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"Entrepreneurship and the Boundaries of the Firm"

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*presenting

Entrepreneurship and the Boundaries of the Firm

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1 Introduction

Economists have traditionally seen the firm as an efficiency-maximizing organization. This is most evident in the neoclassical theory that equates a firm with a production function, embodying purely technological considerations. But more sophisticated modern analyses remain focused on efficiency.

Building upon Coase's (1937) seminal contribution, the transaction-cost literature developed in particular by Williamson (1971, 1975, 1985) portrays the firm as minimizing the costs of organization, rather than of production *per se*; Coase (1988) summarizes: "The limit to the size of the firm is set where its costs of organizing a transaction become equal to the cost of carrying it out through the market."

The property-rights theory pioneered by Grossman and Hart (1986) and Hart and Moore (1990) provides an endogenous foundation for the different efficiency properties of integration and market transactions. Asset ownership grants residual rights of control, a crucial incentive device when contracts are incomplete, due to complexity, uncertainty and contracting costs. Thus the optimal allocation of property rights, which defines the boundaries of the firm, is meant to achieve the constrained-optimal level of relationship-specific investments. These augment efficiency within the partnership, but not equally outside of it, thus exposing the investor to the hold-up problem.

Yet firms are not merely mechanisms to organize production cost-effectively: at least since Schumpeter (1934), it has been recognized that their role in generating economic value and earning profits is more fundamentally based on entrepreneurship and innovation. Seen in this light, the firm is an instrument in the hands of the entrepreneur, and is shaped by his two guiding considerations: not only how to maximize profits from his innovation, but also how to secure these profits for himself.

In theory, legal protection of intellectual property should be sufficient to guarantee the innovator's monopoly power. In practice, imitation remains possible, and is often far from

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prohibitevely costly: Rajan and Zingales (2001) highlight in particular the risk posed by an entrepreneur's partners, who have been granted access to his innovative know-how.[1]

Ownership of specialized complementary physical assets can then be useful to the entrepreneur not to maximize efficiency, but to bolster his monopolistic control of an innovation. This is a major concern for real-world firms: Teece (1986) stresses the risk that "profits from innovation may accrue to the owners of complementary assets, rather than to the developers of the intellectual property."

The boundaries of the firm can thus be drawn by a trade-off between efficiency and security. On the one hand, the entrepreneur's partner will make bigger relationship-specific investments if he is the owner of specific assets. On the other hand, ownership also increases his incentives to steal the innovation. As a consequence, the original entrepreneur will opt for an efficiency-maximizing outsourcing partnership when his intellectual property is sufficiently protected by the legal environment and by his non-transferable skills. But in the case of an asset-intensive innovation, he will organize an integrated firm so that strong property rights over tangibles may secure weak property rights over intangibles.

This expansion of the property-rights theory can also shed light on organizational dynamics. As Coase (1934) already recognized, the boundaries of a firm are rarely constant over the life cycle of a product: firms expand and contract, integrate and spin off divisions. A purely efficiency-based theory of the firm can account for such dynamics to the extent that exogenous technological changes modify the relative importance of different relationship-specific investments: such a mechanism underpins the product-cycle model presented by Antràs (2005). However, the efficiency-security trade-off can provide an endogenous motivation, because it is intrinsically dynamic: the efficiency gains are reflected in flow profits, but imitation and asset acquisition generate sunk costs. As a consequence, when the expected remaining lifetime of an innovation changes, so do the optimal boundaries of the firm exploiting it.

Finally, the model also has implications for the management of innovation in relation to asset ownership. An innovating entrepreneur may need an integrated firm, but he can fully appropriate constrained-optimal profits. On the contrary, an inventor lacking entrepreneurial skills needs to share the profits arising from an innovation with an entrepreneur who can more successfully bring it to market. In this case, as stressed by Teece (1986), it is crucial for the inventor to establish a prior position in the complementary physical assets, to strengthen his bargaining power *vis à vis* the entrepreneur at the stage of partnership formation.

An acute example of this problem emerges when innovation is generated by an inventor-entrepreneur within an existing firm. Even if the employer legally owns the invention, he may not be able to profit from it at all if the innovating employee can leave to set up his own firm and beat him to the market. Bhidé (2000) suggests that this was a typical pattern of IT innovation at the end of the twentieth century.

[1] In their model, an employee chooses between specializing to his manager or defecting and becoming a competitor. Protection from expropriation then requires the organic development of an internal hierarchy. The authors thus develop a model of the firm that completely abstracts from assets and their ownership.

2 Efficiency and Appropriation

An entrepreneur H has devised an innovation that enables him to produce a uniquely differentiated final product. However, to produce he needs to partner with a manager M who can operate a complementary physical asset. We can think of M as the manufacturer of a specialized intermediate input, and of the asset as the production plant; alternatively, for instance, M could be a distributor and the asset a sales organization that will market the innovative product.

The two partners are endowed with specialized human capital that allows each to invest in making the respective stage of production more efficient. But after the partnership is formed a classic hold-up problem emerges: at the time of unverifiable relationship-specific investment, the partners cannot write an enforceable long-term contract specifying the quality and quantity of intermediates to be supplied and the price to be paid, due to uncertainty regarding the *ex-post* optimal characteristics of the intermediates themselves; moreover, costs, revenues and profits, while perfectly predictable by the parties, are not verifiable by the legal system and thus cannot be part of an enforceable contract. Because of this contractual incompleteness, *ex ante* the parties can only trade lump-sum payments and allocate property rights over tangible assets, and they will bargain *ex post* over the division of surplus from their relationship.

Incentives for investment in a world of incomplete contracts depend on the ownership of assets, as established by the property-rights theory. Since each agent is uniquely specialized in one stage of the production process, his incentives are assumed to depend one one asset only: the innovation for H, and the physical asset for M. In this context, it is a standard result (Hart 1995) that non-integration yields the best incentives for relationship-specific investment, and therefore the highest productive efficiency.

However, the standard analysis disregards an important difference between tangible and intangible assets: unlike the former, the latter are not subject to a tight appropriability regime, or in plain words they can be stolen with relative ease. M has to become acquainted with H's proprietary technology. This allows M to specialize within the partnership, but also to imitate the innovation, by such means as reverse-engineering H's stage of the production process, inventing around his patent, violating a non-compete agreement, and generally expropriating substantially, if not formally, the entrepreneur's intellectual property rights.

Monopoly power over an innovation relies on a combination of three factors:

1. The cost of imitation, which Teece (1986) calls the "appropriability regime". This is a function both of the legal environment and of the specific nature of the technology: some products, like the Coca-Cola formula, are easy to protect even within a partnership; most are not, and innovative processes tend to be even less protected.

2. The unique individual skill of the entrepreneur, which gives him an intrinsic advantage over competitors in developing and exploiting his idea. This is the defining characteristic of entrepreneurial talent according to Schumpeter's (1947), who remarks that "it is particularly important to distinguish the entrepreneur from the inventor", because the latter may well be a scientist producing new ideas, but the latter "gets things done". Entrepreneurial innovation is not invention, but the ability to turn an invention to economic use, which "in most cases only one man" possesses.

3. The presence of a specialized complementary asset whose acquisition represents a sunk cost of entry into the market, and therefore endows it with the characteristics of a natural monopoly. Hence, incentives deriving from asset ownership are a double-edged sword: since they generate a higher outside option whenever the relationship breaks down, they induce higher investment at the *interim* stage, but they also also generate a more acute temptation to defect from the partnership *ex ante*.

A non-integrated partnership can be preserved if H's idea is sufficiently protected by the exogenous appropriability regime; or if H's irreplaceable contribution to the continued development of the innovation is substantial. Yet, both of these forces can prove insufficient to secure the cooperation of a partner controlling a key complementary asset. It becomes then necessary to organize an integrated firm, albeit sacrificing *interim* efficiency, to secure monopoly rights over the innovation.

The timeline of the model is the following:

1. *Organization*:

   An entrepreneur H endowed with a unique innovative idea recruits from a competitive pool a manager M. The partners build a specialized physical asset at a cost f, trade lump sums and optimally allocate property rights over the idea and the asset.

2. *Appropriation*:

   The agent who does not own the idea can steal it and defect from the partnership, at a cost $s \geq 0$.

   Then each agent, if he wants to remain in the market, has to repeat the start-up stage, replacing the assets he does not own already and recruiting a new partner with the complementary skill.

3. *Competition*:

   The market is composed of measure one of homogeneous consumers, each of which buys exactly one unit of the product if its price is lower than its consumption value v, and none otherwise.

   Each firm operating in the market post a price $p \leq v$: the firm with the lowest price faces unit demand, and all competitors with higher prices face no demand.

4. *Production*:

   The winner in Bertrand competition produces measure one of the final good to satify demand.

   Production involves relationship-specific investments and the hold-up problem, following the classic Grossman-Hart-Moore model. The profits are shared through Nash bargaining.

The operation of the firm can be seen as a game to be analyzed by backwards induction.

2.1 Production

The modelling of the hold-up problem follows closely Hart (1995). Production involves two separate stages: M produces a specialized intermediate at a cost c_M, and H transforms it into the differentiated final good at an additional cost c_H. Each partner can make a cost-reducing investment, so that total costs are

$$C(i_H, i_M) = c_H(i_H) + c_M(i_M) + i_H + i_M$$

where for $a \in \{H, M\}$ the cost of production is a decreasing and convex function

$$c_a'(i_a) < 0 \text{ and } c_a''(i_a) > 0 \ \forall i_a \geq 0$$

satisfying the boundary conditions $|c_a'(0)| > 2$ and $\lim_{i_a \to \infty} |c_a'(i_a)| < 1$. The first-best investment is

$$i_a^* = \arg\min_{i_a} \{c_a(i_a) + i_a\} \Rightarrow |c_a'(i_a^*)| = 1$$

Each partner is completely specialized in carrying out one stage of the production process. Hence H's outside option is $r_H(i_H) \geq 0$ if he owns the idea, and zero otherwise, because he cannot operate the physical asset without M. Analogously, M's outside option is $r_M(i_M) \geq 0$ if he owns the asset, and zero otherwise.[2] The marginal value of investment is always greater within the relationship than outside of it:

$$|c_a'(i_a)| > r_a'(i_a) > 0 > r_a''(i_a) \ \ \forall i_a \geq 0$$

Profit $\Pi = p - C(i_H, i_M)$ is shared through Nash bargaining. Thus if an agent owns the asset employed in his own productive activity, his invesment is

$$i_a^O = \arg\min_{i_a} \left\{ \frac{1}{2} c_a(i_a) + i_a - \frac{1}{2} r_a(i_a) \right\} \Rightarrow \frac{1}{2} \left| c_a'\left(i_a^O\right) \right| + \frac{1}{2} r_a'\left(i_a^O\right) = 1$$

while if the agent is employed by his partner, who owns the asset, his investment is

$$i_a^E = \arg\min_{i_a} \left\{ \frac{1}{2} c_a(i_a) + i_a \right\} \Rightarrow \frac{1}{2} \left| c_a'\left(i_a^E\right) \right| = 1$$

Hence $i^* > i^O > i^E$: suboptimal investment is unambiguously reduced by increasing the residual rights of control over the asset the partner uses in production, while it is unaffected by ownership of the other asset. According to Hart's (1995) Proposition 2.C, the tangible and intangible assets are independent, so that non-integration maximizes efficiency.

Second-best joint surplus is attained through non-integration, yielding monopoly profits

$$\Pi^O \equiv v - C\left(i_H^O, i_M^O\right) < \Pi^*$$

which are shared in Nash bargaining according to

$$\begin{cases} \pi_H^O = \frac{1}{2}\Pi^O + \frac{1}{2}\left[i_M^O - i_H^O - r_M\left(i_M^O\right) + r_H\left(i_H^O\right)\right] \\ \pi_M^O = \frac{1}{2}\Pi^O - \frac{1}{2}\left[i_M^O - i_H^O - r_M\left(i_M^O\right) + r_H\left(i_H^O\right)\right] \end{cases}$$

[2] Each agent could recruit a partner with the complementary skill in the start-up stage, but it is too late to do this at the production stage.

Instead H-integration reduces monopoly profits to

$$\Pi^H \equiv v - C\left(i_H^O, i_M^E\right) < \Pi^O$$

which are shared in Nash bargaining according to

$$\begin{cases} \pi_H^H = \frac{1}{2}\Pi^H + \frac{1}{2}\left[i_M^E - i_H^O + r_H\left(i_H^O\right)\right] \\ \pi_M^H = \frac{1}{2}\Pi^H - \frac{1}{2}\left[i_M^E - i_H^O + r_H\left(i_H^O\right)\right] < \pi_M^O \end{cases}$$

and M-integration to

$$\Pi^M \equiv v - C\left(i_H^E, i_M^O\right) < \Pi^O$$

which are shared in Nash bargaining according to

$$\begin{cases} \pi_H^M = \frac{1}{2}\Pi^M + \frac{1}{2}\left[i_M^O - i_H^M - r_M\left(i_M^O\right)\right] < \pi_H^O \\ \pi_M^M = \frac{1}{2}\Pi^M - \frac{1}{2}\left[i_M^O - i_H^M - r_M\left(i_M^O\right)\right] \end{cases}$$

To simplify notation, let the third-best profit level be

$$\Pi^I \equiv \max\left\{\Pi^H, \Pi^M\right\} < \Pi^O$$

depending as usual on the relative importance of the two partners' incentives for relationship-specific investment.

If appropriation were not a concern, H and M would agree *ex ante* on a non-integrated partnership To some extent, this is a vindication of the neoclassical theory of production in perfectly competitive markets: without a monopoly position to protect, each firm would coincide with a technologically-defined stage of the production process.

2.2 Competition

If the market is not controlled monopolistically by a single partnership, in Bertrand competition each partnership j has a minimum incentive-compatible price

$$\bar{p}_j = C\left(i_H, i_M\right)$$

where the endogenous investment levels depend on asset ownership as detailed above.[3]

Ranking partnerships by their limit price $\bar{p}_1 < \bar{p}_2 \leq ...$, Bertrand competition implies that the first oligopolist will post a price marginally below $\bar{p}_2$ to shut out his competitors, and will invest and produce as if he were a monopolist, leaving surplus $v - \bar{p}_2$ to the consumers.

To capture parsimoniously the H's unique entrepreneurial ability, assume that he has a cost advantage over any manager entrusted with carrying out the final stage of production: an imitator H' has costs $h + c_H\left(i_H\right)$, with $h > 0$. Identically, this could be interpreted as a quality advantage for the original entreprenur. This enables H to be the Bertrand winner if he chooses to compete in an oligopoly, with oligopoly profits precisely h since both oligopolists adopt the same optimal organizational form.

[3] Agents who have not defected from the partnership at the appropriation stage can be required to participate in production, so the incentive-compatibility constraint is relevant, but the participation constraint is not. Otherwise the minimum compatible price would be $\bar{p}_j = C\left(i_H, i_M\right) + \left|\pi_H - \pi_M\right|$, leaving each partner with non-negative *interim* profits: this would not materially affect the analysis, but merely increase the algebraic burden.

2.3 Appropriation

Even in an integrated firm, there is the risk that the employee could steal the idea and leave to establish a competing firm. H-integration guarantees against this threat: M has no incentive to steal the idea, as he would be unable to earn any profit competing against the original entrepreneur. Thus H-integration is always feasible M-integration is not equally robust: at a cost $s + f$, H could steal the idea and replicate the asset; he would be the winner in Bertrand competition, and earn h. Thus M-integration is feasible if and only if $h \leq f + s + \pi_H^M$

In an arm's length relationship, M could steal the idea and become a competitor. H can deter M's defection by threatening to re-enter the market: in a Bertrand oligopoly he would earn profits h, while holding the competitor to zero profits. This deterrence mechanism is credible if and only if $h \geq f$. If instead $f > h$, asset ownership enables the manager to steal the entrepreneur's idea and profit from it in his stead. Since this condition is stronger than feasibility of M-integration, M can choose between employing his new partner H', or selling to him both the stolen idea and the physical asset for a competitive price equal to the latter's anticipated profits $\Pi^H - h$. Hence non-integration is not feasible if $f > h$ and $\Pi^I > h + s + \pi_M^O$: then both forms of integration are feasible.

2.4 Organization

Taking into account the threat of expropriation, the optimal organizational form is:

1. non-integration if $h \geq f$ or $h + s + \pi_M^O \geq \Pi^I$;
2. H-integration if $f > h$ and $\Pi^H = \Pi^I > h + s + \pi_M^O$;
3. M-integration if $f > h$ and $\Pi^M = \Pi^I > h + s + \pi_M^O$.

This taxonomy highlights the intuitive operation of different forces binding the partnership together or pulling it apart.

An asset-intensive company (high f) is likely to need integration, because the owner of the asset effectively controls the innovation regardless of intellectual property rights. This mirrors Teece's (1986) observation that innovating firms may not be able to survive in the market if they do not directly own the necessary manufacturing capabilities.

On the other hand, an entrepreneurial company (high h) is more likely to be able to operate by outsourcing, since the controlling position is established not by assets, but by the entrepreneur's own skill. To the extent that an individual entrepreneur is essentially irreplaceable, he can operate as a free-lance provider of entrepreneurial talent, without needing asset ownership or even intellectual property rights to secure control of his innovations.

In any case, non-integration is the more likely to be possible, the stronger protection is afforded to owners of intangibles. It is worth noting that the model highlights an often neglected efficiency-enhancing role of patent protection. Traditional analysis focuses on the trade-off between providing incentives for innovation and allowing distortions due to monopoly power. In our case, however, the innovation is a natural monopoly, and it will actually be monopolized regardless of the institutional regime: granting patent protection

eliminates the need for the monopolist to take efficiency-reducing measures to secure his market power.

Finally and most traditionally, integration is the less likely the more costly it is in terms of suboptimal incentives. However, unlike in the standard efficiency-based theories of the firm, what matters is not the comparison between joint profits $\Pi^O > \Pi^I$: only M's share of the outsourcing profits is relevant π_M^O as deterrence. Therefore we will observe integration even if outsourcing is the unique organizational form that induces second-best investment. As a consequence, the role of M's own investment is ambiguous: if it is greater than H's, leading to a highly unequal division of joint profits in favour of the latter in the non-integrated partnership, it will be a force pushing towards inefficient integration.

3 Organizational Dynamics

An innovative product can be made obsolete by a subsequent innovation that will displace it in the consumers' eyes, as in Aghion and Howitt's (1990) model of quality ladders. If displacement occurs with a non-constant hazard rate, the optimal organizational form will change over the product cycle, in response to changes in the expected future lifetime of the innovation. As usual, a constant hazard rate would instead determine a stationary equilibrium.

In particular, suppose that as the product ages it is more likely to become obsolete: this assumption corresponds to a continuous-time survival model with a monotone increasing hazard rate $\lambda(t) \geq 0$ with $\lambda'(t) > 0$. Given a constant instantaneous interest rate r, the expected present value at time t of a stream of instantaneous unit profits for the remaining lifetime of the product is

$$V(t) \equiv \int_0^\infty \exp\left\{-\int_t^{t+s} [r + \lambda(\tau)]\, d\tau\right\} ds \in \left(0, \frac{1}{r}\right)$$

which is monotone decreasing when the hazard rate is monotone increasing:

$$\lambda'(t) > 0 \Rightarrow V'(t) = \int_0^\infty [\lambda(t) - \lambda(t+s)] \exp\left\{-\int_t^{t+s} [r + \lambda(\tau)]\, d\tau\right\} ds < 0$$

An analogous extreme case is a deterministic finite lifetime T, leading to decreasing value $V(t) = \frac{1-e^{r(t-T)}}{r}$ for $t \leq T$ (cf. Ethier and Markusen 1996).

Considering that profits are instantaneous flows, while the cost of the asset f and of appropriation s are lump sums, non-integration is feasible at time t if and only if

$$f \leq hV(t) \text{ or } s \geq \left(\Pi^I - \pi_M^O - h\right) V(t)$$

Thus we can define a time

$$T^O = \begin{cases} V^{-1}\left(\frac{s}{\Pi^I - \pi_M^O - h}\right) & s < \left(\Pi^I - \pi_M^O - h\right) V(0) \\ 0 & s \geq \left(\Pi^I - \pi_M^O - h\right) V(0) \end{cases}$$

such that for $t \geq T^O$ non-integration is feasible because the appropriability regime (s) makes stealing the innovation too costly. Analogously we can define a time

$$t^O = \begin{cases} V^{-1}\left(\frac{f}{h}\right) & f < hV(0) \\ 0 & f \geq hV(0) \end{cases}$$

such that for $t \leq t^O$ non-integration is feasible because the value of M's asset (f) is insufficient to deter H from reconquering the market from an imitator.

Hence if

$$t^O < T^O \Leftrightarrow \frac{\Pi^I - \pi_M^O - h}{s} > \max\left\{\frac{1}{V(0)}, \frac{h}{f}\right\}$$

the firm's organization will change over the duration of the product cycle.

1. If the innovation is not too asset-intensive ($\frac{h}{f} > \frac{1}{V(0)}$) there can be an initial stage of non-integration $\left[0, t^O\right]$, supported by the original entrepreneur's credible threat to outcompete any imitator.

2. There will be a period $\left(t^O, T^O\right)$ when production needs to be integrated in order to preserve control over the innovation.

3. Finally, there will be a period $\left[T^O, \infty\right)$ when a mature product is sufficiently protected by the intellectual-property regime, despite its imperfections, so that non-integration is possible.

4 Profiting from innovation

We have analyzed so far the organizational form that allows constrained-optimal profits to be earned from the innovation. *Ex ante*, these profits accrue entirely to H when he is simultaneously the entrepreneur, the inventor and the original owner of the idea, so that he has all the bargaining power during partnership formation. Although this is the standard case, Schumpeter (1947) observed that "[m]any inventors have become entrepreneurs and the relative frequency of this case is no doubt an interesting subject to investigate, but there is no necessary connection between the two functions."

Separating the roles that were so far attributed to H has two consequences. The most obvious is that *ex ante* more than one agent has bargaining power, so that the profits of innovation are devided instead of accruing in their entirety to the inventor-entrepeneur. It is less evident and more interesting that the timing of the acquisition of the complementary asset will become crucial. As in Teece (1986) an important advantage of the innovator's is that he is "in the position, at least before its innovation is announced, to buy up capacity in the complementary assets, possiblyto its great subsequent advantage".

Suppose that M instead of H is the inventor; alternatively, the inventor could be a third party, who could do no better than selling his invention to M, with respect to whom he holds all the bargaining power. The constrained-optimum profit is still obtained from the analysis above, and will be denoted by $\Pi \in \left\{\Pi^O, \Pi^I\right\}$; assume furhermore that $\Pi - f > h$, so that

the innovation is valuable even in H's absence, and $\Pi - f > s$, so that the appropriability regime is not perfectly tight.

The timeline of the firm game now has a preliminary stage:

0. *Pre-emptive asset acquisition:*

   Having first-mover advantage, M can choose to build the specialized asset at a cost f to strengthen his bargaining position *vis à vis* H.

Moreover, in the start-up stage H and M divide anticipated profits in Nash bargaining. If bargaining breaks down, both agents decide whether to enter or leave the market. H's cost of entry is $f + s$, while M's is nil if he the cost of the physical asset is already sunk, and zero otherwise. To avoid the problem of equilibrium selection in the simultanous entry game, assume that H can move first with probability $\eta \in [0, 1]$, and M moves first with complementary probability $1 - \eta$. If only one agent has entered the market he enjoys a monopoly, while if both have entered they will behave as a Bertrand duopoly.

The presence of this entry game off the equilibrium path implies that preliminary asset acquisition is a valuable commitment device, so that M will always incur the sunk cost before bargaining with H. It is convenient to treat two cases separately

1. If $f + s > h$ entry by M deters H, just as entry by H deters M: therefore M will enter if he regains first-mover advantage.

   (a) If bargaining occurs before asset acquisition, the joint surplus is $U = \Pi - f$ and the outside options are respectively $o_H = \eta(\Pi - f - s)$ and $o_M = (1 - \eta)(\Pi - f - h)$. Thus Nash-bargaining payoffs are

   $$\begin{cases} u_H = \eta(\Pi - f) + \frac{1}{2}(1 - \eta)h - \frac{1}{2}\eta s \\ u_M = (1 - \eta)(\Pi - f) - \frac{1}{2}(1 - \eta)h + \frac{1}{2}\eta s \end{cases}$$

   (b) If bargaining occurs after asset acquisition, the joint surplus if Π and the outside options are respectively $o_H = 0$ and $o_M = \Pi - f - h$. Thus payoffs, adjusted for the previously incurred sunk cost, are

   $$\begin{cases} u_H = \frac{1}{2}h \\ u_M = \Pi - f - \frac{1}{2}h \end{cases}$$

   Thus, M's payoff is higher with pre-emptive acquisition, strictly if $\eta > 0$.

2. If $f + s \leq h$, M cannot deter H's entry: therefore M cannot credibly threaten to enter if he has not exploited his first-mover advantage before bargaining begins.

   (a) If bargaining occurs before asset acquisition, the joint surplus is $U = \Pi - f$ and the outside options are respectively $o_H = \Pi - f - s$ and $o_M = 0$. Thus Nash-bargaining payoffs are

   $$\begin{cases} u_H = \Pi - f - \frac{1}{2}s \\ u_M = \frac{1}{2}s \end{cases}$$

(b) If bargaining occurs after asset acquisition, the joint surplus if Π and the outside options are respectively $o_H = h - f - s$ and $o_M = 0$. Thus payoffs, adjusted for the previously incurred sunk cost, are

$$\begin{cases} u_H = \frac{1}{2}(\Pi - f) + \frac{1}{2}h - \frac{1}{2}s \\ u_M = \frac{1}{2}(\Pi - f) - \frac{1}{2}h + \frac{1}{2}s \end{cases}$$

Thus, M's payoff is strictly higher with pre-emptive acquisition, regardless of η.

The model shows that in an imperfect appropriability regime, an inventor facing imitators with entrepreneurial skills superior to his own needs to acquire complementary physical assets before his innovation becomes known. Otherwise he may hardly be able to profit from it, or at a minimum he will earn a significantly smaller share of the profits.

Since either entrepreneurial skills or first-mover advantage are key to profitability, there is one important case where it is extremely difficult to capture profits from innovation given the possibility of expropriation. This is when H is both the inventor and the entrepreneur, but his innovation has been produced thanks to the R&D activities of a pre-existing firm, and thus formally belongs to his employer M.

If H enjoys the innovator's first-mover advantage, at the pre-emption stage he can acquire the complementary asset: he will then purchase his own idea from M at a price $\frac{1}{2}s$, and leave to set up his own firm. This is consistent with evidence of employees quitting to exploit new discoveries before the employer can do so himself: perhaps most famously in the case of Fairchild and Intel.

To profit from innovation when his employee H combines the roles of inventor and entrepreneur, M needs to own the complementary assets before the innovation is even obtained. It follows that an established firm needs to focus its R&D activity towards inventions that will be complementary to its pre-existing assets. The theory thus implies that "intrapreneurship" should mostly occur within large firms, who are more likely to control the relevant specialized assets: a prediction that conforms with Teece's (1986) analysis.

Furthermore, the model can be seen as a formalization of the two main strands of the Schumpeterian theory of innovation. In his earlier works, Schumpeter (1934) focuses on the independent individual entrepreneur, financed by credit rather than a claim on his invention, as the creative agent of economic change. In his later writings, Schumpeter (1949) considers the individual entrepreneur as an employee of a large-scale corporation that includes an "entrepreneurial function". These correspond to the cases of H as the original owner of the innovation, and M as the original owner of both innovation and the relvant physical assets.