE}) = \frac{2((1-\theta)x + \theta y) - (1-\theta)^2 x p_j^{EE}}{4k}. \tag{20}$$

Comparing (20) with (15) reveals that employee i's effort has a lower sensitivity to employee j's effort compared to the case where the firm does not invest in employee human capital. Formally, this can be seen by noting that $\frac{\partial p_1^{EE}(.)}{\partial p_2^{EE}} = -\frac{(1-\theta)^2 x}{4k} \leq \frac{\partial p_1^{FF}(.)}{\partial p_2^{FF}} = -\frac{x}{4k}$. This property follows from the fact that employee 1 and employee 2, conditional on generating an innovation, compete for the firm's resources only in the state where both of them generate a firm specific innovation. In other words, each employee receives the full amount of resources for his innovation when the competing employee obtains a non firm specific innovation and leaves the firm. This implies that human capital investment eases the competition for the firm's resources and proves to be beneficial for the firm as it improves the incentives of both employees, compared to the case where the firm does not invest in employee human capital.

The firm's expected profit, π_F^{EE}, when both employees acquire the entrepreneurial skill is given by

$$\begin{aligned} \pi_F^{EE} \equiv\ & p_i^{EE}(1-\theta)(p_j^{EE}(1-\theta)\frac{x}{2} + p_j^{EE}\theta\frac{x}{2} + (1-p_j^{EE})\frac{x}{2}) \\ & + p_j^{EE}(1-\theta)(p_i^{EE}(1-\theta)\frac{x}{2} + p_i^{EE}\theta\frac{x}{2} + (1-p_i^{EE})\frac{x}{2}). \end{aligned} \tag{21}$$

A closer look at the firm's expected profit reveals the potential costs and benefits of the human capital investment. Human capital investment is costly for the firm as it increases the likelihood that the firm loses its employees who may leave the firm with probability $p_i^{EE}\theta, i = 1, 2$. In other words, human capital investment dilutes the core business of the firm by introducing some likelihood that the employees obtain a non firm specific innovation and leave the firm. However, the firm can benefit from the investment because it affects incentives positively for two different reasons. The first is that the employees, anticipating that they may leave the firm and found their own start-up, may have stronger incentives to exert effort, resulting in a higher level of effort. Secondly, each employee, anticipating that with some probability the other employee will leave the firm and there will be no competition for the firm's resources, can become more motivated and exert a higher level of effort. Hence, human capital investment can enhance employee incentives, increase their success probability and benefit the firm. Formally, this can be seen by noting that each employee generates a firm specific innovation with probability p_i^{FF} without the human capital investment, and with probability $p_i^{EE}(1-\theta)$ with the human capital investment. Even though the probability of firm specific innovations is diluted by $1-\theta$ with the human capital investment, it is still possible that $p_i^{EE}(1-\theta) > p_i^{FF}$ if the positive effect of the human capital investment on incentives is sufficiently strong, that is, p_i^{EE} is sufficiently larger than p_i^{FF}. An alternative explanation for the firm's trade-off in encouraging entrepreneurship is that the firm loses from the increased likelihood that the

employees turn into an external entrepreneur and leave the firm. However, the firm benefits from the increased likelihood of both employees generating a firm specific innovation compared to the case with no investment in employee human capital.

Given the firm's investment in employee human capital, the VC's ex ante expected profits, π_{VC}^{EE}, is given by

$$\pi_{VC}^{EE} \equiv p_1^{EE}\theta\frac{y}{2}+p_2^{EE}\theta\frac{y}{2}-K. \tag{22}$$

The following lemma establishes the Nash equilibrium level of employee effort and the corresponding expected profits, given that the VC's participation constrained is satisfied, that is,

$$p_1^{EE*}\theta\frac{y}{2}+p_2^{EE*}\theta\frac{y}{2}-K \geq 0. \tag{23}$$

Lemma 7 *The Nash equilibrium level of efforts, p_i^{EE*}, $i = 1, 2$, is given by*

$$p_1^{EE*} = p_2^{EE*} = \frac{2((1-\theta)x+\theta y)}{4k+(1-\theta)^2 x}. \tag{24}$$

The corresponding level of profits for the firm and the employees are given by

$$\begin{aligned}
\pi_F^{EE*} &= \frac{2(1-\theta)x((1-\theta)x+\theta y)(4k-(1-\theta)\theta y)}{(4k+(1-\theta)^2 x)^2}, && (25)\\
\pi_{E1}^{EE*} &= \pi_{E2}^{EE*} = \frac{2k\left((1-\theta)x+\theta y\right)^2}{(4k+(1-\theta)^2 x)^2}, && (26)\\
\pi_{VC}^{EE*} &= \frac{2\left(x-x\theta+\theta y\right)\theta y}{4k+x-2x\theta+x\theta^2}-K. && (27)
\end{aligned}$$

The following lemma shows the beneficial impact of human capital investment on employee effort and firm profits given that the firm invests in employee human capital and both employees acquire the entrepreneurial skill.

Lemma 8 *Conditional on the VC's participation constraint being satisfied, $p_1^{EE*} \geq p_1^{FF*}$ if and only if $y \geq y_3 \equiv \frac{(4k-(1-\theta)x)x}{4k+x}$. Firm expected profit with the human capital investment is greater than that without the investment, that is, $\pi_F^{EE*} \geq \pi_F^{FF*}$ for $y \geq y_4 = \frac{4(2-\theta)kx}{(1-\theta)(4k+x)}$.*

Proposition 3 shows that effort incentives are stronger for sufficiently high values of y, that is, $y \geq y_3$, when both employees acquire the entrepreneurial skill. Once again the intuition for this result is that acquiring the entrepreneurial skill not only introduces the possibility of becoming an entrepreneur, but also reduces the competition for the firm's limited resources, and improves the incentives for both employees.

As a result of improved incentives, firm expected profits go up as well since improved incentives (higher effort p_i^{EE}) translates directly into a high the probability of firm specific innovations (high $p_i^{EE}(1-\theta)$).

It is interesting to note that $y_3 \equiv \frac{(4k-(1-\theta)x)x}{4k+x} \leq x$ and $y_4 = \frac{4(2-\theta)kx}{(1-\theta)(4k+x)} \leq x$. $y_3 \leq x$ implies that there are values of $y < x$ for which $p_1^{EE*} \geq p_1^{FF*}$. Hence, the improvement in effort incentives of the employees is not only limited to the case where the VC has a superior production technology than the firm. Similarly, $y_4 \leq x$ implies that even if the surplus y that the VC and the employees can generate from a non firm specific innovation is lower than x, human capital investment increases firm profits by resulting in higher probability of firm specific innovations. Another way to see this result is to note that $p_1^{EE*}(1-\theta) \geq p_1^{FF*}$ for $y \geq y_4$, which implies that the human capital investment not only leads to non firm specific innovations and departure of employees, but also increases the probability of a firm specific innovation and improves firm profitability. Hence, the firm can use the human capital investment as a tool to increase growth and profitability.

As before, it is worth mentioning that at lower values of θ, the expected profits of the firm increases in θ at sufficiently high values of y, showing that the firm benefits from an increase in the likelihood that its employees leave the firm to become an entrepreneur. This happens because the anticipation of becoming an entrepreneur improves employee incentives and the firm benefits from this as long as it retains some of the employees with strong incentives. Hence, the firm finds it beneficial to contribute to the entrepreneurial potential of its employees by investing in employee human capital even if this increases the probability of losing them.

Lemma 9 *For* $\theta \leq \frac{1}{2x}\left(8k - 2\sqrt{(16k^2 - x(4k-x))}\right)$, *the expected profits of the firm* π_F^{EE*} *increases in* θ *for* $y > y_5 \equiv \frac{8(1-\theta)xk}{(1-\theta)^2 x + 4(1-2\theta)k}$.

Given that the firm invests in employee human capital and both employees acquire the entrepreneurial skill, the following lemma shows how the creation of the VC is affected by the fundamentals of our model economy.

Lemma 10 *The expected profits of the VC, that is,* $\pi_{VC}^{EE*} = \frac{2\theta((1-\theta)x+\theta y)y}{4k+(1-\theta)^2 x} - K$ *is increasing in* y *and decreasing in* k *and* K. *Moreover,* $\pi_{VC}^{EE*} > \pi_{VC}^{E*}$.

As before, as the favorability of the entrepreneurial environment improves, that is, as y increases, it becomes more attractive to be a VC. In addition, an improvement in the skill level of employees, that is, a reduction in k, increases the expected profits of the VC and invites more entry from investors with a

potential to become a VC. Finally, a reduction in the cost of becoming a VC, that is, a reduction in K, facilitates the creation of the VCs.

Note that $\pi_{VC}^{EE*} > \pi_{VC}^{E*}$ indicates that the investor's willingness to become a VC depends positively on the number of employees acquiring the entrepreneurial skill, establishing a complementarity between the creation of entrepreneurs and VCs. When two employees acquire the entrepreneurial skill, the expected number of entrepreneurs in the economy increases, making it more attractive to become a VC and hence inviting more entry from the would-be VC investors.

Given that the firm invests in employee human capital and both employees acquire the entrepreneurial skill, the rate at which the firm supplies entrepreneurs to the economy, e^{EE*}, is given by $e^{EE*} \equiv p_1^{EE*}\theta + p_2^{EE*}\theta = \frac{4\theta((1-\theta)x+\theta y)}{4k+(1-\theta)^2 x}$.

Lemma 11 *$e^{EE*} > e^{E*}$ and $\frac{\partial e^{EE*}}{\partial y} > 0$, $\frac{\partial e^{EE*}}{\partial k} < 0$.*

$e^{EE*} > e^{E*}$ implies that the rate of entrepreneurship creation is increasing in the number of employees acquiring the entrepreneurial skill. Moreover, the productivity of the employees, and the favorability of the entrepreneurial environment have a positive impact on the creation of entrepreneurs implied by $\frac{\partial e^{EE*}}{\partial k} > 0$ and $\frac{\partial e^{EE*}}{\partial y} < 0$ respectively.

The following proposition characterizes the equilibrium formally.

Proposition 2 *High entrepreneurship equilibrium with VC creation: The firm invests in employee human capital and both employees acquire the entrepreneurial skill if $y \geq Y_2^*$ where*

$$Y_2^* \equiv \begin{cases} Y_3 \equiv \frac{4xk(2-\theta)}{(4k+x)(1-\theta)} & \text{if } K < K_2 \equiv \frac{8\theta k(2-\theta)x^2}{(1-\theta)^2(x+4k)^2} \\ Y_4 \equiv \frac{-x(1-\theta)+\sqrt{x^2(1-\theta)^2+2Kx(1-\theta)^2+8kK}}{2\theta} & \text{if } K > K_2. \end{cases}$$

Low (no) entrepreneurship equilibrium with no VC creation: The firm does not invest in employee human capital and there is no VC creation if $y < Y_2^*$. Furthermore, $Y_3 \leq Y_4$ if $K > K_2$.

There are two types of equilibrium when the firm has two employees. In the first equilibrium, the firm does not invest in employee human capital and the employees generate firm specific innovations and always stay with the firm. Moreover, the investor does not incur the cost of becoming a VC and hence, there is no VC creation in this equilibrium. We refer to this equilibrium as the low (or no) entrepreneurship equilibrium. This equilibrium arises when the entrepreneurial environment is not appealing enough to induce the firm to invest in employee human capital. This result originates from the fact that both the

probability of firm specific and non firm specific innovations increase in y. At lower values of y, the benefit of the human capital investment in terms of higher firm specific innovations does not offset its cost in terms of losing the employees. Hence, the firm does not invest in employee human capital. Second this equilibrium also arises when the value of K is high. K measures the cost for the investor to become a VC and can be interpreted as the cost of raising capital, acquiring skills and hiring General Partners for the VC firm. The intuition behind this result is that the firm's benefit from the human capital investment in terms of motivating the employees is weaker when the value of K is higher since at higher values of K, it is less likely for the investor to incur the cost and become a VC. Hence, it is less attractive for the employees to generate an innovation which can be implemented with the VC. As a result, the human capital investment does not have a strong positive effect on employee incentives and hence,the firm does not benefit from it. The third possibility for this equilibrium is that the core prospects of the firm is so strong (value of x is high) that the firm does not want to dilute its core business by increasing the probability of employee departures.

In the second equilibrium, the firm invests in employee human capital and both employees acquire the entrepreneurial skill [11]. This equilibrium arises when the value of the non firm specific innovation increases or the favorability of the entrepreneurial environment improves (higher y), when it becomes easier and cheaper to become a VC, (lower K), and when the core business prospects of the firm deteriorates (lower x). We refer to this equilibrium as the high entrepreneurship equilibrium.

Figure 2 illustrates the equilibrium as a function of parameter values. The firm invests in employee human capital for $y \geq Y_2^*$. At lower values of K, the VC's participation constraint is satisfied more easily and the condition $y > Y_3$ is necessary for the firm to benefit from encouraging entrepreneurship. Note that the threshold level Y_1 is independent of K because the VC's participation constraint is not binding at lower values of K. As K increases, the firm needs a more favorable entrepreneurial environment not only to be able to benefit from the human capital investment but also to facilitate the creation of VCs. Hence, the threshold level for y increases, that is, $Y_3 \leq Y_4$ to induce the firm to invest in employee human capital. In addition, Y_2 is an increasing function of K, implying that at higher values of K, the VC's participation constraint binds and the firm needs a more appealing entrepreneurial environment in order to encourage

[11] Note that we focus only on symmetric equilibrium where both employees acquire the entrepreneurial skill given the firm's investment in employee human capital.

VC creation.

The following proposition presents the comparative statics results on the properties of the equilibrium.

Proposition 3 $\frac{\partial Y_3}{\partial k} > 0$, $\frac{\partial Y_4}{\partial k} > 0$, $\frac{\partial Y_4}{\partial K} > 0$, $\frac{\partial K_2}{\partial \theta} < 0$.

$\frac{\partial Y_3}{\partial k} > 0$ and $\frac{\partial Y_4}{\partial k} > 0$ imply that the firm's willingness to invest in employee human capital decreases as k,that is, the cost of exerting effort for the employees increases. At higher values of k, the firm becomes less likely to invest in employee human capital as the incentive benefit of the investment gets smaller. Since a low level of k implies a high level of effort and productivity we can interpret k as measuring the productivity of the employees and generate the following prediction: As the productivity of the employees increases, the firm is more likely to invest in employee human capital and supply more entrepreneurs to the economy.

Note that our model generates an interesting externality between the availability of VC financing and established firms' willingness to be entrepreneurial by investing in employee human capital. This result can be seen from the property that $\frac{\partial Y_4}{\partial K} > 0$ which implies that as the availability of VC financing increases or improves, that is, as K goes down, firms become more entrepreneurial by investing in employee human capital. Hence, the firm's investment in entrepreneurship depends on how favorable the environment to the entry of VCs or the extent of the development of the VC industry. An interesting, perhaps also counterintuitive, implication of this result is that the abundance of VC financing (which, in our model corresponds to $K = 0$) implies that firms will be more willing to invest in employee human capital and encourage their employees to become more entrepreneurial since easier availability of VC financing improves employee motivation and effort of all employees, some of whom will generate firm specific innovations and stay with their firms.

Finally, $\frac{\partial K_2}{\partial \theta} < 0$ suggests that established firms play a role in accelerating the development of the VC industry by encouraging entrepreneurship at their organizations and by supplying more entrepreneurs to the economy. In other words, there is a positive externality between the willingness of established firms to be entrepreneurial and the development of the VC industry.

5 Extensions and Robustness

5.1 Corporate Venture Capital Investment

Contrary to our previous set up where the firm cannot capture any rents from the ventures of departing employees, suppose now that the firm can extract ϕ proportion, with $\phi \geq 0$, of the rents that a departing employee generates with the VC. It is worth mentioning that even though we rule out ex-ante equity contracts between the firm and the employee, we allow the firm to obtain a fraction of the payoff from the employee's start-up. The justification for this assumption is that since the firm and the employee bargain at the interim if the employee generates a firm specific innovation, even if they write a contract specifying the allocation of surplus from the implementation of the innovation, the contract will be renegotiated. This follows from the notion that the employee's human capital and the firm's organizational capital are essential inputs for the implementation of the innovation, and each party can withdraw his involvement from the implementation even if there is a equity contract written at the outset. However, for firm specific innovations, the firm can require a certain fraction of the payoff since the implementation of such innovations are performed by the VC and the payoff from the employee's venture is verifiable. (See Aghion and Tirole (1994) for a more detailed discussion on the role of equity contracts and renegotiation). Once again, we make this assumption for analytical simplicity and in Appendix A we show that the main results of the paper are robust to the introduction of equity contracts.

The following proposition establishes the equilibrium under this specification. We refer to this structure as Corporate Venture Capital investment where the firm invests in human capital of its employee, the employee leaves the firm and sets-up his start-up with the VC and the firm, the employee and the VC share the revenues from the start-up.

Proposition 4 *i)If $K \leq K_3$, the firm invests in employee human capital, sets $\phi^* = \frac{1}{2}$ for $y \geq y_5$. The firm does not invest in employee human capital if $y < y_5$.*

$K_3 < K \leq K_4$, the firm invests in employee human capital, sets $\phi^* = \frac{x\theta^2 y - x\theta y + 4Kk}{\theta^2 y^2}$ for $y \geq y_6$. The firm does not invest in employee human capital if $y < y_6$.

If $K > K_4$, the firm does not invest in employee human capital (y_5, y_6, K_3 and K_4 are defined in appendix).

In part (i) of Proposition 4, the cost of becoming a VC is sufficiently low that the firm finds it optimal to invest in employee human capital for sufficiently high values of y. Moreover, the firm obtains 50% of the potential future revenues from the employee's start-up if the employee generates a non firm

specific innovation and commercializes the innovation with the VC. This result provides an explanation for corporate venture capital investment made by many established firms such as Intel, Microsoft whereby these firms allow their employees with innovative ideas to separate from the parent firm and set up entrepreneurial ventures with the parent firm having a certain level of equity participation in the venture.

When the cost of becoming a VC increases, that is, when $K_3 < K \leq K_4$, the firm invests in employee human capital and sets $\phi^* = \frac{x\theta^2 y - x\theta y + 4Kk}{\theta^2 y^2} \leq \frac{1}{2}$ only if $y > y_5$. The firm finds it optimal to require a lower payoff from the future start-up as K increases, that is, as it becomes more expensive for the investor to turn into a VC. The intuition for this result is that revenue sharing by the firm weakens the incentives of the employee, reduces the probability that the employee obtains a non firm specific innovation and leaves the firm. Since the investor's future expected profits from becoming a VC is directly proportional to the likelihood that the employee obtains a non firm specific innovation and leaves the firm, it becomes more difficult to encourage VC creation in the economy. As a result, the firm finds it optimal to lower its equity participation in the revenues of the start-up to maintain strong incentives for the employee and to restore the investor's incentives to incur K. Stronger employee incentives lead to higher probability of the employee leaving the firm and increases the expected profits of the would-be VC investor and induces him to become a VC. Note that at $K = K_4$ the optimal value of ϕ is equal to 0, meaning that the firm does not participate in the future revenues of the start-up at all, justifying the assumption we made in the earlier parts of the analysis. This result is important since it may explain why many firms allow employee mobility, let their employees leave the firm without imposing any constraints or without requiring revenue sharing from their employees' future profits. What motivates employees to exert high effort and obtain an innovative idea is precisely the expectation that in the future they may obtain a business idea, leave their firm and obtain a high payoff from setting up their own firm. Firms can further improve the positive role of future entrepreneurship opportunities on employee incentives by committing not to extract any surplus from their employees' future start-ups. Although this is costly for the firm ex post, it improves employee incentives ex ante, facilitates the creation of the VCs, and ultimately proves to be beneficial for the firm since strong employee incentives increase the probability of firm specific innovations.

5.2 No-compete clauses

In our basic model, we assume that when the employee obtains a non firm specific innovation he leaves the firm to establish his own start-up and the firm cannot prevent the employee from founding his own venture.

Note that although our model does not assume that the employee's start-up creates direct competition in the product market for the established firm's business, it proves to be costly for the firm since the firm incurs a loss ($\frac{x}{2}$) in its business when the employee obtains a non firm specific innovation and departs the firm.

In this section, we extend our model such that prior to date $t = 0$, the firm can require the employee to sign a no-compete clause which prohibits the employee from establishing his own business. We assume that if the firm invests in emplpyee human capital and the employee obtains a non firm specific innovation, he stays with the firm and his non firm specific innovation generates a payoff of z, with $x < z < y$ and as before, the firm and the employee splits the payoff equally and each obtains $\frac{z}{2}$. Suppose for simplicity that $K = 0$, implying that if the employee obtains a non firm specific innovation, for all values of y, he will be able to collaborate with a VC to commercialize his idea.

The following proposition shows that, under certain conditions, the firm will not find it beneficial to impose a no-compete agreement since doing so will worsen employee incentives and lead to a reduction in the likelihood of a firm specific innovation and reduce firm profitability.

Proposition 5 *If* $z \leq \frac{\left(-2(1-\theta)x+2\sqrt{(1-\theta)x(x-\theta(x-y))}\right)}{2\theta}$, *the firm invests in employee human capital and does not require its employee to sign a no-compete clause.*

6 Empirical Predictions

Our analysis establishes that firms' investment in employee human capital drives the emergence of entrepreneurs out of established firms and contribute to the development of an active VC industry. Hence, we have the following empirical predictions:

Prediction 1: Entrepreneurial established firms, VC firms and start-ups cluster in the same geographical areas.

Prediction 2: Established firms contribute to the development of an active VC industry.

One of our key results is that established firms become more willing to invest in employee human capital and encourage entrepreneurship in their organization as the availability of VC financing improves, leading to the following empirical prediction:

Prediction 3: A more developed VC industry increases established firms willingness to be more entrepreneurial.

Our analysis shows that firms' willingness to invest in employee human capital decreases as k, the cost of exerting effort for the employees increases. At higher values of k, the firm becomes less likely to invest in employee human capital as the incentive benefit of the investment gets smaller. Since a low level of k implies a high level of effort we can interpret k as measuring the productivity of the employees and generate the following prediction:

Prediction 4: *An increase in the skill level of employees increases firms willingness to encourage entrepreneurship and facilitates VC creation.*

Established firms benefit from investing in employee human capital since this increases the probability of firm specific innovations and firm profits. Hence, we have the following empirical prediction:

Prediction 5: *Investment in employee human capital has a positive affect on established firms performance.*

7 Conclusions

This paper studies the determinants of the creation of VCs and VC-backed entrepreneurs. We argue that, as documented by recent empirical research by Gompers, Lerner and Scharfstein (2005), established firms play a key role in the creation of entrepreneurs and VCs. Our model shows that the emergence of entrepreneurs out of established firms is a byproduct of these firms' investment in employee human capital to improve firm profitability. Human capital investment leads some employees to generate firm specific innovations and other employees to generate non firm specific innovations and to leave their firm to set-up their own ventures. Although firms' investment results in the loss of some employees, it can still be profitable since it may increase the ex-ante likelihood of employees generating firm specific ideas which are implemented within the firm.

The second outcome of human capital investment is that it drives the creation of VCs. The economy is endowed with agents who can become VCs after incurring some cost. These agents anticipate the departure of employees from established firms with entrepreneurial ideas and become more willing to turn into VCs by making the necessary investment. Hence, established firms' investment in entrepreneurship facilitates the creation of VCs. Similarly, as the availability of VC financing gets easier and cheaper, established firms become more willing to invest in employee human capital and as a result they supply more entrepreneurs to the economy.

The results in this paper help understand regional variation in the amount of entrepreneurship activity and the availability of VC financing. The model predicts the clustering of entrepreneurial *established* firms, entrepreneurial *start-ups* and VCs, as observed in Silicon Valley. It also explains the lack of entrepreneurial ventures, lack of VC financing and low employee mobility in certain parts of Europe and Japan.

While we admit that there are other possible sources of entrepreneurship in the economy, in this paper we focus exclusively on the role of established firms as the driver of entrepreneurship and the creation VCs. Overall our analysis suggests that established firms represent an important source of entrepreneurship and they play an important role in the development of an active VC industry. It would be certainly interesting to investigate in future research alternative sources of entrepreneurship and VC creation.

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8 Appendix

Proof of Lemma 1 Direct comparison of p^{F*} given by (3) with p^{E*} given by (8) reveals that $p^{E*} \geq p^{F*}$ if and only if $y \geq x$. Similarly, comparing π_F^{F*} given by (4) with π_F^{E*} given by (10) reveals that $\pi_F^{E*} \geq \pi_F^{F*}$ for $y \geq y_1 \equiv x\frac{2-\theta}{1-\theta}$.

Proof of Proposition 1 For the firm to be willing to invest in employee human capital, first the employee should be willing to acquire the entrepreneurial skill. Comparing employee profits without the entrepreneurial skill given by (5) to those with the entrepreneurial skill given by (11) reveals that the employee is willing to acquire the entrepreneurial skill only if $c \leq \frac{((1-\theta)x+\theta y)^2-x^2}{8k}$, the first necessary condition for the firm's human capital investment. Second, the would-be VC investor should be willing to incur the cost K of becoming a VC, which is possible only if $\pi_{VC}^{E*} \geq 0$. Third, given that there is VC creation and the employee's willingness to acquire the entrepreneurial skill, firm profits with the human capital investment given by (10) should be greater than those without given by (4). Comparing (10) with (4) gives that $\pi_F^{E*} \geq \pi_F^{F*}$ if and only if $y \geq Y_1$.When $y \geq Y_1$, it is straightforward to show that $\pi_{VC}^{E*} \geq 0$ only if $K \leq \frac{\theta(2-\theta)x^2}{4(1-\theta)^2k}$. However, when $K > \frac{\theta(2-\theta)x^2}{4(1-\theta)^2k}$, the investor's participation constraint $\pi_{VC}^{E*} \geq 0$ is satisfied only if $y \geq Y_2$.

Proof of Lemma 2 It is all immediate to see that p^{E*}, π_F^{E*}, and π_E^{E*} are increasing in y.

Proof of Lemma 3 Taking the partial derivative of π_F^{E*} given by (10) with respect to θ gives that $\frac{\partial \pi_F^{E*}}{\partial \theta} = \frac{x}{4k}(y(1-2\theta) - 2x(1-\theta))$. $\frac{\partial \pi_F^{E*}}{\partial \theta} \geq 0$ when $\theta < \frac{1}{2}$ and $y > y_2 \equiv \frac{2(1-\theta)x}{1-2\theta}$. Note that we need to make sure that $y > y_2$ does not violate $p^{E*} \leq 1$ or $y \leq \frac{2k-(1-\theta)x}{\theta}$. It is straightforward to show that $y_2 \leq \frac{2k-(1-\theta)x}{\theta}$ for $\theta \leq \frac{2k-x}{4k-x} < \frac{1}{2}$. Hence, $\frac{\partial \pi_F^{E*}}{\partial \theta} \geq 0$ when $\theta \leq \frac{2k-x}{4k-x}$ and $y > y_2$.

Proof of Lemma 4 It is immediate to see that π_{VC}^{E*} given by (12) is increasing in y and decreasing in k and K. Taking the partial derivative of π_{VC}^{E*} with respect to θ gives that $\frac{\partial \pi_{VC}^{E*}}{\partial \theta} = \frac{(2y\theta+x(1-2\theta))y}{4k} \geq 0$.

Proof of Lemma 5 It is immediate to see that $e^{E*} = \frac{\theta((1-\theta)x+\theta y)}{2k}$ is increasing in y and decreasing in k.

Proof of Lemma 6 Setting $p_1^{FF} = p_2^{FF}$ and solving (15) for p_1^{FF} gives (16). Substituting (16) into (13) and (14) gives (18) and (17).

Proof of Lemma 7

Setting $p_j^{EE} = p_i^{EE}$ and solving (20) for p_i^{EE} gives (24), the optimal value of p_i^{EE}. Plugging (24) into (21), (19) and (23) gives (25), (26) and (27).

Proof of Lemma 8

Direct comparison of p_1^{EE*} given in (24) with p_1^{FF*} given in (16) reveals that $p_1^{EE*} \geq p_1^{FF*}$ if and only if $y \geq y_3 \equiv x\frac{4k-x(1-\theta)}{4k+x}$. Similarly, comparison of π_F^{EE*} with π_F^{FF*} gives that $\pi_F^{EE*} \geq \pi_F^{FF*}$ if and only if $y \geq y_4 \equiv \frac{4(2-\theta)kx}{(1-\theta)(4k+x)}$.

Proof of Lemma 9

Taking the partial derivative of π_F^{EE*} given by (25) yields that

$$\frac{\partial \pi_F^{EE*}}{\partial \theta} = -2x\frac{(4k(-2x\left(1-\theta\right)-y\left(2\theta-1\right))+\left(1-\theta\right)^2 xy)\left(-4k+\left(1-\theta\right)\left(2\theta y-x\theta+x\right)\right)}{(4k+x\left(1-\theta\right)^2)^3}.$$

Note that the denominator of $-2x\frac{(4k(-2x(1-\theta)-y(2\theta-1))+(1-\theta)^2xy)(-4k+(1-\theta)(2\theta y-x\theta+x))}{(4k+x(1-\theta)^2)^3}$ is always positive. By using the requirement that $p_1^{EE*} \leq 1$ it is straightforward to show that $(-4k+\left(1-\theta\right)\left(2\theta y-x\theta+x\right)) \leq 0$. Hence, $\frac{\partial \pi_F^{EE*}}{\partial \theta} \geq 0$ when $(4k(-2x\left(1-\theta\right)-y\left(2\theta-1\right))+\left(1-\theta\right)^2 xy) \geq 0$. The condition $(4k(-2x\left(1-\theta\right)-y\left(2\theta-1\right))+\left(1-\theta\right)^2 xy) \geq 0$ translates into $y \geq \frac{8xk(1-\theta)}{4k(1-2\theta)+x(1-\theta)^2}$ if $4k\left(1-2\theta\right)+x\left(1-\theta\right)^2 > 0$. Hence, $\frac{\partial \pi_F^{EE*}}{\partial \theta} \geq 0 \geq 0$ when $4k\left(1-2\theta\right)+x\left(1-\theta\right)^2 > 0$ and $y \geq \frac{8xk(1-\theta)}{4k(1-2\theta)+x(1-\theta)^2}$. As a last condition, we need to make sure that $y \geq \frac{8xk(1-\theta)}{4k(1-2\theta)+x(1-\theta)^2}$ does not violate $p_1^{EE*} \leq 1$ or equivalently $y \leq \frac{1}{2}\frac{4k-x(1-\theta^2)}{\theta}$. By straightforward algebra, it is immediate to show that $\frac{8xk(1-\theta)}{4k(1-2\theta)+x(1-\theta)^2} \leq \frac{1}{2}\frac{4k-x(1-\theta^2)}{\theta}$ when $\theta \leq \frac{1}{2x}\left(8k-2\sqrt{(16k^2-x\left(4k-x\right))}\right)$. Finally, note that $\theta \leq \frac{1}{2x}\left(8k-2\sqrt{(16k^2-x\left(4k-x\right))}\right)$ implies that $(4k(-2x\left(1-\theta\right)-y\left(2\theta-1\right))+\left(1-\theta\right)^2 xy) \geq 0$. Defining $y_5 \equiv \frac{8xk(1-\theta)}{4k(1-2\theta)+x(1-\theta)^2}$ completes the proof.

Proof of Lemma 10

Inspection of $\pi_{VC}^{EE*} = 2\theta y\frac{\theta y+x(1-\theta)}{4k+x(1-\theta)^2} - K$ reveals that π_{VC}^{EE*} is increasing in y and x, and decreases in k and K.

Proof of Lemma 11

Direct comparison of e^{EE*} with e^{E*} reveals that $e^{EE*} \geq e^{E*}$. Since p_1^{EE*} and p_2^{EE*} are increasing in y and decreasing in k, it follows that $\frac{\partial e^{EE*}}{\partial y} > 0$ and $\frac{\partial e^{EE*}}{\partial k} < 0$.

Proof of Proposition 2

Suppose there is a candidate equilibrium where the firm invests in employee human capital and both employee 1 and employee 2 acquire the entrepreneurial skill. For existence of such an equilibrium we need to make sure the following conditions hold: C1)Firm profit, π_F^{EE*}, is greater than or equal to firm profit when the firm does not invest in employee human capital π_F^{FF*}, formally $\pi_F^{EE*} \geq \pi_F^{FF*}$.C2) The VC's participation constraint is satisfied and he makes a non-negative expected profit, i.e., $\pi_{VC}^{EE*} \equiv p_1^{EE*}\theta\frac{y}{2} + p_2^{EE*}\theta\frac{y}{2} = 2\frac{-x\theta+\theta y+x}{x\theta^2-2x\theta+x+4k}\theta y - K \geq 0$. C3) employee 1 and employee 2 have the incentives to acquire the entrepreneurial skill.

C1)$\pi_F^{EE*} \geq \pi_F^{FF*}$ if and only if $y \geq Y_3 \equiv \frac{4xk(2-\theta)}{(4k+x)(1-\theta)}$.

C2) $\pi_{VC}^{EE*} \geq 0$ if and only if $y \geq Y_4 \equiv \frac{-x(1-\theta)+\sqrt{x^2(1-\theta)^2+2Kx(1-\theta)^2+8kK}}{2\theta}$.

C3) $\pi_{E2}^{EE*} = \frac{2k((1-\theta)x+\theta y)^2}{(4k+(1-\theta)^2x)^2} \geq \pi_{E2}^{EF*} = \frac{2x^2k(4k-(1-\theta)((1-\theta)x+\theta y))^2}{\left(16k^2-x^2(1-\theta)^2\right)^2}$ makes sure that given that each employee is willing to acquire the entrepreneurial skill given that the other employee acquires the entrepreneurial skill. It it straightforward to show that $\pi_{E2}^{EE*} \geq \pi_{E2}^{EF*}$ when $y \geq Y_5 \equiv \frac{x(16k^2-x^2(\theta-1)^3)}{16k^2+x(1-\theta)(x\theta^2-x\theta+4k)}$.

It is straightforward to show that $Y_3 > Y_5$. In addition $Y_3 > Y_5$ if and only if $K < K_2 = \frac{8\theta k(2-\theta)x^2}{(1-\theta)^2(x+4k)^2}$. Hence, when $K < K_2$, $y > Y_3$ is sufficient to induce the firm to invest in employee human capital and the employees to acquire the entrepreneurial skill. When $K \geq K_2$, we need the condition $y \geq Y_4$ to induce the investor to turn into VC. Note that when $K \geq K_2$, we have that $Y_4 > Y_3 > Y_5$, satisfying C1 and C2 as well. Defining

$$Y_2^* \equiv \begin{cases} Y_3 & \text{if } K < K_2 \\ Y_4 & \text{if } K > K_2 \end{cases}$$

completes the proof.

Proof of Proposition 3

i) Taking the partial derivative of $Y_3 = \frac{4xk(2-\theta)}{(4k+x)(1-\theta)}$ with respect to k gives that $\frac{\partial Y_3}{\partial k} = \frac{(2-\theta)4x^2}{(1-\theta)(4k+x)^2} > 0$. It is immediate to see from the definition of Y_4 that it is increasing in k and K, thus $\frac{\partial Y_4}{\partial k} > 0$ and $\frac{\partial Y_4}{\partial K} > 0$. Finally, taking the partial derivative of $K_2 = \frac{8\theta k(2-\theta)x^2}{(1-\theta)^2(x+4k)^2}$ yields that $\frac{\partial K_2}{\partial \theta} = \frac{-16kx^2}{(-1+\theta)^3(4k+x)^2} < 0$.

Proof of Proposition 4

As in the proof of Proposition 1 and Proposition 2, we will compare firm profits with and without investment in employee human capital. From (4), we have that when the firm has one employee and does not invest in employee human capital, firm expected profits are given by $\pi_F^{F*} = \frac{x^2}{4k}$. The firm will invest in employee human capital if its expected profits with the investment exceed its profits without the investment. However, now we assume that the firm can extract ϕ portion of the payoff of the start-up that

the employee establishes with the VC. Solving the model backwards, first let us consider the employee's objective function with the human capital investment:

$$\max_{p_1} \pi_E^E \equiv p_1(1-\theta)(\frac{x}{2}) + p_1\theta\frac{(1-\phi)y}{2} - \frac{k}{2}(p_1)^2. \tag{28}$$

Note that (32) implies that the employee captures only $1-\phi$ proportion of the payoff from his future start-up if he generates a non firm specific innovation. Taking the first order condition of (32) gives

$$p_1^*(\phi) = \frac{1}{2}\frac{-x\theta + \theta\phi y + x}{k}.$$

The firm, anticipating the impact of requiring ϕ proportion of the start-up's payoff on employee incentives chooses ϕ to maximize its own expected profits given by

$$\max_{\phi} \pi_F^E \equiv p_1^*(\phi)(1-\theta)(\frac{x}{2}) + p_1^*(\phi)\theta\frac{\phi y}{2}. \tag{29}$$

Taking the first order condition of (29) with respect to ϕ yields $\phi^* = \frac{1}{2}$.

Next we need to consider the VC's participation constraint given by

$$\pi_{VC}^E \equiv p_1^*(\phi^*)\frac{\theta y}{2} - K \geq 0. \tag{30}$$

Note that from (30) the VC's participation constraint is satisfied if $K \leq K_3 \equiv \frac{(2(1-\theta)x+\theta y)\theta y}{8k}$. Comparing firm profits $\pi_F^{E*}(\phi = \frac{1}{2})$ with π_F^{F*} gives that the firm invests in employee human capital only if $y \geq y_5 \equiv 2x$.

Suppose now that $K_3 < K \leq K_4 \equiv \frac{x(1-\theta)\theta y}{4k}$. The firm sets ϕ such that the VC's participation constrained is satisfied $p_1^*(\phi)\frac{y}{2} - K = 0$, yielding $\phi^*(K) \equiv \frac{\theta y((1-\theta)x+\theta y)-4kK}{\theta^2 y^2} < \frac{1}{2}$. As a result, firm expected profits are given by

$$\pi_F^{E*}(\phi = \phi^*(K)) \equiv \frac{K}{\theta^2 y^2}\left(2x\left(1-\theta\right)\theta y + \theta^2 y^2 - 4Kk\right).$$

Comparing $\pi_F^{E*}(K)$ with π_F^{F*} reveals that the firm invests in employee human capital only if $y \geq y_6 \equiv \frac{kK}{2\theta(4Kk-x^2)}\left(-8x\left(1-\theta\right) + 8\sqrt{\left(4Kk - \theta\left(2-\theta\right)x^2\right)}\right)$.

Finally, when $K > K_4$, the cost of becoming a VC is so high that it is impossible to induce the investor to become a VC even with setting $\phi = 1$. Hence, the firm does not invest in employee human capital.

Proof of Proposition 5

If the firm imposes a no-compete clause, the employee exerts effort p_{nc} to maximize his expected profits given by

$$\pi_E^{nc} \equiv p_{nc}(1-\theta)\frac{x}{2} + p_{nc}\theta\frac{z}{2} - \frac{k}{2}(p_{nc})^2.$$

Taking the first order condition with respect to p_{nc} gives the optimal level of employee effort $p^*_{nc} = \frac{x+\theta(z-x)}{2k}$. Plugging p^*_{nc} into firm expected profits given by $\pi^{nc*}_E \equiv p^*_{nc}(1-\theta)\frac{x}{2} + p^*_{nc}\theta\frac{z}{2}$, and comparing π^{nc*}_E with π^{E*}_E given in (10) reveals that the firm does not require the employee to sign a no compete clause if $z \leq \frac{\left(-2(1-\theta)x+2\sqrt{(1-\theta)x(x-\theta(x-y))}\right)}{2\theta}$.

8.1 Appendix A: Equity contracts

This section analyzes the firm's investment when the firm and the employee can enter into a contractual agreement at the outset of the game. We show that the main results of the paper are robust to the introduction of incentive (equity) contracts.

The game is modified as follows. At $t = 0$, the firm decides whether to invest in employee human capital or not and the firm also offers a contractual agreement specifying the employee's payoffs in different states of the world. If the firm invests in employee human capital, the employee can acquire the entrepreneurial skill at $t = 1$. If the firm does not invest in employee human capital, the employee cannot acquire the entrepreneurial skill and is assumed to have the firm specific skill. The employee exerts effort at $t = 2$, which determines the likelihood that he generates an innovation or not. The outcome of whether the employee has an innovation is observed at $t = 3$. The payoff from employee innovation is realized at $t = 4$, and the employee and the firm split the payoff according to the contract signed at $t = 1$.

We will first analyze the subgame and the optimal contract between the firm and the employee where the firm does not invest in employee human capital. Second we will analyze the subgame and the optimal contract where the firm invests in employee human capital. Finally, we will characterize the equilibrium.

The payoff from employee innovations is verifiable, and thus contractible. The contract specifies for the employee a share α of the final payoff from firm specific innovation implemented within the firm and it specifies a share β of the final verifiable return that the employee obtains from founding his own business if he leaves the firm. Note that, as in the earlier analysis of the model, we assume that if an employee leaves the firm with a non firm specific innovation, his innovation generates a total payoff of y, and the employee shares this payoff with the VC and obtains $\frac{y}{2}$.

8.1.1 The firm does not invest in employee human capital

Note that in this section we normalize $k = 1$ for analytical simplicity. The employee 's effort, p, is determined by his incentive compatibility condition, denoted by $(IC)_E$:

$$p \in \arg\max_p p\alpha x - \frac{1}{2}p_1^2. \tag{31}$$

The first order condition of the incentive compatibility condition $(IC)_{E1}$ is given by:

$$p^* = \alpha x \tag{32}$$

The firm chooses the contract to maximize its expected profits. The optimal contract must satisfy the participation constraint of the employee, making sure that he breaks even from exerting effort. The participation constraint of the employee denoted by,$(PC)_E$, is given by

$$p^*\alpha x - \frac{1}{2}(p^*)^2 \geq 0. \tag{33}$$

The firm then solves the following problem:

$$\underset{\alpha}{max} \pi_F \equiv p_1^*(1-\alpha)x \tag{34}$$

$$s.t.\ (PC)_E,$$

$$(IC)_E,$$

$$0 \leq \alpha \leq 1.$$

Lemma 12 *The firm maximizes its expected profit by setting $\alpha^* = \frac{1}{2}$. The firm's and the employees' expected profits are given by*

$$\pi_F^* = \frac{x^2}{4}, \tag{38}$$

$$\pi_E^* = \frac{x^2}{8}. \tag{39}$$

Note that when the firm does not invest in employee human capital, the investor does not incur the personal cost K of becoming a VC and hence there is no VC creation.

8.1.2 The firm invests in employee human capital

In this case, the employee's effort can lead to a firm specific innovation as well as an innovation unrelated to the core business of the firm. If the employee generates a firm specific innovation, he obtains an α

proportion of the payoff that the innovation generates. In addition, we assume that the firm can write a contract, contingent on the employee leaving the firm and founding his own business, which specifies for the employee a β proportion of the payoff that he can obtain. We assume that, the VC and the employee share the total surplus, y equally. The VC obtains $\frac{y}{2}$, the employee obtains $\frac{\beta y}{2}$ and the firm obtains $\frac{(1-\beta)y}{2}$.

Employee effort, p^E, is determined by his incentive compatibility condition, denoted by $(IC^E)_E$:

$$p_1^E \in \arg\max_{p_1^E} p^E(1-\theta)\alpha x + p^E\theta\frac{\beta y}{2} - \frac{1}{2} \quad (40)$$

$$. \quad (41)$$

The first order condition of the incentive compatibility conditions $(IC^E)_E$ is given by:

$$p^{E*} = \alpha(1-\theta)x + \frac{\theta\beta y}{2} \quad (42)$$

The firm chooses the contract to maximize its expected profit. The optimal contract must satisfy the participation constraint of the employee and the VC, ensuring that the employee breaks even from exerting effort and the VC recoup his investment, K, in expectations. The participation constraint of the employee, denoted by,$(PC^E)_E$, is given by

$$p^{E*}(1-\theta)\alpha x + p^{E*}\theta\frac{\beta y}{2} - \frac{1}{2}(p^{E*})^2 \geq 0. \quad (43)$$

The participation constraint of the VC, denoted by $(PC)_{VC}$, is given by

$$p^{E*}\theta\frac{y}{2} - K \geq 0. \quad (44)$$

The firm then solves the following program:

$$\underset{\alpha,\beta}{max} \ \pi_F^E \equiv p^{E*}(1-\theta)(1-\alpha)x + p^{E*}\theta\frac{(1-\beta)y}{2}; \quad (45)$$

$s.t.\ (PC^E)_E,$

$(PC)_{VC},$

$(IC^E)_E$

$0 \leq \alpha \leq 1.$

$0 \leq \beta \leq 1.$

Solving (45) subject to (46), (47), (48), (49) and (50) gives the following lemma.

Lemma 13 *When* $K \leq \frac{\theta(\theta y+2x(1-\theta))y}{8}$, *the firm chooses* ($\alpha_0^* = \frac{\theta y(1-2\beta_0)+2(1-\theta)x}{4(1-\theta)x}, \beta_0^* = \beta_0$; *s.t* $0 \leq \frac{\theta y(1-2\beta_0)+2(1-\theta)x}{4(1-\theta)x} \leq 1$ *and* $0 \leq \beta_0 \leq 1$) *and firm, employee and VC expected profits are given by*

$$\pi_F^{E*} = \frac{(\theta y + 2(1-\theta)x)^2}{16}; \tag{51}$$

$$\pi_E^{E*} = \frac{(\theta y + 2(1-\theta)x)^2}{32}; \tag{52}$$

$$\pi_{VC}^{E*} = \frac{\theta\left(\theta y + 2x\left(1-\theta\right)\right)y}{8} - K. \tag{53}$$

When $K > \frac{\theta(\theta y+2x(1-\theta))y}{8}$, *the firm chooses* ($\alpha_1^* = \frac{4K-\theta^2y^2\beta_1}{2(1-\theta)\theta xy}, \beta_1^* = \beta_1$;*s.t* $0 \leq \frac{4K-\theta^2y^2\beta_1}{2(1-\theta)\theta xy} \leq 1$ *and* $0 \leq \beta_1 \leq 1$) *and firm, employee and VC expected profits are given by*

$$\pi_F^{E*} = \frac{\left(\theta\left(2x(1-\theta)+\theta y\right)y - 4K\right)K}{\theta^2 y^2}; \tag{54}$$

$$\pi_E^{E*} = \frac{2K^2}{\theta^2 y^2}; \tag{55}$$

$$\pi_{VC}^{E*} = 0. \tag{56}$$

The following proposition characterizes the equilibrium.

Proposition 6 *The firm invests in employee human capital for* $y > Y_1^*$ *where*

$$\overline{Y}^* \equiv \begin{cases} \overline{Y}_1 \equiv 2x & \text{if } K \leq \frac{\theta x^2}{2} \\ \overline{Y}_2 \equiv \frac{\left(-8x\theta+8x-8\sqrt{(x^2\theta^2-2x^2\theta+4K)}\right)K}{2\theta(-4K+x^2)} & \text{if } K > \frac{\theta x^2}{2}. \end{cases}$$

Comparing Proposition 5 with Propositions 1 and 2 reveals that our results are robust to the introduction of equity contracts and earlier intuition of our model continues to hold under optimal contracting as well.

Proof of Lemma 12

Plugging (32) into (34) and maximizing (34) with respect to α yields $\alpha^* = \frac{1}{2}$. Plugging (32)and $\alpha^* = \frac{1}{2}$ into (34) and (34) yields (38) and (39).

Proof of Lemma 13

First suppose that the VC's participation constraint does not bind. Plugging (42) into (45) and maximizing (45) with respect to α and β yields ($\alpha_0^* = \frac{\theta y(1-2\beta_0)+2(1-\theta)x}{4(1-\theta)x}, \beta_0^* = \beta_0$;s.t $0 \leq \frac{\theta y(1-2\beta_0)+2(1-\theta)x}{4(1-\theta)x} \leq 1$ and $0 \leq \beta_0 \leq 1$). Plugging α_0^* and β_0^* into (45), (40) and (44) yields (51), (52), and (53). Note that $K \leq \frac{\theta(\theta y+2x(1-\theta))y}{8}$ makes sure that the VC's participation constraint is satisfied. Now consider the case

where the VC's participation constraint binds, that is, $K > \frac{\theta(\theta y+2x(1-\theta))y}{8}$. The firm sets α^* such that the VC's participation constraint is satisfied as an equality and the investor has incentives to incur K and to become a VC, that is, α^* is such that $p^{E*}\theta\frac{y}{2} - K = 0$. Solving $p^{E*}\theta\frac{y}{2} - K = 0$ for α yields $(\alpha_1^* = \frac{4K-\theta^2y^2\beta_1}{2(1-\theta)\theta xy}, \beta^* = \beta_1$;s.t.$0 \leq \frac{4K-\theta^2y^2\beta_1}{2(1-\theta)\theta xy} \leq 1$ and $0 \leq \beta_1 \leq 1)$. Plugging α_1^* and β_1^* into (45), (40) and (44) yields (54), (55), and (56).

Proof of Proposition 6

The proof of this proposition follows the same steps as the proofs of Propositions 1 and 2 and will be omitted.