Inventor's quandary: In-house or start-up?*

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Abstract

We analyze a model where a financially constrained inventor has to decide whether to work as an employee in a firm's lab or establish a start-up company. Only the inventor knows whether he is a high or low type. If he chooses to set up a start-up, it reduces his productivity, as he has to deal with the bureaucracy himself. We show that in high payoff projects and the inventor employed in the lab, the compensation of the inventor will be a proportion of the prevailing (non-invention) market wage. Furthermore, we characterize the case, when, despite the productivity reduction, a start-up increases his expected compensation. The preference of the inventor for a start-up works opposite for the financing firm. This may be a possible explanation for the tension that may arise between the inventor and the financing firm, because the latter may try to convince the former to leave the bureaucracy to a professional manager and concentrate on inventions in the firm's lab.

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1. Introduction

In the United States venture capital has become an important source of funding for people with ideas for new products. In particular, corporate venture capital investment plays a significant role in funding new start-up companies. From 1994 to the first half of 2006 the total (nominal) amount of money that corporate venture capital invested in start-up companies added up to about $41 billion, which represented 11.6% of the total amount invested by venture capital (and about 19% of the deals). In the first half of 2006 alone the number of deals that had corporate venture capital participation added up to 21% of the total number of venture capital deals, which represented about $1 billion, and 8.2% of the total invested by venture capital.[1]

On the other hand, many reputed companies have internal laboratories that develop or have developed widely renowned products. In general, one would think that the resources available to companies will increase the revenue from the new enterprise compared to a development of the enterprise in a start-up.

These stylized facts give rise to a few interesting questions: Why would such reputed companies choose to finance a start-up and not develop an idea internally? Who is pushing for a start-up, the inventor or the firm? Can the firm offer the inventor a proportion of the invention profit? Why will a firm finance a start-up and not duplicate the start-up contract internally?[2]. What is the maximum that the firm in the market is willing to give to the inventor?

We address these questions in the context of a simple, but yet general, setting. Consider an inventor who has a project in mind, but is financially constrained. He approaches a company for

[1] Data from the National Venture Capital Association website, www.nvca.org.

[2] Anton and Yao (1995) call this type of set up a "spin-off". They quote an article in the *Wall Street Journal,* August 5, 1993: "Many companies cultivate new innovations by forming separate units and then tying a "product champion's" compensation at least partially to the performance of those units" (p. 366, footnote 8 in Anton and Yao (1995)).

funding. The project can end in success or in failure. The inventor can be one of two possible types: one who can have a high probability of success or one with a low probability of success. The inventor knows his own type, but the financing company does not.[3] The inventor has the choice of working as an innovator in the firm's lab, or to establish his own start-up company. In the first case, he has all the resources available to him that the company provides (infrastructure, legal support, labs, etc.). In the case of a start-up, the inventor has to deal with the bureaucratic proceedings himself to get the undertaking off the ground. Such dealing with bureaucracy and paperwork is wasteful, and we model this as a parameter that reduces the inventor's probability of success[4].

The central message of the paper is twofold. First, if the payoff of the project is high enough (as many of the inventions in the high tech and biomedical industry are) and the inventor is employed by the firm, the inventor's compensation is only a fixed proportion of the market salary, *regardless* of the size of the project payoff. This is important, because it may help explain why (in the United States) most scientists in the research labs of companies get paid a fixed wage and not a share of the profit of their invention. In our model this is a consequence of the competitive market and asymmetric information on the type of inventor, and *not* a result of the legal framework. Secondly, if the value of the project is big enough, we show that the profit to the inventor will be *higher* in the start-up than working in the firm's lab. We see this as a possible explanation for the blossoming of start-ups in the high tech and biomedical industries observed over the last twenty years or so. In other words, the firm would have to

[3] Following Leland and Pyle (1977), Anton and Yao (1994, p. 191) stated that "when the inventor has large financial resources it is straightforward to show that an inventor can credibly signal the value of the invention by agreeing to part with assets if the invention turns out to be useless". It is when the inventor is cash constrained that is the focus of their paper and ours.

[4] This assumption appears among others in Teece (1986), Anton and Yao (1995) and Cassiman and Ueda (2006). Hellmann (2002) even considers that a firm financing a start-up can create a higher probability of success than an independent venture capitalist.

yield to the inventor more money if he sets up a start-up company than if he works in the firm's lab. It illustrates why, at times, there could be tension between the inventor and the financing company, and why established companies try hard to convince inventors to stay in-house and leave the management of the project to a "professional" manager, so that the inventor has all the time to devote to improve on his project.

A close paper to ours is Anton and Yao (1994). They examine the case of a financially weak independent inventor, who can sell his invention to a pair of duopolistic firms. The inventor's predicament is whether to release information about the invention to the potential buyer before signing an agreement. Such information would allow the latter to "expropriate" the invention, as the invention can easily be imitated and property rights on it are non-existent. The invention can be "good" or "bad", and this is the private information of the inventor. In a (separating) equilibrium a "good" inventor with limited resources releases the information prior to the contract, while carrying the risk of being imitated. The inventor captures a sizable share of the invention by "blackmailing" the firm with the threat of revealing the idea to the competitor. Anton and Yao (2002) extended the model to partial disclosure, which allowed the inventor's reward to be based on the nondisclosure part. Anton and Yao (2005) pursued it even further to include partial legal property rights.

Aghion and Tirole (1994) analyze the allocation of the property rights of an innovation between a research unit (inventor) and a customer (finance firm) in the incomplete contracts framework of Grossman and Hart (1986). In their model the research unit decides about the non-contractual effort, which determines the probability of success. The customer decides about the second parameter of success, the amount of investment. In the part that relates to our paper, the allocation of property rights is determined by: a) the marginal effect of effort compared to the investment, and, b) the bargaining power. In the case where the research unit has weak bargaining power, namely is "cash constrained", then the allocation of the property rights is inefficient, since it goes to the customer.

As our first result states that if the inventor is employed by the firm he gets only a fixed proportion of the market salary, it is worth examining it in the context of the legal framework in the United States and other countries. In the United States, without a written agreement, employees who are hired for the purpose of inventing, or who are assigned to a project which primarily involves inventing, must surrender to their employers any ownership right of their inventions (Caldwell, 2006).[5] On the other hand, in Germany, the "Law Regulating Inventions Made by Employees *(Arbeitnehmererfindungsgesetz)*" from 1955 (and posterior amendments) determines that inventions made by employees belong to the employees. Only by a very specific act, which includes compensation to the employee, can the invention become property of the employer.[6] Similarly, in Japan, the property rights of an invention are retained by the employee. The employer can obtain the right to the patent if the employer pays "reasonable remuneration"[7] (the famed article 35 of Japanese Patent Law of 1959). Technology historian David Noble (1977) chronicles that in the first half of the 19th century employees in the United States had a strong right over the inventions they produced. However, this situation changed in the latter half of the 19th century. Noble states forcefully that "[This change] set the basis for a new 'formalism' in the handling of patents, which progressively eliminated the individual inventor, who, unlike the large corporations with their well-staffed legal departments, was not equipped to cope with

[5] Papers that criticisize this status quo include Bartow (1997), Cherensky (1993) and Fisk (1998).

[6] There are three different methods laid out, but the most common one is the so-called "license analogy". With the "license analogy" the employee-inventor receives a certain percentage based on the net sales made by the employer (see Goddar (1996), Gross (1997)).

[7] No guidelines are specified on how much compensation should be paid, which in recent years has led to several high profile lawsuits with consequent costly awards (Shigetomi, 2004).

its intricacies and complexities. ... [These] changes in the mechanism of the patent system [...] presented a formidable obstacle to the individual inventor." (Noble, 1977, pp. 108/109, quoted in Merges (1999, p.11)). Few have tried to give a justification of the status quo. An exception is Merges (1999), who gives an explanation based on strategic bargaining analysis and team production theory. In our case, we show that, if the compensation scheme for the inventor (which presently is a flat payment) would be changed, more low quality inventors would be attracted to work in the firm as an inventor, and thus more low quality projects (economically unjustified) would be developed.[8]

Substantial literature exists on a related issue that focuses on the case where a worker can "be inspired" in the workplace about the idea of enterprise. Then the question is whether such an idea should be developed internally or externally. The literature includes among others an early work by Pakes and Nitzan (1983), who consider a complete information case which results in an efficient outcome. Anton and Yao (1995) explore an asymmetric information case in which the employee forms a startup, even though a spin-off generates greater joint profits. Cassiman and Ueda (2006) analyze a real options model, where a firm has limited commercialization capacity of projects (rather than asymmetric information). Therefore, the firm may "give up a good enterprise". Subramanian (2005) investigates the case that a firm tolerates private entrepreneurship if it is complementary to the firm's activity. Hellmann (2006) considers the firm's incentives to prevent its workers from developing a new idea instead of the core task.

The next section introduces the model. Section 3 presents the results and section 4 considers an extension to the model.

[8] Anecdotal observation seems to indicate that innovation activity in the USA is more entrepreneurship-oriented. For example, a survey by the Global Entrepreneurship Monitor conducted in 2006 states that about 10% of the US working population stated that they are "currently engaged in early-stage entrepreneurial activity" compared to 4.2% in Germany and 4.4% in France (Bosma and Harding, 2006 Results). See also Edmund S Phelps "Entrepreneurial Culture Why European economies lag behind the U.S".

2. The Model

An inventor has a project in mind, but is financially constrained. He approaches a firm (the financing company, which hereafter is called "the firm") for project funding. The cost of funding the project is a fixed amount K.

For simplicity we assume that the project's fruition is binary: it may end in success or in failure. The value of success is S dollars and the value of failure is 0 dollars. We denote by P the probability of success.

The inventor can be one of two types, H for "high" quality inventor and L for "low" quality inventor. These types have probability μ and $1-\mu$ respectively. The firm does not know the type of the inventor; however, the inventor knows his own type. Each inventor type has a different probability of success: for H, it is P_H, and for L, it is P_L ($P_H > P_L$). The different types may arise from the nature of the project or the ability of the inventor. Furthermore, there is a labor market[9], where scientists can obtain a wage W. Both the inventor and the firm are risk neutral.

We make the following two assumptions:

A1) $P_H \times S + (1 - P_H) \times 0 > K + W$ and $P_L \times S + (1 - P_L) \times 0 < K + W$

The expected value of the project with the high quality inventor is bigger than the cost of the project K plus the market wage for inventors W. Therefore there is a reason to finance an H-type inventor, but not an L one.[10]

A2) The market is competitive. Thus, the firms are competing for inventors.

2.1. Two Finance Structures

Consider the following two possible project structures:

[9] The idea of this labor market is that here the inventors work in "non-invention" tasks.

[10] To eliminate pooling equilibria we can assume that $\mu P_H S + [1 - \mu] P_L S < K + W$. This means that the probability of the H-type is small, which seems a reasonable assumption when considering entrepreneurship.

I) The inventor may work as a scientist in the firm's own lab. In this case, the inventor has all the resources available to him that the firm provides: a laboratory, physical and administrative infrastructure, legal support, etc (denote as "in the firm's lab").

II) The firm may provide financing for a start-up company led by the inventor. In this case, the inventor does not have access to the infrastructure provided by the firm, and has to deal with much of the bureaucratic proceedings himself (this option is the "start-up").

Running a start-up company in the Research & Development stage reduces the productivity of the R&D. We model this waste as a parameter $\alpha \in (0,1)$ that reduces the probability of success (a full description is given in section 3.2).

We are going to assume, for simplicity, that the contract is written on the share of the profit that the inventor and firm obtain. The contract will establish that the inventor gets a share β of the profit of the enterprise and the firm obtains the rest. This assumption will hold for the two finance structures: in the firm's development lab and the start-up. In reality it may be that the inventor gets some of his compensation as a salary. Including such feature would not change the results, but make the analysis more tedious.

3. Results

3.1. In the firm's lab

If the inventor decides to work in the firm's own lab, in a separating equilibrium the firm hires only the H type scientist and the L type goes to the labor market with a wage of W. The incentive compatibility constraint (ICC) for the L type is:

$$W \geq \beta P_L S. \tag{3.1}$$

For the L-type inventor not to pretend that he is a high type, the market wage W has to be at least as big as his expected revenue of the invention.

Similarly, the ICC for the H-type is:

$$W \leq \beta P_H S. \tag{3.2}$$

As $P_H > P_L$, for every W and S there is a range of β that satisfies (3.1) and (3.2).

The firm will finance the project, if it thinks that it is run by an H-type and if the share it keeps is at least as big as the investment K, so that we have[11]:

$$(1-\beta)P_H S \geq K. \tag{3.3}$$

Let β_M^I be the share that the H-type will get *if* all the firms in the market know his type (M for "myopic" and I for "its lab"). This definition β_M^I of is used for calculation only. We will not consider the full information case.

From inequality (3.3), and the competitive market for inventors (assumption A2), β_M^I is:

$$(1-\beta_M^I)P_H S = K \Longrightarrow \beta_M^I = 1 - \frac{K}{P_H S}. \tag{3.4}$$

The L-type will not try to mimic the H-type if:

$$W \geq \beta_M^I P_L S, \text{ or equivalently: } W \geq P_L S - \frac{P_L}{P_H} K \iff \frac{P_H}{P_L} W \geq P_H S - K \tag{3.5}$$

With this, we can can establish our first result.

Lemma 1. *If* $W \geq P_L S - \frac{P_L}{P_H} K$, *then the* H*-type will get* $\beta = \beta_M^I$ *in the firm's lab. Therefore, the inventor's expected compensation is* $P_H S - K$ *and the financier's expected (economic) profit is* 0.

[11] The amount K includes the opportunity cost of the project.

From Assumption A1, we have that $P_H S - K > W$, which in turn means that the ICC for the H-type is satisfied.

If the market wage $W < P_L S - \frac{P_L}{P_H} K$ and the firm offers β_M^I, the L type will try to mimic H. Therefore, the firm will offer a lower share β that prevents the mimicking. But from A2, it has to be the highest that prevents it. We denote such share as β^I, which we obtain from inequality (3.1):

$$\beta^I = \frac{W}{P_L S}. \tag{3.6}$$

In this case the inventor's expected compensation is $\beta^I P_H S$, which equals:

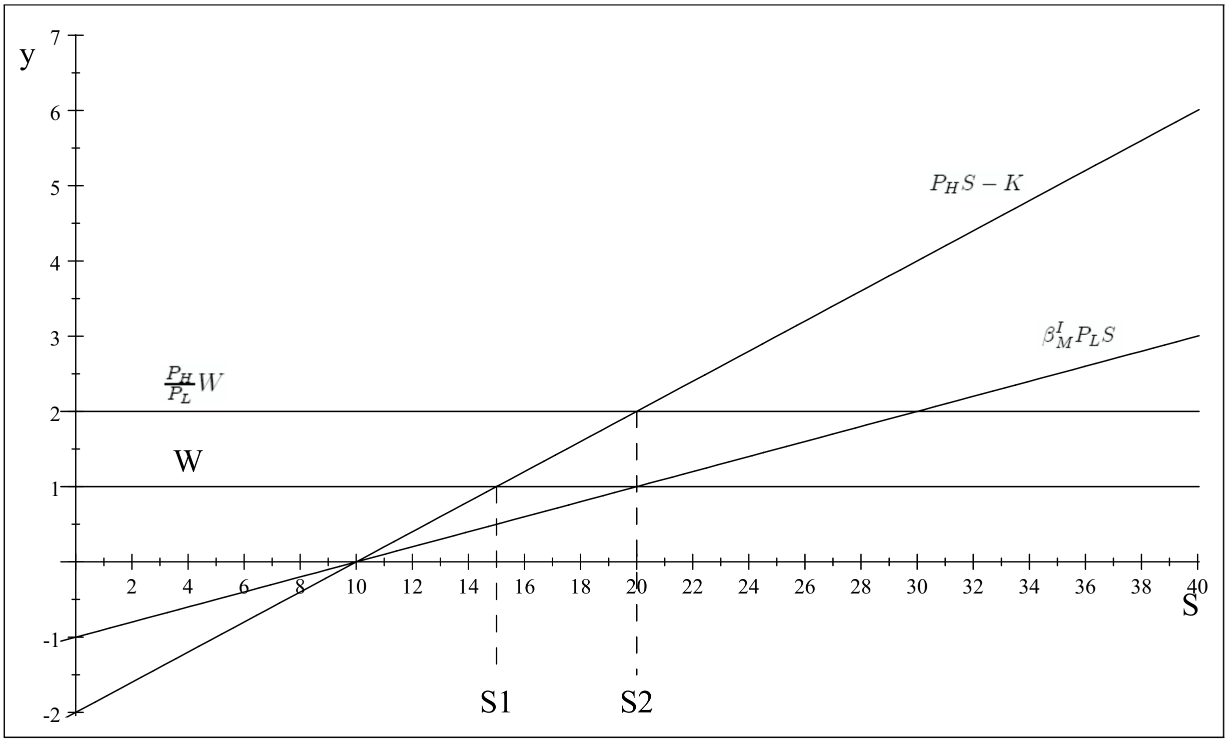
$$\frac{P_H}{P_L} W. \tag{3.7}$$

Lemma 2. *In a competitive market and in a separating equilibrium, if $W < P_L S - \frac{P_L}{P_H} K$, an inventor who works in the firm's own lab will get an expected compensation that does not depend on the value of the project S. This holds even if the contract is conditional on success (in the event of success and only then the inventor will get $\frac{1}{P_L} W$). The H-type inventor gets a premium that equals $\frac{P_H}{P_L}$ above the labor market, but he does not earn his productivity.*

To illustrate the result of Lemma 2, consider two different projects S_1 and S_2. Let $S_1 > S_2$, and allow S_2 large enough to be in the range of Lemma 2. In these two projects the inventor will get his share β^I of the project, but this share will be different with S_1 than with S_2; however, the expected compensation is $\frac{P_H}{P_L} W$ in both of the projects, no matter how much S_1 differs from S_2. The reason is that, if the firm pays the inventor even a small amount more, it will attract L-type inventors. The amount $\frac{P_H}{P_L} W$ is the highest possible quantity that does not induce that, *regardless* how high the value of the project.

Corollary 1. *If* $W < P_L S - \frac{P_L}{P_H} K$ *and development is in the firm's lab, the firm can get expected profits that equal* $P_H S - K - \frac{P_H}{P_L} W$.

Below is a simple example with the following numerical parameters: $W = 1, K = 2,\ \ P_H = 0.2,\ \ P_L = 0.1$, and S is variable on the horizontal axis.



Graph 1

If $S < S1$, then the payoff of the project is too low for assumption A1 to hold. For every $S \in (S1, S2]$, offering β^I_M (which leads to an inventor payoff of $P_H S - K$) will not attract the L-type, since $\beta^I_M P_L S < W$. Therefore, the H-type gets all the surplus, namely, the whole $P_H S - K$. (This is the range of Lemma 1). For the range $S > S2$, offering β^I_M will attract the L-type as $\beta^I_M P_L S > W$. Therefore, the H-type gets only $\beta^I = \frac{W}{P_L S}$, which leads to an expected profit of $\frac{P_H}{P_L} W$ for the H-type and an expected profit of $P_H S - K - \frac{P_H}{P_L} W$ to the firm (this is the range of Lemma 2).

3.2. In a start-up

We turn to the case of a start-up. This means that the inventor has to deal with the "bureaucracy" which reduces his probability of success. We consider the event where the expected value of the project run by the H-type is $(P_H - \alpha) \times S + [1 - (P_H - \alpha)] \times 0$ and the one run by L is $(P_L - \alpha) \times S + [1 - (P_L - \alpha)] \times 0$. Thus, note that both types have the same loss, which is αS (we relax this assumption in the next section).

To save computation space and use the previous results, we denote by $P_H^\alpha = (P_H - \alpha)$ and $P_L^\alpha = (P_L - \alpha)$. Also, we write β_M^α as the share that the H-type will get if all the firms know his type (the superscript α is for reduction of αS). As the market is competitive, this β_M^α will be (counterpart to (3.4)):

$$\beta_M^\alpha = 1 - \frac{K}{(P_H^\alpha)S} = 1 - \frac{K}{(P_H - \alpha)S}. \tag{3.8}$$

The L-type will not try to mimic the H-type if:

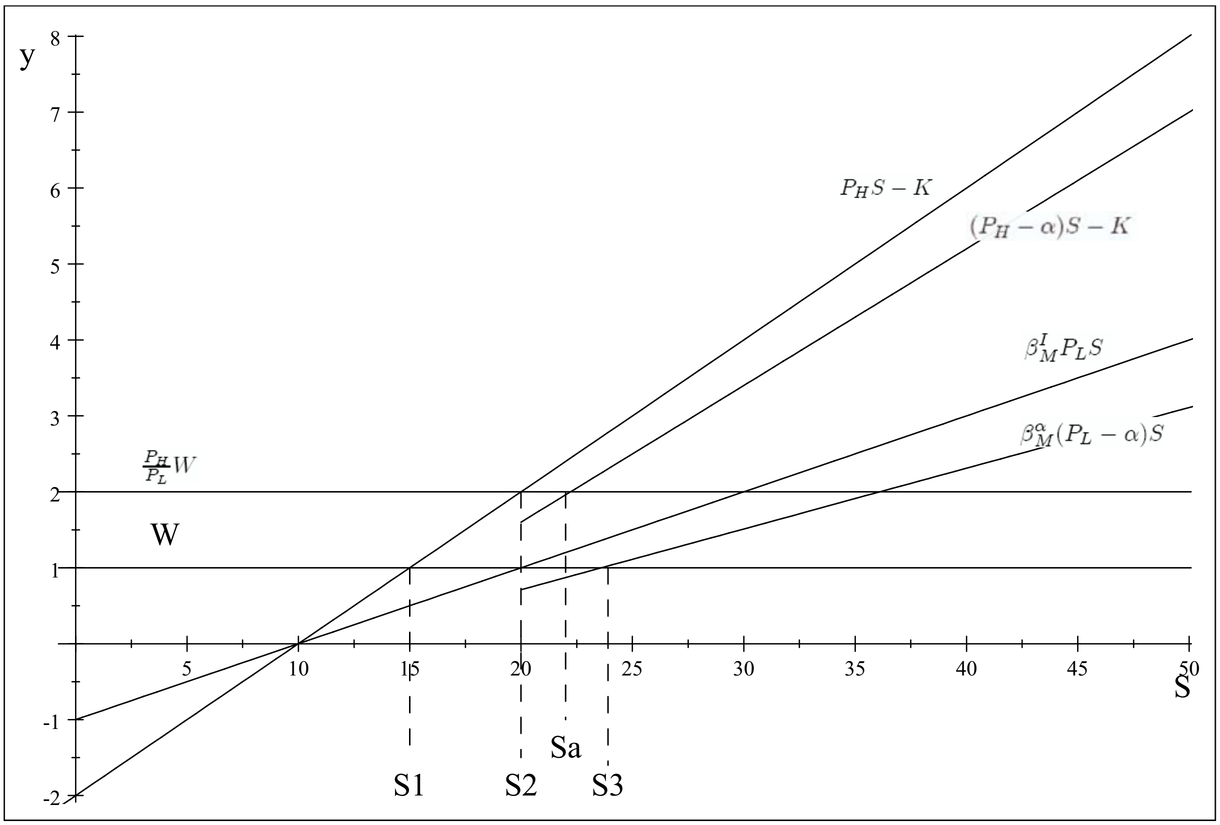
$$W \geq \beta_M^\alpha P_L^\alpha S \Leftrightarrow W \geq P_L^\alpha S - \frac{P_L^\alpha}{P_H^\alpha} K \Longleftrightarrow \frac{P_H^\alpha}{P_L^\alpha} W \geq P_H^\alpha S - K \Leftrightarrow \tag{3.9}$$
$$W \geq (P_L - \alpha)S - \frac{(P_L - \alpha)}{(P_H - \alpha)} K \Leftrightarrow \frac{(P_H - \alpha)}{(P_L - \alpha)} W \geq (P_H - \alpha)S - K.$$

In this case the share that the H-type will get is $\beta = \beta_M^\alpha$. The inventor's profit is $(P_H - \alpha)S - K$ and the financier's is 0. With this, we can state the following lemma.

Lemma 3. *In the range $(P_L - \alpha)S - \frac{(P_L - \alpha)}{(P_H - \alpha)} K \leq W < P_L S - \frac{P_L}{P_H} K$, the H-type inventor gets a profit of $\frac{P_H}{P_L} W$, if he decides to work in the firm lab; or a profit of $(P_H - \alpha)S - K$, if he opens a start up. In the case $(P_H - \alpha)S - K > \frac{P_H}{P_L} W$, the inventor prefers to open a start up.*

To obtain an intuitive feel for lemma 3 consider the case where W, P_H, P_L, α are fixed and S is variable. If $W < P_L S - \frac{P_L}{P_H} K$, then in the firm's lab the inventor will get only $\frac{P_H}{P_L} W$, since any higher share will attract the L-type. If S is such that $(P_L - \alpha)S - \frac{(P_L-\alpha)}{(P_H-\alpha)}K \leq W$, the L-type will not try to mimic the H-type with a start up; the H-type will get all the surplus (minus the bureaucratic waste).

We continue with our previous example (fixed $W = 1,\ K = 2,\ P_H = 0.2,\ \ P_L = 0.1$, and S is variable), adding the bureaucratic waste $\alpha = 0.02$. (see Graph 2)



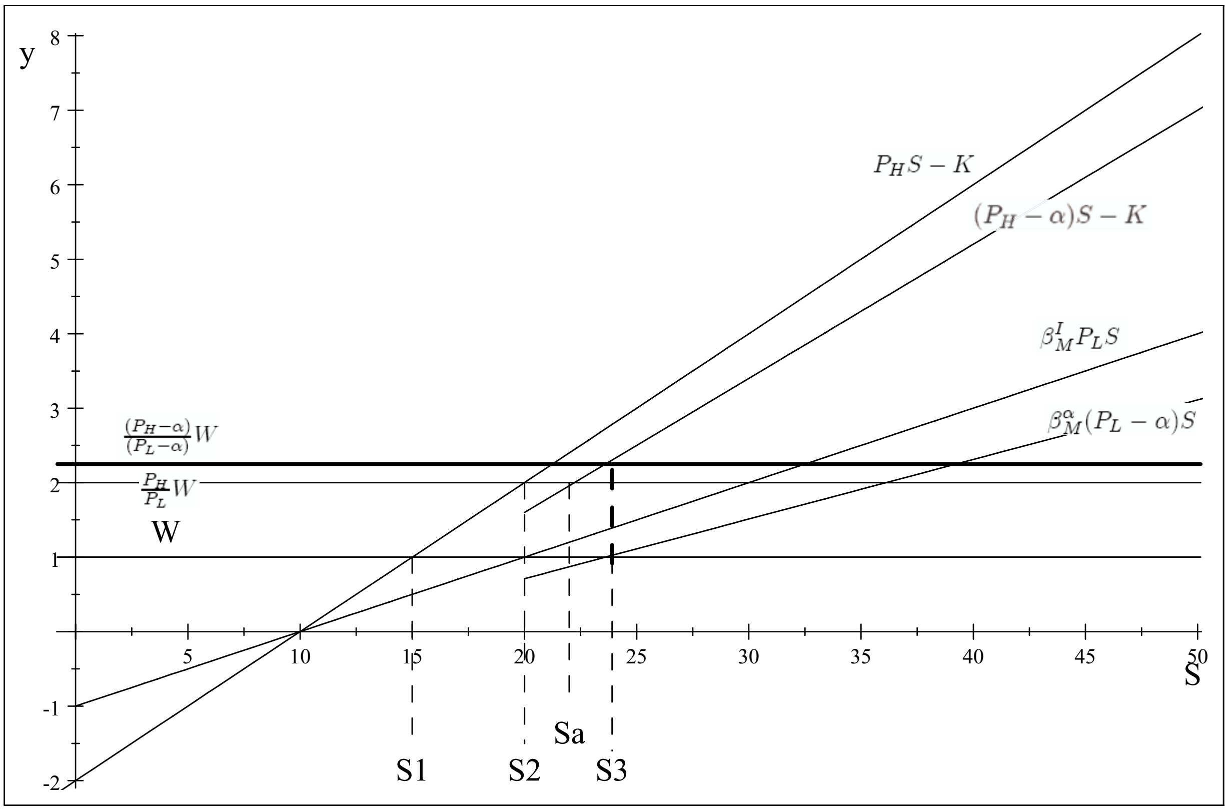
Graph 2

In the range $S \in (S2, S3]$ the L-type will not mimic the H-type with a start-up as $W \geq \beta_M^{\alpha}(P_L - \alpha)S$. When $S \in (S2, Sa]$ the H-type will prefer to develop in the firm lab because $(P_H - \alpha)S - K < \frac{P_H}{P_L}W$. He will get $\frac{P_H}{P_L}W$ and the firm $(P_H - \alpha)S - K - \frac{P_H}{P_L}W$. In the case of $S \in (Sa, S3]$, the H-type will prefer start up development as $(P_H - \alpha)S - K > \frac{P_H}{P_L}W$.

Finally, consider the range $(P_L - \alpha)S - \frac{(P_L-\alpha)}{(P_H-\alpha)}K > W$. The firm cannot offer a share $\beta = \beta_M^{\alpha}$, as the L-type will mimic it. Therefore, the firm will offer a lower share $\beta^{\alpha} = \frac{W}{P_L^{\alpha} S} = \frac{W}{(P_L - \alpha)S}$ (counterpart to (3.6)).

Lemma 4. *In the range* $W < (P_L - \alpha)S - \frac{(P_L-\alpha)}{(P_H-\alpha)}K$, *the expected compensation to the inventor is* $\frac{P_H^{\alpha}}{P_L^{\alpha}}W = \frac{(P_H-\alpha)}{(P_L-\alpha)}W$ *in the start-up (counterpart to 3.7), which is bigger than the one he obtains in the firm lab (which is* $\frac{P_H}{P_L}W$*). The firm gets economic profits equal to* $(P_H - \alpha)S - K - \frac{(P_H-\alpha)}{(P_L-\alpha)}W$.

The next graph illustrates the case of $S > S3$.



Graph 3

In the range $S > S3$ the H-type will get the highest β that prevents the L-type from mimicking, which leads to an expected profit of $\frac{(P_H-\alpha)}{(P_L-\alpha)}W$. Therefore, in this range the inventor will prefer to work in a start-up and not in a firm's lab. However the same phenomena as in lemma 2 occurs, namely his expected compensation from the project does not depend on parameter S.

Notice that the firm will profit in its lab and in the start-up, but in its lab the profits are greater.

One interesting fact to be noticed is that the (high type) inventor is not interested in reducing α. To the contrary, in the range of Lemma 4, it is beneficial to the inventor that the bureaucratic loss will be as high as $\alpha = P_L$ since it decreases the incentive of the low type to mimic the high type.

We can summarize the previous results in the following proposition:

Proposition 1. *Let the loss from the start up be smaller than the firm profit from development in the firm lab. This is necessary and sufficient for the H-type to prefer to set a start-up.*

Proof Recall that the loss is αS and the profit of the firm from development in the lab is $P_H S - K - \frac{P_H}{P_L} W$, and that lemmas 1, 3 and 4 cover all the ranges of the parameters.

First, consider the range of lemma 1. The firm's profit in its own lab is 0, while the start-up loss is αS. Therefore, by proposition 1, the inventor will not set up a start-up, which is the result of Lemma 1.

Second, take the range of Lemma 3. The condition of the theorem is

$$\alpha S < P_H S - K - \frac{P_H}{P_L} W \Leftrightarrow (P_H - \alpha) S - K > \frac{P_H}{P_L} W.$$

This is, in fact, the condition of the start-up to be preferred by the inventor.

Lastly, we need to consider the range of Lemma 4. For every fixed K, W, P_H, P_L and $\alpha > 0$, we can define $\underline{S}$ and $\overline{S}$ such that:

a) let $\underline{S}$ be the lowest S in the range of Lemma 3. Namely, it satisfies $W = P_L \underline{S} - \frac{P_L}{P_H} K$. Therefore,

$$\frac{P_H}{P_L} W > (P_H - \alpha) \underline{S} - K. \tag{3.10}$$

b) let $\overline{S}$ be the highest S in the range of Lemma 3. Namely, satisfy $W = (P_L - \alpha)\overline{S} - \frac{(P_L-\alpha)}{(P_H-\alpha)}K$. Therefore,

$$\frac{(P_H - \alpha)}{(P_L - \alpha)}W = (P_H - \alpha)\overline{S} - K. \tag{3.11}$$

As $P_H > P_L$, then

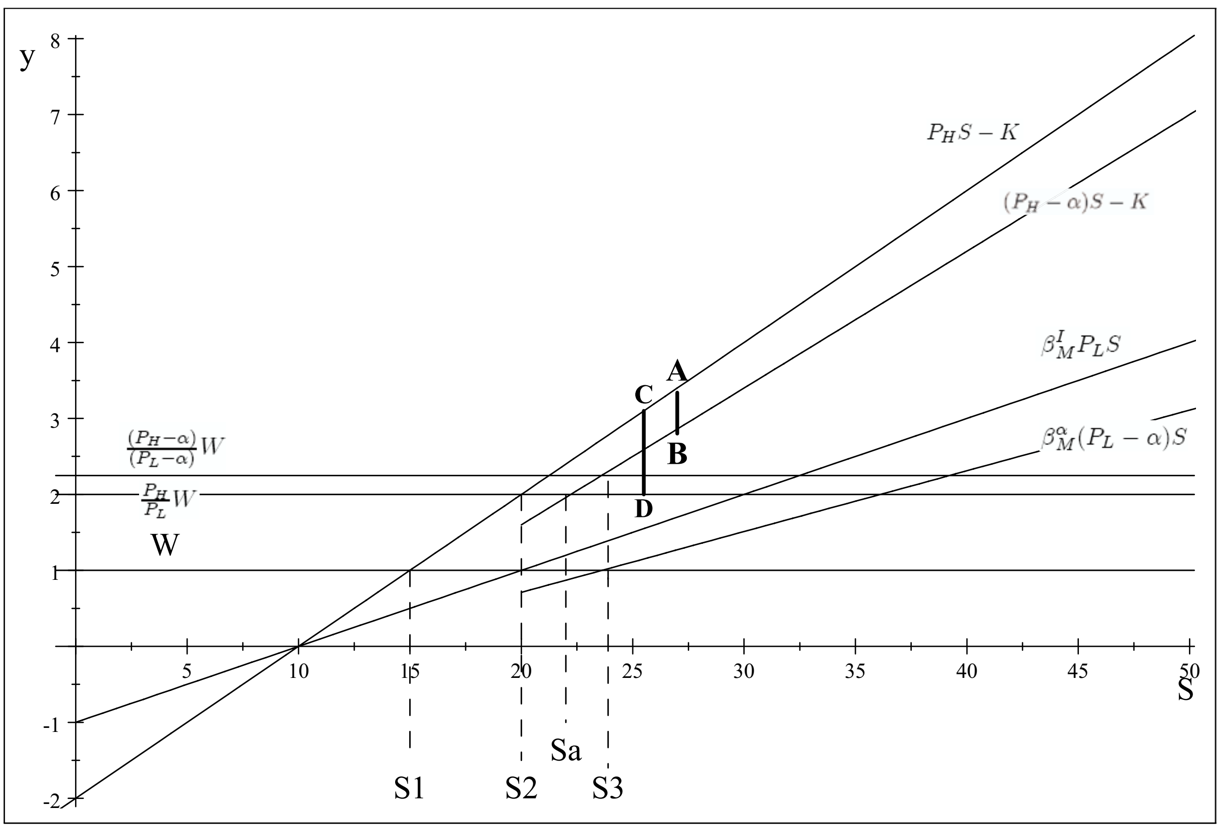
$$\frac{(P_H - \alpha)}{(P_L - \alpha)}W > \frac{P_H}{P_L}W \tag{3.12}$$

From (3.10), (3.11) and (3.12) there exists $\widehat{S} \in [\underline{S}, \overline{S}]$ such that

$$\frac{P_H}{P_L}W = (P_H - \alpha)\widehat{S} - K.$$

This means that already in the range of Lemma 3 the H type prefers to set a start-up. Moreover, for all $S > \widehat{S}$ the inventor prefers a start-up, and that is the result of Lemma 4. ■

Below is a graphical illustration.



Graph 4

As we saw before (see Graphs 2 and 3) the inventor prefers a start up for every $S > Sa$. Notice that $\|A,B\| = \|C,D\|$ at Sa and $\|A,B\| < \|C,D\|$ for all $S > Sa$. The segment $\|A,B\|$ is the start-up waste αS and $\|C,D\|$ is the firm's profit from developing in the firm's lab.

4. Different Bureaucracy Losses for Different Types

In section 3 we assumed that the bureaucracy loss is the same for both types. In this section we will examine the robustness of the result to this assumption. Consider first that "good inventors are less capable to deal with bureaucracy".

Higher loss for the H-type. Here the expected value of the project run by the H-type is $(P_H - \alpha) \times S$, and the one run by L is $(P_L - \epsilon\alpha) \times S$ where $\epsilon \in [0,1]$. If $\epsilon = 0$ there is no loss for the L type if $\epsilon = 1$ the L type loss is the same as the H type. Making a small change in notation again, we write as $P_H^\epsilon = (P_H - \alpha)$ and $P_L^\epsilon = (P_L - \epsilon\alpha)$. Also, β_M^ϵ is the share that the H-type will get, if the all the firms know his type:

$$(1 - \beta_M^\epsilon)(P_H - \alpha)S = K \Longrightarrow \beta_M^\epsilon = 1 - \frac{K}{P_H^\epsilon S} = 1 - \frac{K}{(P_H - \alpha)S} \tag{4.1}$$

The L-type will not try to mimic the H type if:

$$W \geq \beta_M^\epsilon (P_L - \epsilon\alpha)S \;\Leftrightarrow W \geq P_L^\epsilon S - \frac{P_L^\epsilon}{P_H^\epsilon} K \Leftrightarrow \frac{P_H^\epsilon}{P_L^\epsilon} W \geq P_H^\epsilon S - K \tag{4.2}$$

$$\Leftrightarrow \frac{(P_H - \alpha)}{(P_L - \epsilon\alpha)} W \geq (P_H - \alpha)S - K$$

Lemma 5. *(Counterpart to lemma 3) In the range* $(P_L - \epsilon\alpha)S - \frac{(P_L - \epsilon\alpha)}{(P_H - \alpha)} K \leq W < P_L S - \frac{P_L}{P_H} K$ *an inventor that opens a start up gets an expected profit of* $(P_H - \alpha)S - K$ *compared to in house profit of* $\frac{P_H}{P_L} W$*. If* $(P_H - \alpha)S - K > \frac{P_H}{P_L} W$*, then the inventor will prefer a start up.*

This condition is similar to the one in Lemma 3, but the range of Lemma 5 is *smaller* than the one in Lemma 3. Consider for example the case where $W, P_H, P_L, \alpha, \epsilon$ are fixed and S is variable. Then, the boundary on S in Lemma 5 is tighter on higher S.

Lemma 6. *(Counterpart to lemma 4) In the range $W < (P_L - \epsilon\alpha)S - \frac{(P_L-\epsilon\alpha)}{(P_H-\alpha)}K$, an inventor who opens a start up gets an expected profit $\frac{(P_H-\alpha)}{(P_L-\epsilon\alpha)}W$ compared to in firm lab profits of $\frac{P_H}{P_L}W$.*

If we compare Lemma 6 with Lemma 4, we notice that by Lemma 4 it is better from the point of view of the inventor to open a start up. However, in Lemma 6 it is not *always* the case, as $\frac{(P_H-\alpha)}{(P_L-\epsilon\alpha)}W$ may be less than $\frac{P_H}{P_L}W$.

Using proposition 1, Lemma 5 and Lemma 6 we can obtain the following proposition.

Proposition 2. *The H-type inventor is worse off if the market knows that the waste of the start up is greater for the H-type than for the L-type. Moreover, the smaller the waste that the market assigns to the L-type, the worse it is for the H-type.*

Corollary 2. *The firm is better off if the market knows that the waste of the start up is greater for the H-type than for the L-type. Moreover, the smaller the waste that the market assigns to the L-type, the better it is for the firm.*

The conclusion of Corollary 2 is straightforward. What needs to be recognized is that we have three "players" who share in the project's profit: the inventor, the firm *and* the "bureaucratic waste" (which gets a fixed amount αS in the case of a start-up). Thus, if the investor is worse off (as Proposition 2 claims), the firm is better off (Corollary 2). The importance Proposition 2 and Corollary 2 lies in the notion that "the market knows" that in a separating equilibrium there are no investments by the L-type inventor. Therefore ϵ does not effect any R&D in a separating equilibrium, but it affects the allocation of payoff for both, the inventor and the firm.

Higher loss for the L-type. We will not develop this subsection formally, but the equivalent of Lemma 5 would be that it widens the range where the H-type gets all the surplus minus the bureaucratic waste. The equivalent of Lemma 6 is that the H-type always prefers to open a start up as $\frac{(P_H - \epsilon\alpha)}{(P_L - \alpha)} W > \frac{P_H}{P_L} W$ for $\epsilon < 1$. The equivalents of Proposition 2 and Corollary 2 are that the worse the market believes about the ability of the L-type to deal with bureaucracy, the better it is for the H-type, and worse for the financing firm.

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