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CREATING A "MARKET FOR INVENTIONS": A REFEREE MODEL.*

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Abstract

This article considers that the flow of new not patented innovations is difficult to occur among firms, especially when some inventions are caused by serendipity. Here I develop a model to analyze the conditions for a "market for inventions" to exist.

With the help of game theory in particular, I show that the creation of such a market is quite unlikely because unfair buyer's behaviour and the possibility of expropriation of the new innovation renders the seller reluctant to negotiate with a potential buyer. So I argue for a solution that involves a third referenced party into the negotiation so that it can guarantee the flow of ideas among institutions and generate a surplus for the whole society.

Keywords: Errors, Ideas, Innovation, Invention, Knowledge, Technology Transfer.
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1. Introduction

As is well known, innovation processes often bear characteristics that favour market failure. In particular, once the innovation is widespread, its application cannot be excluded. Such a peculiarity is even sharper when serendipitous inventions are considered. Such circumstances illustrate the importance of dealing with this issue, and the purpose of this work is to derive the conditions according to which a "market for errors" can exist. A bargaining model involving two firms and its evolution will be discussed. In this framework I will not deal with final goods but with, something not complete enough to be patentable. In this paper I have used a broad definition of technology drawn from Arora Fosfuri Gambardella (2001) who stated that technology can take the form of intellectual property, or intangibles, be embodied in a product or take the form of technical services. Technology is an imprecise term for "useful knowledge" rooted in engineering, scientific disciplines, but also drawing from practical experience of production.

A two-period bargaining model with and without uncertainty about the "type" of buyer will be presented[1]. Many models (e.g., Anton & Yao 1994) in the literature consider buyers the "weakest" link in this kind of negotiation since they suffer from asymmetric information. Here the approach is different because it is the seller who has to disclose a new invention is considered to be weak and who may not have a well-known reputation. Consequently the "Market for Inventions" will exist only after the seller makes such a decision. Such choice will depend not only on the buyer having fair or unfair behaviour (Grimaldi 2008), but also on the presence of some structures that can guarantee the transfer of the new innovation from one firm to another one. The work is divided as follows: Section 2 deals with the possible expropriation of non-patented inventions. Section 3 tackles the topic of innovation and R&D activities within a firm. Section 4 deals with the construction of strategic negotiations between sellers and buyers and tries to derive the conditions according to which a "market for new inventions" can exist. In section 5 the use of a sanction will be discussed, while, at the end in section 6 the presence of a third independent party will be included in the model.

2. Expropriation and Inventions

In recent studies, knowledge has been classified as a key resource for a firm and is included in the larger set of intangible resources. Hall (1993) has defined intangible resources of a firm as reputation, employee know-how, culture, and databases. Each of these, according to Hall, constitutes a vital part of a firm's business strategy. Only the development and protection of such assets can create a competitive advantage for the firm itself. In his work, Hall (1992) particularly stresses the importance of skills like employee know-how and culture. With the former he means intangible resources that result in distinctive competences, which are capabilities that the organization possesses and that set it apart from its competitors. By culture Hall means the beliefs, knowledge, attitudes of mind, and customs to which individuals in an organization are exposed, and by which they acquire a language, values, and habits of behaviour and thought. The culture of an organization both sets it apart from others and binds its members together.

Knowledge is seen as the source of Ricardian rents. Ricardo (1926) used the example of "good land" as a rent-bearing resource. Good land produces more per acre than poor land, so its unit costs of agricultural production are lower. In modern economies, this idea can be applied to knowledge. As noted by Liebeskind (1996), superior knowledge enables firms to build a better piece of machinery, train its workers more effectively, or devise a more productive work organization. Similarly, a firm with superior product design knowledge can produce a unique product and earn monopoly rents. In this sense the concept of Ricardian rents can be understood. Of course, there are other sources of Ricardian rents, such as luck and chance, but unfortunately they cannot be managed. However, the fact that rents derive from the knowledge of a firm means that knowledge must be protected. For many types of assets, exclusion is a relatively easy task. Many assets can de defined according to property laws, unambiguously asserting ownership. Think of buildings, land, and equipment; all are considered property under the law. These assets can be protected by social institutions that enforce property ownership (i.e., courts), and sometimes protection can be enforced by private tools. Land can be fenced, machinery can be locked, and so on. But an aspect that renders tangible goods more protectable than intangible ones is that they are clearly observable and have finite productive capacity; expropriation can be easily detected. These different features have been considered by the US department of justice (1995) which distinguished between market for goods, market for technologies and market for innovations. Market for technologies are markets for intellectual property that is licensed. Markets for innovation include arrangements in which the parties involved agree to conduct activities, jointly or independently leading for future developments of technologies that will be exchanged among them. This is typically the market for contract R&D and technological joint ventures and collaborations.

[1] However there is also a wide body of literature on externalities of R&D and Unintended technology transfer, see d'Aspremont C., and A. Jacquemin (1988), Kamien, M.I., E. Muller and I. Zang (1992), but the aim of this paper is to focus on intended transfer of technology between firms.

Roughly speaking the distinction between the market for technology and the market for innovation corresponds to the distinction between transactions for the use and diffusion of technology on one hand and transaction for the creation of new technology on the other.

Protection of knowledge underling new innovations, if not yet patented, is difficult. Property rights, patents, copyrights, trade secrets are narrowly defined under the law and costly to write and enforce (Cooter & Ulen 1988). New innovations are difficult to protect because it is difficult to perceive its expropriation or illegal imitation. Thus illegal use of new innovations can be costly and difficult to detect. Moreover, sometimes it is impossible or economically unfeasible to patent something because the costs to bring a certain product to the market could be higher than those of competitors. Development of an innovation can be costly if a firm lacks the right tools, equipment, and trained people to manage it. Sometimes an innovation can be better exploited in a different sector in which there are entry barriers. If a firm has the necessary know-how, it can try to develop a new invention by itself; if not, a faster way to realize some profits is to sell the new invention or "error" to a firm better equipped to develop and realize the product. This may involve an outright sale of the invention.

Companied often develop innovations that they do not commercialize, in many cases, there could be other companies that could profitably use these innovations. Often there are strategic reasons, but sometimes they do not sell the technology to the other company because Technology contracts are thought to be inefficient and returns for licensing are inadequate to offset the costs (Arora et al 2001). As suggested by Anton and Yao (1994), when an inventor can rely on patents or other forms of property rights to protect intellectual property, theory suggests that the inventor can appropriate a substantial fraction of the invention's value. If property rights are weak or non-existent, the inventor's ability to capture rents could be lower. Of course, the presence of instruments to protect products of R&D activities can help firms undertake costly research, but the protection of a new non patented invention is much more difficult. The issue of appropriability and expropriation is a central topic here. In the next section we will see that the possibility of expropriation makes the "market for new inventions" quite unlikely to open.

3. Innovation, Errors and Bargaining.

Innovators who generate a new innovation or idea face a strategic choice about how to bring the product to the consumer. Developing a product from scratch allows the innovator to enter the product market and compete directly with more established players. Alternatively, strategic cooperation with more established players – whether through licensing, alliance, partnership, or even outright acquisition – allows the innovation to be directly integrated into an already functioning sector, but it eliminates the possibility of competing directly in the product market and displacing established products with the innovation. Pursuing both strategies simultaneously is difficult. Not only do most firms lack the resources for a dual strategy, but some key elements of cooperation (e.g., open disclosure with established firms) are key hazards (e.g., disclosure allows established firms to imitate the competitive value proposition more quickly). Commercialization strategy is thus one of the most crucial decisions a firm makes in terms of its ability to profit from innovations developed from within[2].

As noted by Jolly (1997) technology is essentially a "capability" that can be used in more than one product. Products are occasional embodiments of this capability. In both cases it is important to make profits, but the different cases influence the concept of commercialization. For products, it can be the process of taking a design through development, manufacturing and marketing. For innovations, value realization encompasses a broad range of things, including all stages of commercial development, application and transfer, the focusing of ideas or inventions on specific objects, downstream transfer of R&D results, and so on. As such, the process begins before products are even conceived and stretches out to after they have been developed and launched.

Effective commercialization strategy results from careful analysis of the commercialization environment, weighing the benefits and costs of alternative strategies for securing profits, and competitive advantage through innovation. For most start-up innovators, the commercialization environment has two crucial elements for choosing a strategy. First, the firm evaluates the relative cost and profitability of pioneering a new product compared to leveraging an established product. Second, the innovator assesses the ability to control the fundamental knowledge after the established firm becomes aware of the new technology. Together, these factors determine the potential for advantage under a cooperative or competitive strategy, shaping optimal commercialization strategy.

The inventor should thus take care of acquiring and accessing the manufacturing, distribution, and technology capabilities necessary to deliver value from the innovation to customers.

[2] In this case, the term commercialization is a broad one that can be used when thinking both about innovations and commodities sold in different markets.

There are five subprocesses in commercialization of innovations: (1) imagination (when a technical breakthrough gets combined with a potential profitable and attractive market opportunity); (2) incubation (when the idea is proved both technologically and in terms of the needs it is projected to fulfil); (3) demonstration (when the product is developed); (4) promotion (persuading people to adopt the innovation and relating to the infrastructure that has to be built in order to deliver the innovation's benefits); (5) sustaining (the value can be realized only if it enjoys a long presence on the market and a fair share of long term value is appropriated by the innovation/technology initiator. (Vijay 1997)

Another crucial aspect to the commercialization environment facing a start-up innovator is the degree of appropriability, the ability to control the knowledge underlying an innovation after more established firms recognize its potential impact on the market. Pavitt (1984) faced the issue of appropriability analyzing sectoral patterns of technical change and discovering different degrees of appropriability and of innovation in different sectors. In the absence of effective intellectual property protection, start-up innovators face potential expropriation by market leaders. Established firms may imitate the new innovation without sharing their profits with the initial innovator. When expropriation is possible, negotiations to pursue cooperation by the start-up are particularly hazardous. Reaching an agreement usually requires detailed disclosure of technical information. This knowledge helps the established firm develop its own version of the new innovation (Gans J.S., Stern S. 2002). Rubinstein (1982) referred to the bargaining problem as the situation in which "two individuals have before them several possible contractual agreements. Both have interests in reaching agreement, but their interests are not entirely identical". Arora, Fosfuri and Gambardella (2001) considered a model in which opportunistic behaviour takes place on both sides. They showed that a simple contract, where know-how is bundled with codified technology (protected by patents), can successfully achieve the transfer of know-how. Aghion and Tirole (1994) analyzed the control rights in an alliance between a R&D firm and a customer firm when developing a new product. They allow, in their model, the R&D firm to be financed not by a third party, say a venture capitalist, but directly by another firm which may intend to use the product or to resell it to others, but cannot make the discovery independently. In their paper, the point is to set up a contract between the two parties. The authors underlined that while the ownership of the product can be specified in an enforceable contract, and the resources provided by the customer firm may be so specified, the uncertain nature of the innovation precludes writing a contract for the delivery of a specific innovation.

The present work considers something that is not yet patented and hence easily expropriated once known. The conditions for creating a market for "errors" made during a research process will be faced. The initial idea is that a certain firm is undertaking R&D activity for its own purposes, but at a certain point discovers something it is not able to exploit directly because it needs further development in a field the firm is not interested in. As a consequence the firm considers the possibility of selling the unpatented invention to another firm that could use it commercially.

For the sake of precision, I will try to describe the whole process the firm faces after it decides to undertake R&D activities. In particular if a firm (F_1) decides to start an R&D process, it faces certain costs (R&D expenses) and an uncertain outcome; consequently it has to maximize its expected profits according to these considerations.

Assumption 1: If F_1 has already decided on the optimal quantity of resources devoted to R&D expenses, it has the following expected profit:

$$\pi^e_{f1} = v(e)\,[p^e_p - rz - m - RD_1] + (1-(1-v(e))\,[-m - RD_1] \qquad [1]$$

where:

πe_{f1} are the expected profits arising from the new product;
$v(e)$ is the probability the firm discovers something commercially valuable;
$(1-v(e))$ is the probability it discovers nothing;
p^e_p is the expected price it is going to sell the new product;
r is the royalty rate guaranteed to the researcher in order to maximize his effort;
z is the quantity of the new output sold;
m is the fee paid to the researcher;
RD_1 are R&D activity expenses, including running the laboratory and adapting it to a new research;

As can be noted in equation [1], there are no costs other than R&D expenses. Production costs are assumed to be the same if F_1 does or does not do research. Here profits and extra costs arising from a research activity are taken into account.

F_1 considers two states of the world: the first in which it discovers something valuable and the second in which it fails to do so. What the firm is not considering is the possibility of discovering something inconsistent with the research program but having value anyway in the "market of errors".

Suppose the firm finds something that cannot be patented because it needs further development, and hence commercialization, by the firm buying it. This paper focuses only on this specific case. This issue is thought to be a crucial one, since his-

torically many inventions have been made by chance and others are scrapped by firms when they are not commercially valuable. The issue is thus to understand if a market for errors exists and if firms have incentive to negotiate in this market. In fact, once F_1 has something valuable to sell, the problem is that it must be sold as soon as possible because a new invention assures market power to buyer. Hence they must transact secretly, without making the new invention public at all. A strategic behaviour can arise between the two firms since the owner of the invention does not want to give away, but wants a part of Firm 2's (F_2) surplus, and the buyer does not want to spend too much because the invention needs further development Moreover the two firms face another problem that is summarized in the so called Arrow paradox (1962). The firm selling the invention must on one hand fascinate the buyer, while on the other hand not disclose too much because the buyer may lose interest or steal the invention if relevant information has been revealed. In this article, I consider the case of product innovation, assuming that a firm discovers something it is not interested in and which can be better exploited by another firm in another market.

In this situation, another relevant issue usually is represented by the optimal contract between the researcher and the firm. An assumption is that the researcher is paid a fixed fee and a royalty; his additional effort thus depends on the rate of the latter, since a higher royalty creates a higher incentive to work. Controls are very difficult in this case.

Assumption 2: The possibility of a secret negotiation with F2 for the transfer of the invention is not contemplated, since the researcher wants to finish the research and gain the royalty; he is thus considered a faithful employee whose effort can be represented as:

$$e_r\ (r\cdot, m) \qquad [2]$$

Last, F_2 has the same profit function as F_1, but with one more assumption. F_2 will (or will not) buy the by-product of the research process of F_1, which is unable to exploit it by itself.

Assumption 3: If F_2 buys the new invention, it will be able to develop a commercially successful product[3] .

F_2's expected profits are dependent on the price charged by F_1. In the case it does not purchase the innovation, nothing happens. Its expected profit equation, which resembles equation [1], must be modified, taking into account the fact that F_2 will produce something commercially valuable with further R&D costs.

$$\pi^e_{f1} = [p_p x - rx - m - RD_2] \qquad [3]$$

where the symbols have the meaning illustrated above and x is the quantity of new output sold once the invention has been bought from F_1.

Here, profits depend on the effort, which depends on the royalty guaranteed to the researcher and the expenses of developing the new innovation.

From equation [3], the price paid to F_1 for the invention must be subtracted.

$$\pi^e_{f1} = [p_p x - rx - m - RD_2] - p_{R\&D1} \qquad [4]$$

where $p_{R\&D1}$ is the price paid to F_1. Assuming that the optimal contract set up for the researcher works, if F_1 makes an error and discovers something unpatentable and useless for itself, equation [1] can be changed as follows:

$$\pi^e_{f1} = \alpha\,(-m - RD_1) \qquad [5]$$

The price charged by F1 to F2 will be at least:

$$p_{R\&D1} \geq \alpha\,(m + RD_1) \qquad [6]$$

This represents the minimum price at which F_1 wants to sell the invention, and α is a portion of the total R&D expenses. In particular if $\alpha=1$, it means that all the expenses for R&D have been put on the discovery of such an invention. However, here $\alpha<1$ since it is supposed that the discovery has been made by chance and thus only a portion of the total costs will be recovered.

If the researcher suggests selling it to F_2, an unexpected state of the world occurs and equation [5] can be modified as follows:

$$\pi^e_{f1} = \alpha\,(-m - RD_1) + p_{R\&D1}$$

Profits of F_2 will be the same as equation [4]. Of course F_2 will have an incentive for buying the invention if and only if:

$$p_p > (r\,x + m + RD_2 + p_{R\&D1}) \qquad [7]$$

If equation [7] is satisfied the market for errors will open.

[3] This is a quite strong assumption, however, it could be more realistic by introducing a probability for considering uncertainty for commercialization of the new technology and/or the concept of absorptive capacity, however it will just affect the ultimate value of γ and it will complicate the calculations without adding useful information to the model.

4. A strategic model of behaviour

My approach resembles that of Fundenberg and Tirole (1983), although some simplifications have been added. In their article they analyzed the simplest model of non-cooperative bargaining that captures both facts that bargaining involves a succession of steps and bargainers typically do not know the value to others of reaching an agreement.

This is a kind of selection game (see Nie 2007) in which there are two different strategies. Selection games have been traditionally used in the biology field, but have been extended to economics as well. Selection games can be used to analyze the behaviour of a firm that wants to enter a market and a firm that is already in it. The strategic behaviour of the firms will determine the outcome and consequently equilibrium of the game. Another important contribution in the analysis of strategic behaviours has been made by Sanna-Randaccio and Veugelers (2007). They analyzed spillover effects in the case that a parent firm wants to transfer know-how to a subsidiary firm granting or not granting an active role in innovation. If the subsidiary has a central role in innovation, leakages are possible and competitors might benefit. In this kind of game, whether or not the firm decides to decentralize, a certain activity is considered and the conditions according to which it is worthy have been derived.

However, the game I am going to consider in this section is not a "normal" bargaining case. The firms cannot negotiate continuously because the specific nature of the "good" does not make negotiation interesting for either firm. The longer they contract, the greater the danger of leaks. Leaks are to be avoided because they cause F_1's invention to lose appeal and F_2 to lose monopoly rents to competitors. It is realistic to think of this as a one-shot game, even if other cases will be analyzed.

F_1 can ask for a high price or for a low price, F_2 can buy at a high price or a low price, or either can exit the transaction.

Description of the Game:

The game is made up of two players who do not move simultaneously. F_1 starts and once it has made its move, F_2 makes its decision. So sequential representation is better that a strategic one.

F_1 has two possibilities: sell the invention at a high price (pR&D1H) or a low price (pR&D1L). The choice depends on the kind of buyer F_1 faces. If F_2 has a high willingness-to-pay (WTP), F1 can charge a high price; if it has a low WTP, F_1 must lower the price[4].

If F_1 sells at a high price, its revenue will be:

$$p_{R\&D1H} - \alpha(m+RD_1)=a \text{ with } p_{R\&D1H} > \alpha(m+RD_1); \quad [8]$$

If it sells at a low price:

$$p_{R\&D1L} - \alpha(m+RD_1)=b \text{ with } p_{R\&D1L} > \alpha(m+RD_1); \quad [9]$$

consequently $a>b>0$ [10]

being $p_{R\&D1H} > p_{R\&D1L}$

Of course if F_1 sells but F_2 does not buy, F_1 could still gain from the trade, assuming that it can sell the invention to someone else.

Once F_1 has decided on the price, F_2 decides to buy or not, and this decision affects its total revenue and thus net profits.

If F_2 buys at a *low* price, given that the development of the invention will certainly be a commercial success, it will have a revenue equal to:

$$\pi_{f2} = px - (r\,x + m + RD_2 + p_{R\&D1}) = d \quad [11]$$

But if F_2 buys at a high price, it will again have positive profits but much lower than the previous case since $p_{R\&D1}$ will be higher than before:

$$\pi_{f2} = px - (r\,x + m + RD_2 + p_{R\&D1H}) = e \quad [12]$$

Finally if F_2 does not buy at all, its incremental profits will be a constant equal to 0:

with $d>e>0$. [13]

Two cases will be analysed, the first in which F_2 has fair behaviour and the negotiation proceeds correctly, the second in which the buyer may assume an opportunistic behaviour. F_1 is assumed to be risk neutral.

This is a typical bargaining approach, widely used in the literature. In particular the game deals with symmetric and complete information.

The game can be detailed in the following way.

[4] This means that the game is played more than once.

Game 1

Players:
There are two players: F_1 wants to sell the invention and F_2 wants to buy it.
F_2 is supposed to be fair.

Information:
Symmetric and Complete.

Actions:
F_1 sets a price p1; F_2 can accept or refuse.
If F_2 does not accept, F_1 can offer a lower price p_2, and again F_2 can accept or not;

Payoffs:

$$\Pi_{f1} = \begin{cases} a \text{ if a high price (p1) is accepted;} \\ b \text{ if a low price (p2) is accepted;} \\ 0 \text{ if none of the two prices is accepted;} \end{cases}$$

$$\Pi_{f2} = \begin{cases} e \text{ if an high price (p1) is accepted;} \\ d \text{ if a low price (p2) is accepted;} \\ 0 \text{ if none of the two prices is accepted;} \end{cases}$$

where $a>b>0$ and $d>e>0$.

Note that a discount rate has not been chosen, since it is assumed that the bargaining occurs over a very short time period.

In this particular game, F_1 will always set a high price[5], but F_2 will not accept it. F_1 will lower the price and firms will gain b and d. However, the two strategies are equivalent, since they lead to the same outcome.

Up to this moment, F_2's fair behaviour has been assumed. Now a complication of the model is included; opportunistic behaviour on the part of F_2 becomes possible. The model can thus be changed:

Game 2

Players:
There are 2 players: F_1 wants to sell the invention and F_2 wants to buy it.

Information:
Asymmetric and incomplete.

Actions:
(0) Nature determines if F_2 is opportunistic with probability $(1-\gamma)$, or fair with probability (γ)
If F_2 is fair:
(1) F_1 sets price p1; F_2 can accept or refuse (in this case refusal does not lead to the commercial use of the invention on the part of F_2)

[5] Since F_1 does not know the WTP of F_2 and so it will always try to set an high price, knowing that in the second period it has the opportunity of lowering the price.

(2) If F_2 does not accept, F_1 offers the lower price p_2; F_2 can accept or refuse.
If F_2 is unfair:
(1) F_1 sets price
(2) F_2 will not accept any price, since it will steal the invention anyway.

Payoffs (fair behaviour):

$$\Pi_{f1} = \begin{cases} a \text{ if a high price } (p_1) \text{ is accepted;} \\ b \text{ if a low price } (p_2) \text{ is accepted;} \\ 0 \text{ if none of the two prices is accepted;} \end{cases}$$

$$\Pi_{f2} = \begin{cases} e \text{ if an high price } (p_1) \text{ is accepted;} \\ d \text{ if a low price } (p_2) \text{ is accepted;} \\ 0 \text{ if none of the two prices is accepted;} \end{cases}$$

where $a>b>0$ and $d>e>0$.
If F2 is opportunistic:
F_1 sets price p1; F_2 could accept or refuse, but here we assume that F_2 will not bargain and whatever the price asked by F_1, F_2 will steal the invention and cause a loss to F_1.

Payoffs (unfair behaviour):

$$\Pi_{f1} = \begin{cases} a \text{ if high price } (p_1) \text{ is accepted;} \\ c \text{ if the loss of the opportunistic behaviour;} \\ b \text{ if low price } (p_2) \text{ is accepted;} \end{cases}$$

$$\Pi_{f2} = \begin{cases} z \text{ if a price is accepted;} \\ h \text{ if both prices are rejected and the invention is stolen;} \end{cases}$$

Now the nature of the new payoffs involved in the game must be explained. In particular if F_2 has opportunistic behaviour it means that it will incur a loss by buying the invention, since it is not in its nature to do so. So the payoff z is a negative one, showing this particular attitude of F_2[6]. On the other side, given equation [6], if F_2 does not pay any price to F_1, it will have the highest profits and h indicates this possibility. Finally if F_2 steals the invention, F_1 will not be able to sell it to someone else. In this case its costs become sunk and it faces a loss equal to:

$$c = -\alpha(m+RD_1) \qquad [14]$$

So for F_2 $h>d>e>0>z$

[6] Developing an opportunistic behaviour may require investing resource, so not pursuing an opportunistic behaviour may cause a loss to the unfair firm.

Intuitively, possible equilibria are represented by (*d;b)* and (*h;c*), and even in this case that the two strategies are equivalent[7]. In the first case (fair behaviour) it will lower the price having (*d;b*); in the second case, whatever price it asks, it will always be fooled by F_2 who will steal the invention. Given the incomplete information of F_1 (it does not know if it is dealing with a fair or an unfair firm), before it starts negotiating F_1 has the following expected profits:

$$\pi_{f1} = \gamma\,(b) + (1 - \gamma)(c) \qquad [15]$$

F_1 will start the negotiation if its expected profits are higher than 0:

$$\gamma b + (1 - \gamma)(c) \geq 0;$$

$$\gamma(b - c) \geq -c; \qquad [16]$$

$$\gamma = \frac{c}{(b - c)}$$

Remembering equation [14], we know that c has a negative value and so both parts of the fraction are greater than 0.

For profits to be positive, $\gamma > \frac{c}{(b - c)}$ which is a positive number. This leads to the main proposition of this paper:

If γ is not as high as required, the "market of errors" will never open.

There will not be a flow of ideas across firms, reducing the possibility of inventing new goods which could be useful for the whole society; this is of course an instance of market failure.

The model could be complicated by adding a discount rate for the negotiation in the two periods, but nothing changes since the expected profits will always depend on the value of γ. If F_1 is risk averse, the value of γ increases, reducing a possible creation of the "market for errors". [8]

Concluding this section, it cannot be said that reducing the patentability threshold could be a possible solution to assigning property rights of a certain product. In fact, as has been noted by Pamolli and Rossi (2005), a low patentability threshold may lead just to an increase in transaction costs (especially litigation and negotiation costs) without an increase in incentive to innovate. Public policy intervention should thus care about the conditions according to which this market could exist. I argue that bargaining in the market for inventions cannot occur directly with buyer and seller, but should happen through a third party, a sort of referee. A referee can represent a kind of guarantee for both seller and buyer, given that the third party does not suffer from asymmetric information from either side. This new institution knows not only the project the $F_1$is trying to sell, but also the projects F_2 is working on. The referee can thus guarantee the seller against expropriation since it knows the real ownership of the invention and be a kind of "witness". The buyer, on the other side, knows the invention comes from a certified subject. In this way, the value of γ can be as high as required, because unfair firms will not bargain at all and the market for inventions will open. Hence the implementation of such a structure (a Technology Transfer Office, for example) may help the creation of further surplus.

5. The use of a sanction.

In the past section it has been shown that "Market for Errors" will have very small possibilities to exist thus creating a market failure. It is straightforward that such a failure will reduce the flow of ideas across firms, lowering social welfare. The threat of a high sanction can, at least theoretically, make this negotiation feasible, but practically, as it will be seen in the next lines its application is quite difficult.

As it has been seen in the foregoing lines, a sanction can be applied to the unfair firm if it steals the new innovation. Remembering the profit function of F_2 it can be modified as follows:

$$\pi_{f2} = px - rx - m - RD_2 - s; \qquad [17]$$

Where s is the sanction and it must be high enough such that profits become negative, algebraically it means that:

$$s > px - rx - m - RD_2$$

Game no. 1 can be now modified by taking into account this new result. In fact, the sanction modifies both the profits of F_1 and F_2 F_2 is compelled to behave fairly and F_1can have the same profits as in the case of fair behaviour and so when this modi-

7 I mean that whatever price F_1 asks F_2, the latter will always steal the idea if unfair or buy the idea if fair. So the end of the game is always the same with respect to the nature of the buyer.

8 The higher value of γ can be computed using a Von Newman-Morgenstern utility function ($U = m - \frac{p}{\pi^e}$), showing that a risk-averse firm has a greater γ that a risk-neutral one;

fication is taken into account, the negotiation will take place.

The equilibrium outcome is unique and it implies a fair behaviour of F_2 and a selling from F_1 gaining profits (*d;b*). This outcome derives from the fact that, with a sufficiently high sanction, unfair behaviours will be avoided. In this case the seller knows that γ=1 this means that only fair players will negotiate and that the seller knows that it is on the upper part of the game (fair). This circumstance combined with the certainty of the application of the sanction, pushes the seller to start the negotiation.

However this result is difficult to occur since our assumptions rely upon the fact that the sanction will be applied with certainty. In fact, as it has been written in the lines above, the certainty of the sanction is not very plausible, and as mentioned by Cooter and Ulen (1988), courts are very reluctant in enforcing such penalties. This derives from the fact that contracts reflecting asymmetric information are not perfect one. They defined a perfect contract as "a promise that, if enforceable, is ideally suited to achieving the ends of the promisor and the "promise". In a "complete contingent contract", every possible contingency would be foreseen and regulated by the parties. In this ideal world of perfect information and competition, opportunism would wane, given the existence of reputational effects (since information is costless) and the possibility of private sanctions.

Hence the solution of a complete contract that involves the threat of a sanction is not always applicable, so the aim of the next section is to suggest a model that tries to solve this problem form both buyer's and seller's perspective.

6. The "Referee" model.

The past section has shown that the use of a sanction is not always possible for curbing opportunistic behaviour of unfair firms. However, as it has been discussed, the limit of the foregoing models lies in the applicability of such a sanction; here I am considering new and not patented inventions, consequently, a firm may have many difficulties to prove in a proceedings what belongs to whom. In fact, commercialization of "new inventions" is a dual problem; on one side it represents a problem for the seller (as already analyzed above), but it is also a problem for buyer's perspective; in fact, many authors have pointed out that the buyer faces an adverse selection problem given that it does not know the "goodness" of the invention it is going to buy.

A better solution, other than the sanction, should include both the buyer's and the seller's perspective in order to achieve more efficient results. A possible way out can be the insert of a third subject, that here is called referee and that in practice can be represented by a "Technology Transfer Office".

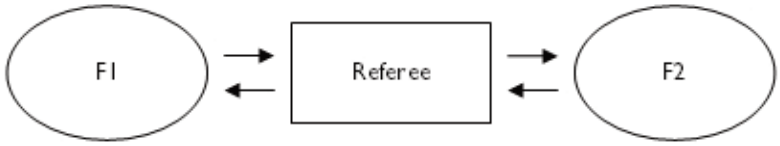

Figure 1

The structure works in the following way: F_1can ask the referee, to save and catalogue a certain invention that by chance has been discovered[9], F_1 does not want to develop on its own. The referee that, by definition, must be secret, honourable (as its employees, in order to avoid possible leakage), can start looking for a firm which can be interested in buying the new innovation.

Once a firm is found, the Referee can ask it to "confess" its R&D activity, in order to not get fooled. When the Referee is aware that the invention can be useful and it is not yet developed by the firm, then it can make the proposal for a negotiation between the referee itself and F_2.

Since the referee knows the cost of "production" of F_1 and even the cost's structure of F_2, it can set a "fair" price for both the firms. In any case if the price asked is too high for F_2 the referee can ask F_2 to lower it in order to sell the invention.

In principle, nothing prevents F_2 from stealing the invention, but this time, the referee which is a public company, is in the position of threatening the application of a sanction being a kind of "witness", and proving the ownership of the invention. So the sanction will be applied for sure.

The payoffs of both firms will be the same as in the case of fair behaviour, consequently not only a market for new inventions will be created, but also a higher surplus will be produced.

Transaction costs and those required for running the public

[9] However F_1 can disclose to the referee every ideas it has discovered and that it wants to sell.

company are not considered, because the assumption it that a higher social welfare will offset the costs just mentioned. So the only possible and economically feasible equilibrium is again (*d;b*), and again it is efficient for F_2 to behave fairly, because it will not gain anything from an opportunistic behaviour.

The conclusion of the bargaining is the logical consequence of the signalling effect of the Referee with respect to both firms, allowing them to be certain of the compliance of obligations and of the goodness of the "product" bought and the behaviour adopted.

7. Conclusion

This work started with the recognition that intellectual properties have different features than tangible goods. Their characteristics can hinder the creation of a specific market for their transmission and circulation. This is not acceptable from a social point of view, because a surplus that could have been produced will not be created at all. The conditions for a "market for inventions" to exist have been derived, considering the roles of both seller and buyer. The seller fears a possible expropriation of its own discovery, since it is aware that once the invention is known, a buyer will have little incentive to pay for it.

The introduction of a sanction renders the market for inventions quite likely to open, at least theoretically. However, such a threat is not always enforceable. What seems more appropriate is that the transactions between two firms involved in an innovation process occur through the help of a third party, a kind of referee. This is a signalling case that sorts out all the problems outlined above and helps in negotiating. The presence of a referee, as already underlined in the previous section guarantees both the seller and the buyer being a solution for the creation of the Market for inventions. Hence I argue for a solution in which a neutral public firm directs the negotiations and the commercialization of new not patented innovations.

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