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Technology and intellectual property: a taxonomy of contemporary markets for knowledge and their implications for development

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Technology and intellectual property: a taxonomy of contemporary markets for knowledge and their implications for development

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Abstract

This paper aims to contribute to frame the IP for development debate into a more extensive discussion on appropriability, within the perspective of policies shaping scientific, technological and production capabilities in the light of development theory. Through the lenses of the paradigm based theory of innovation, the authors first recognize that technological asymmetries and gaps between firms and countries appear more as sticky features than as transitory stages of (automatic) adjustment processes, thus reassessing the appropriability ad disclosure function of patents. Then, the paper presents a taxonomy of contemporary markets for knowledge, flagging the existence of what we call *derivative markets for knowledge*. Patents become to a certain extent liquid because they loose the weight and the density of the technological component and they can easily circulate in the market without having necessarily to be entangled in any final artifact. Just as in derivative financial markets, the value of patents is a function of expectations regarding their uncertain potential future value. The paper concludes sketching the implications for development focusing on two major issues: i) how reassessing the role of IP through an evolutionary perspective affects behavioral microfoundations of innovative conducts and ii) how asymmetries in technological and production capacities between countries mould patenting behavior and participation and exclusion in the contemporary markets for knowledge.

Keywords: intellectual property rights, patents, appropriability, markets for knowledge, developing countries

JEL Classification: O10; O31: O34

Introduction

A general property, by now widely acknowledge by economists of different streams, is that the emergence of new products and processes is unequivocally related to development. However, the inquiry of what indeed shapes the generation of innovation is still an open debate. In this discussion, the emergence of new technological paradigms –mainly ICTs, biotech and nanotech-, the re-shaping of world IP systems, and the recent explosion in patenting activity, lead much of contemporary attention of scholars, policy makers and civil society to focus on the relationship between development and intellectual property.

Our point is that any satisfactory attempt to analyze the role of IPRs in influencing the rate of generation, adoption and diffusion of innovative knowledge should start by recognizing

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"what is technology". Technology cannot be reduced to the standard view of a set of well-defined blueprints. Rather, any definition should encompass the means, the methods, the know-how, and the problem-solving activities through which agents "do things". This helps to explain why firms do not always adopt frontier technologies, i.e. it is far more complicated that replicating blueprints. It is precisely because knowledge is partly tacit and embodied in complex organizational practices, that technological lags and leads within and between firms, industries and even countries may well be persistent beyond the boundaries established by legal appropriation mechanisms, like intellectual property rights. Asymmetries in technological capacities (between firms and countries) are likely to persist over rather long spans of time, beyond the legal mechanisms defying the appropriability and transferability conditions of technologies. Moreover, the emergence of new technological paradigms and the re-shaping of world intellectual property systems concur to engender a shift in prevailing patenting behavior of firms. In contemporary markets for knowledge patents -beyond shaping to varying degrees innovative and imitative conduct of agents- are converted in peculiar strategic assets whose relevance is increasingly disentangled from the subjacent technology. Patenting behavior is more and more dependent on non-rational expectations regarding possible future technological settings, thus inducing firms to carry out strategic and defensive patenting.

In this paper, we start by outlining the main properties of knowledge, technology and learning drawing from the main assumptions of the paradigm-based theory of innovation. We identify the sets of constraints that reshape their appropriability and transferability, and hence we revisit the economics of intellectual property, and especially of patents, through this paradigm-based perspective. Then, we suggest an interpretation of contemporary markets for knowledge, considering the role of new technological paradigms, the re-shaping of world IP systems and the speculative behavior of firms in the contemporary patent game. To conclude we identify three major issues of concern –behavioral micorfoundations of innovative conducts and the role of IP rights, asymmetries in countries' scientific, technological and production capacities and the participation or exclusion in contemporary markets for knowledge- and we draw implications for development. This paper, far from being an exhaustive survey, it is rather a road map for analyzing the role of intellectual property rights, i.e. of appropriability and transferability of knowledge- in molding innovative and imitative behavior of firms and to a broader extent of countries, in the light of development theory.

The properties of technology in a paradigm-based theory of innovation

Technology, as defined in standard economics textbooks, is identified with a set of blueprints –i.e. techniques- required or used to produce artifacts. The choice of production techniques rests mainly on relative prices, given that information regarding the existence of such alternative blueprints is assumed to be available -and equally decodifiable- by all agents. However, an appreciative glace to reality shows that this is hardly the case. Firms do not always adopt frontier technologies and asymmetries in technological capacities (between firms and countries) are likely to persist over long spans of time (Atkinson and Stiglitz, 1969; Freeman, 1982, 1994; Dosi, 1982; 1988; Nelson and Winter, 1982; Dosi, Pavitt and Soete, 1990; Cimoli, Dosi, Nelson and Stiglitz, 2006). So, why do firms –and countries- not always adopt the best available set of technologies? A simple, but true answer might be: "because they don't know how to do it".

The paradigm-based theory of innovation entails a vision of how novelty is generated, produced and diffused in any given socio-economic system, which derives from a set of specific properties of knowledge, technology and learning (Pavitt, 1987; Dosi et al. 1988; Cimoli and Dosi, 1995; Metcalfe, 1995).

In this framework knowledge is non-rival, but it is excludable. It encompasses tacit components and it is both codifiable and non-codifiable (Arrow, 1962; Polany, 1969) Hence knowledge transferability is segmented, depending on its nature. Assimilating knowledge to a sort of public good stresses its non rivalry and non excludability, meaning that once it is available in the system –for example after patent expiration- it can be freely "used" or referred to by different agents at the same time. However, the capabilities of agents affect the capacity to access and use knowledge, even more than its legal availability; i.e. knowledge can be assimilated to a club good (non-rival but excludable)- considering that only those who have certain capacities (positioning in network hierarchies, scientific base, production capacities, etc.) will be able to decode it and use it productively.

The definition of technology embodies the identification and the representation of the specific forms of knowledge on which any particular activity is based (Dosi, 1982; Pavitt, 1987). Technology cannot be reduced to the standard view of a set of well-defined blueprints. Rather, it can be defined as the means, the methods, and the know-how through which agents "do things". It concerns problem-solving activities involving- to varying degrees-also tacit forms of knowledge embodied in individuals and organizational procedures, the means and the interfaces through which knowledge is produced, codified or transformed in "transferable" artifacts (Rosenberg, 1976, 1982; Dosi, 1988; Freeman, 1982; 1994; Freeman and Soete, 1997). At the micro level, technologies are to a fair extent incorporated in particular institutions, the firms, whose capabilities, are fundamental in shaping the rates and directions of technological advance. Firms, however, are not the sole repositories of technologies. More ample socio-economic and institutional settings shape the availability of existing technologies within each paradigm (Nelson, 1993).

On its turn, learning is local, cumulative and embedded in organizations and their routines. Local means that the exploration and development of new techniques is likely to occur in the neighborhood of the techniques already in use (Atkinson and Stiglitz, 1969; Antonelli, 1995). Cumulative means that current technological development- at least at the level of individual business units- often builds upon past experiences of production and innovation, and it proceeds via sequences of specific problem-solving junctures (Arthur, 1989; David, 1985). The evolutionary path of technological learning is enhanceable through collective experiences and it is fostered or jeopardized by socio-economic frameworks. But at the same time, requires non-substitutable individual efforts and processes.

This synthetic overview of the properties of knowledge, technology and learning lead to recognize a set of constraints regarding their transferability (and hence the need for appropriability):

- The transferability of knowledge results segmented, according to its nature of public, private or club good, limited by its tacit and non-codifyable nature and enhanced by the proximity of capacities and capabilities of firms, systems and even countries. In a parallel way, the appropriability of knowledge overcomes the set of legal and strategic appropriability measures available to firms in any given socio-economic system. The tacit, non-codifyable and non-transferable component of knowledge embedded in procedures, routines and organizations guarantees its appropriability beyond any direct effort to protect it.

- Transferability of technologies is constrained or enhanced by "technological proximity" of producers and users, by their absorptive capacity, and by networks, partnerships, routines, etc. In such a paradigm-based view of innovation there is no guarantee of automatic substituibility between obsolete or less efficient technologies and improved ones. The choice of techniques is far from being an allocative choice between available sets of blueprints. Technology transfer, licensing are effective means of transferring technology but the effectiveness or the "demand" for this transfer is shaped by the specific characteristics and capacities of agents (firms, countries, etc.).

- The transferability of learning is limited and requires a sequence of adaptive trial and error processes that constitute the bases of learning itself. Transferability of learning in terms of expertise and reverse engineering is possible (through cooperation, interchange of personnel, etc.). However, it is constrained by structural capacities and capabilities of agents. Learning is to a great extent completely appropriable due to its inner nature of being a process embedded in organizations and routines.

Following these archetypal patterns, it is rather straightforward derived the persistency of some sort of non-substitution properties of technologies and techniques, both in the short-term and also in the long-term. *Technological asymmetries and gaps between firms and countries appear more as sticky features than as transitory stages of (automatic) adjustment processes.* Actually, there are components of technology that are of exclusive domain of the repository -like some forms of tacit or non-codified knowledge, cumulated learning effect, etc.- the appropriability of which dose not derive from specific efforts tailored to that (patents, trade marks, etc.), but from the fact that technology refers to certain bodies of knowledge that are embedded in organizations' procedures and routines.

The economics of intellectual property in a paradigm-based theory of innovation

The re-shaped vision regarding the transferability of knowledge, technology and learning, i.e. of the sources and procedures of innovation, leads to revisit the rationale for appropriability in the light of the forces that drive the direction of innovative and imitative search. Thus, the paradigm-based theory entails a discourse on intellectual property that differs from one of standard economics textbooks. Standard IP analysis is primary molded on the theory of choices of techniques: availability of information and relative prices determines firms' choices and intellectual property is defined -as opposed to physical property- stressing the non-rivalry of information and knowledge.

The rationale for protection derives from the need to introduce some discretional excludability in order to create incentives for agents to engage in efforts that would lead to the generation of "conceptual" and "intangible", i.e. intellectual, products, that otherwise would easily be appropriated by competitors. Intellectual property rights, and patents especially, respond, in principle, to the tension between the necessity of rewarding innovators, thus guaranteeing exclusive rights on intangibles, and favoring the diffusion of innovation, through disclosing technical knowledge and know-how embodied in innovations. In other words, IPRs try, in principle, to balance the interests of those who innovate and those who would benefit from innovation (se, among others, Machlup, 1958; Kitch, 1977; Besen y Raskind, 1991; Besen, 1998).

The economics of intellectual property under a paradigm-based theory of innovation rest on different assumptions, and hence perform different functions. The assumption that changes in relative prices and the availability of information primary affect the innovative behavior is not entirely consistent with our framework. Actually, according to us, the rate and direction of innovative search and imitation are shaped by a set of different factors such as (i) technological capabilities of agents, which rest on the knowledge and resources requested for the generation and management of technical change, (ii) production capacities, which concern the stocks of resources, the nature of capital-embodied technologies, labor skills, product and input specification and the organizational routines in use, (iii) the sectoral specificities of the technology in question, (iv) path-depended trajectories of firms (or countries), which shape the collective knowledge shared by agents in each socio-economic system and that define the *entourage* where firms (or countries) are likely to move in their search for innovation, (v) the (non-rational) perception of innovative opportunities, irrespectively of whether relative prices change or not, which might lead to the discovery of intended and unintended new techniques.

The paradigm-based story would predict that, even if all patent information would be feely available and disclosed, the direction of innovative search and the resulting firms' and countries' innovative and imitative trajectories would remain bounded within some relatively narrow paths determined by the nature of the underlying knowledge base, the technological principles it exploits, and the structural characteristics of systems in which every particular activity is embodied. There is no automatic, linear or deterministic relationship between innovative and imitative search and patent protection[1]. (David, 1993; Heller y Eisenberg, 1998; Mazzoleni y Nelson, 1998; Dosi et al. 2006; Eisenberg, 2006; Gosh and Soete. 2006).

It is precisely because knowledge is partly tacit and embodied in complex organizational practices, technological lags and leads within and between firms, industries and even countries may well be persistent beyond the boundaries established by legal appropriation mechanisms, like intellectual property rights[2]. The opposite also holds: if firms show similar technological capabilities, imitation might occur very quickly, patent protection notwithstanding, by means of "inventing around". Considering that technology is highly specific, that it is embedded in routines and procedures, that knowledge has a strong tacit component and that learning is a trial and error process which entail non-substitutable experiences, lead the controversy on blaming or blessing patents for their effect on innovative conducts in developing countries to loose most of its relevance. The paradigm-based theory of innovation, drives to include the intellectual property discourse within the more extensive debate on appropriability mechanisms of innovation efforts and to revisit the scope of the two primary standard functions of the patent system: the appropriability and the disclosure function.

[1] On the discussion regarding the appropriability of knowledge and its effect of the rate and direction of technical change see Plant 1934, Kitch, 1977, Machlup y Pensrose, 1950; Arrow, 1962; Scherer, 1977, and for a critical review of recent stances see Dosi et al. 2006.

[2]For the sake of simplicity (and considering the evergreen controversy regarding the role of patents in innovation and catching up), let us focus the discourse on the patent system.

First, let us revisit the appropriability function. The properties of knowledge, technology and learning taxonomized in the first section lead to assume that the capacity of agents to appropriate the advantages and the rents deriving from innovation goes beyond the regulatory framework and the set of established (intellectual) property rights. Innovations, and the advantages deriving from having conceived or produced a new technology, can be appropriated through a variety of mechanisms.

Firms, and in a wider perspective countries, use a set of complex (sometimes complementary) appropriability mechanisms in order to guarantee the capturing of rents stemming from innovation efforts (Levin et al. 1987; Cockburn and Grilliches, 1988; Coehn et al. 2000; Dosi et al. 2006). Industrial secrets, lead-time advantages, complementary manufacturing or technological capacities, branding and costumer fidelization, are different means, among others, that can be used by firms to appropriate rents deriving from intangibles. The choice between using one -or a combination- of those appropriability mechanisms rests upon different structural factors which include the kind of innovation or technology the firm is willing to protect, the size of the firm which influence the legal, financial and human resources the firm can dedicate to the enforcement of the entitled rights and the strategic management of the firm's technological assets.

At the same time, patents play different roles according to structural characteristics of firms. The asymmetry in patent propensity, i.e in the share of patented inventions, between different technological fields derives on the one hand, from the different appropriability strategies of firms according to the specificities of the concerned technology and innovation, which in general have a high sector specific component. On the other hand, patent propensity is affected by the size of firms and the differences in the value assigned to the disclosure of information to users or consumers, features which, again, have a strong sectoral component related to the replicabilty, decidability and usability of disclosed information for agents others than the "inventor" (Scherer, 1965, 1983; Mansfield, 1986; Horstman et al. 1985; Levin et al. 1987; Harter, 1993; Harabi, 1995; Arundel and Kabla, 1998; Cohen et al. 2000). Thus, patents appear as one but not unique appropriability mechanisms, whose relevance is indeed highly sector specific and influenced by a set of structural characteristics of firms.

In addition to that, it has to be noted that the legal recognition of the intellectual property right conferred by the patent is not automatically translated into effective capacity of guaranteeing the control over technologies. Patents confer the right to defend a temporary exclusive right through legal action. Effective appropriability is a function of the capacity and the willingness of the owner of the right to enforce the right, hence following Shapiro (2003) and Lemely y Shapiro (2005) patents can be defined as probabilistic rights.

Litigation costs, the expertise of legal advisors, the bargaining power, the capacity of monitoring the market and the competitors are some of the factors that influence the possibility of the "legal entitlement" to be converted into "effective entitlement". In order to allow patents to act as effective appropriability mechanisms the legal entitlement should be matched by the capacity -and the willingness- to enforce the right[3].

Second, the paradigm-based theory entails a revisiting of the rationale of the disclosure function of patents. Economists' analyses and courts' rulings tend to emphasize the role of patents in favoring incremental innovation and technical change through the increase in the amount of knowledge available in the public domain. Patents are seen as a mechanism to disseminate (relevant) information into the economic system. Actually a patent should disclose the technical information so that any person skilled in the art would be able to reduce the invention to practice. However, here again, the translation of the potential disclosure function into practice is constrained by the nature of technology and learning and by the structural characteristics of agents.

The disclosure function assumes that patents allow diffusing information that would have otherwise been secret. However, it is quite common that the information disclosed in patents is inadequate or opaque. And even assuming that the disclosed information does not suffer of any limitation –which is quite a strong assumption- given that technology and learning involve organizational and tacit knowledge embedded in routines and procedures, the simple disclosure of information does not guarantee the disclosure of what is needed in order to reverse-engineer, copy or reproduce the technology in question.

Think for example about generics in the pharmaceutical industry: why do not all firms in every country produce them? Because most firms are simply not able to do it. Even if they are informed about the existence of a certain technique or technology, they might not have the capabilities for developing or using it. Pushing the argument further leads us to affirm that even if firms were given all the blueprints of technique, i. .e. assuming the perfect disclosure of patent information- (and supposing in an extreme case also the availability of equal production capacities, basically capital inputs), performances and thus revealed input coefficients might still widely differ. Following R. Nelson –as in Cimoli and Dosi (1995)-, "it is easy to illustrate this by means of a gastronomical metaphor: despite readily available cooking blueprints and codified rules on technical procedures, outcomes in terms of standards of food quality are unequivocally asymmetrical. This applies to comparisons among individual agents and also to institutionally differentiated groups of them: for example, we are

[3] It is not uncommon for firms to avoid engaging in legal action in cases of infringement of their intellectual property rights. In an analysis of the patenting behavior of small and medium enterprises in the US Koen (1991) finds that 55% of firms do not take action against infringement of their patents due to high litigation costs and excessive time length of trials.

ready to bet that most eaters randomly extracted from the world population would systematically rank samples of English cooks to be "worse" than French, Chinese, Italian, Indian,...ones, even when performing on identical recipes!!!". This should apply, much more so, to circumstances whereby performances result from more complex and opaque organizational routines.

The disclosure function of patents is also generally assumed to increase efficiency in the search for novelty and innovation in economic systems allowing preventing the duplication of R&D efforts. Following our critical stance it is quite easy to derive that this is hardly the case. Firms might engage in competitive R&D trajectories. And patent races are a clear example of this behavior. On the other hand, the duplication of R&D efforts is not necessarily to be seen as a systemic inefficiency. Since technology and knowledge are clearly more than a set of blue prints and entail organizational capacities, routines and tacit codes, firms might well have to follow a certain learning path in order to be able to decode technical information. To profit from the availability of technical information deriving from external sources firms need to posses a certain degree of capabilities that allows them to identify potential opportunities related with the technique or the technical information in question, and then they need to dispose of the technical capacities of profiting from the technological interchange. Actually firms' absorptive capacity explains the potential complementarities between in-house R&D efforts and external sourcing (Cohen and Levinthal, 1989; 1990)

A taxonomy of contemporary markets for knowledge

Patents, and the whole set of issues like patent subject matter, patent length and breath, as well as patent quality, and the capacities to enforce the rights conferred, affect entrepreneurial behavior in diverse ways. Patents play different roles in firms' competitive strategies; beyond acting as an incentive to innovate or to technology transfer, patents might influence the perception of what is public or freely available and what is proprietary in given fields of science and knowledge. Patents might shape R&D trajectories of firms – favoring or discouraging the entrance in given research fields-, they can influence mergers and acquisitions within firms. At the same time patens can act as reputation signals between firms and they might perform as negotiation instruments in legal settlements.

If one were asked "why do firms patent? "and "what do firms do with patents?", nowadays the answer should go beyond the logic provided by the market for technology approach. According to this stance, the prevailing patenting behaviors respond to the need of protecting innovative efforts and commercialize technologies. Patents shape –to different extents- innovative and imitative conduct of agents, which on their turn re-shape the patent system through different pressures- but at the same time they convert themselves in peculiar kinds of strategic assets whose relevance ends up to be disentangled from the subjacent technology, being more and more dependent on non-rational expectations regarding possible future technological settings.

Let us briefly review the sets of issues that contribute to re-shape the contemporary reconfiguration of the markets for knowledge: the emergence of new technological paradigms and the re-shaping of world IP regimes.

- The emergence of new technological paradigms, entail a redefinition of what, is innovation, how it is generated and through what means it can be diffused and appropriated. In new technological paradigms, mainly ICT, biotech and nanotech, innovation is each time more incremental and cumulative in character, intensive in interrelations between firms (countries and institutions), and it entails an increasing relevance of science. The concepts of replicabilty, usability and copying are constantly re-defined, the potential technological interrelations are multiple, and uncertainty regarding future possible outcomes is even higher than in past technological paradigms.

- The re-shaping of world intellectual property systems[4]. IP systems are institutional and regulatory infrastructures embodied in evolving socio-economic system, hence they naturally entail change and transformation. IP systems have been subject to various transformations accordingly to the development of modern economies (Machlup and Penrose 1950; David 1993); From a regulation of national scope in the beginning of industrial development and during the phase of inward industrialization, which characterized the take off of first comers, IP systems evolved to supra-national regimes. This transformation went hand in hand with the increase in relevance of international trade and interactions between countries and according to the rising articulation and diversification of production processes which lead to an increase in the role of technical information and know-how and in its appropriability[5]. However, since the 1980s world IP systems experienced significant changes beyond the transformation pushed by the changing needs of socio-economic and production systems and pulled by the emerging technological paradigms (Dasgupta and David, 1994; Mazzoleni and Nelson, 1998; Mowery et al. 2001; Cimoli et al. 2006).

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[4] Any comprehensive analysis of the reshaping of world IP system would go far beyond the scope of this paper; for our purposes here –i.e. analyzing the re-shaping of contemporary markets for knowledge- it suffice to briefly recall the main changes in the institutional infrastructure of IP management that occurred in the last decades, which are considered to be determinant in affective firms' patenting behavior.

[5] The Paris convention of 1883 on industrial property protection and the Berne Convention of 1886, which regulate the protection of original forms of expression like artistic or literary works, represented the first phases of the internationalization of the protection of intellectual property rights.

The contemporary re-shaping of IP - happened in a context characterized by increased trade liberalization and integration pointed to an (upward) harmonization of standards worldwide. It entails two major aspects. First, the changes and the increasing pro-protection aptitude within the US, which to different extents molded subsequent changes in foreign countries, and the inclusion of IP issues within the trade negotiation agenda. The US assisted to a progressive expansion of the patenting frontier, especially through a series of court-rulings that reverted previous doctrines in favor of a more lax interpretation of patent subject matter and to a transition to a more proprietary and commercialization-oriented science model, which departed from the more traditional open science stance, sustained by the adoption of the Bahy-Dole act[6]. Second, in response to a proactive competitiveness strategy IP issues have been included within the trade negotiation agenda. The ratification of the TRIPS agreement in 1994 within the GATT represented the baseline for calling for worldwide harmonization of IP laws. Requirements, exceptions to rights conferred and policy spaces are currently being re-defined by the wave of bilateral agreements and treaties (Fink and Reichenmiler, 2005; Moncayo, 2006).

The table below presents a taxonomy of contemporary markets for knowledge according to four main categories: rationale of the market, prevailing patenting behavior, main patent use and barriers to entry. Those markets encompass what in the literature has been identified as market for technologies, plus two additional categories of markets, the market for science and what we have defined secondary markets for science and technology.

Table 1. A taxonomy of contemporary markets for knowledge

	Markets for knowledge		
	Markets for Technologies	**Markets for Science**	**Secondary Markets for S&T**
The rationale of the market	Specificity of technologies, asymmetries in routines and competences of agents, complementarities between technologies	Increasing "demand" for science due to new technological paradigms and changes in regulatory framework	Increasing cumulativeness and uncertainty in the nature of technological change (new tech. paradigms) and re-shaping of IP systems

[6] Adelman, 1987; Merges, 1992; Mazzoleni y Nelson, 1998; Mowery et al. 1999; Jaffe, 2000; Cohen y Lemely, 2001; Hunt 2001; Hall y Ziedonis, 2001; Gallini, 2002; Graham y Mowery, 2003; Hall, 2003; Bessen y Hunt, 2004

Prevailing patenting behavior	Patent to protect, commercialize and diffuse	Patent to protect, commercialize and diffuse	Strategic, defensive, blocking and sleeping patenting.
	The value of patents is related to the subjacent technology (present or future incorporation in production)	The value of patents is related to the subjacent technology (relevance for further research or present or future incorporation in production	- Patents acquire a value "per-se", independently from that of the subjacent technology. - The value of patents is, to a major extent, a function of expectations regarding future non-deterministically foreseeable technological scenarios. - Patents enter into the asset portfolio of organizations as signal of (technological) reputation.
	Technology transfer through licensing.	Technology transfer through licensing	Cross-licensing, M&A, patent pools, (Liquid market for knowledge) Sleeping, blocking, defensive patenting. (Derivative market for knowledge)
Barriers to entry	Technological and production capacities (structural)	Scientific capabilities and technological capacities (structural)	Size of incumbents, risk-propensity, plus scientific, technological and production capacities

The idea of *markets for technologies* has been explicitly explored by the literature in recent times (Eaton and Kortum, 1996; Arora, Fosfuri and Gambardella, 2001). When the right to produce some artifact, or the knowledge and the know-how required to produce it are clearly separated from the product or the service they are destined to produce, there comes a line between the market for tangibles and the market for the technologies necessary to produce them. These markets arise since there are firms that are specialized in providing technologies and enterprises able -and wiling- to use theses technologies to produce and sell artifacts to consumers. In this view, patents are the basic institutional infrastructure guaranteeing the efficient functioning of the market.

Patents define the conditions for the usage and the transferring of knowledge, allowing agents to specialize according to comparative advantages. Patents consent specialization and division of labor between technology providers and users, fostering efficiency in the technological field. The primary function of this market is to favor the diffusion and the transferability of innovation through licensing. The value of patents mainly derives from its usability in tangible production and it is strictly related to the subjacent technology. The implicit innovation model here is al lineal and smooth one. Form a given body of knowledge available in each socio-economic system firms carry out R&D, patent their inventions, and then incorporate the technology in their production or they license the know how to other firms.

The functioning of markets for technologies as sketched above captures only a fraction – although relevant and worth of analysis-of what firms actually do with patents. The paradigm-based theory, the emergence of new technological paradigms and the re-shaping of world IP systems entails additional interpretations regarding firms' behavior in the knowledge game and involve a variety of conducts related to patenting and trading in knowledge that go beyond this standard approach.

On the one hand, the expansion of patent subject matter and of the category of eligible categories of owners of IPRs modified the traditional open science conception engendering the generation of a *market for science* where R&D labs and universities patent (and commercialize) their inventions. The adoption of the Bayh Dole Act in 1981 in the US represents a critical standpoint in this area (Jaffe 2000, Mowery et al. 2004). This act regulates the conferring and the transferring of patents to subjects that carry out R&D through federally funded budgets. According to Mowery and Sampat (2005) university patenting increased from 1% up to 3.5% in the decade of the 80s. This phenomenon is not limited to the US; in the EU universities own 2.4% of total patent application presented at the EPO between 2001 and 2003 (OECD Patent Database, 2006). The increase in patenting activity of universities challenges the traditional open science paradigm according to which publicly funded research was supposed to increment the pool of available knowledge, since the "filter" to use and exploit this knowledge rested on technological and production capacities of agents, routines and tacit knowledge beyond any legal effort to protect it (Rai, 2001, Dasgupta y David, 1994; Mowery et al. 2004).

The dilemma of proprietary versus open science is clearly beyond the scope of this paper, what is at stake here is the identification of a new kind of market which basically functions as the traditional market for technology, but that constitutes itself as an *anterior* market, to which firm have to recur when results of universities research are subject to proprietary regimes. The rationale for the market - which is a base-line market for the traditional technology one- derives from the latent and diffused demand for science induced by new technological paradigms (which increasingly rely on pure science for their inventions) and by the changing-behaviors that seem to have pushed forward the frontier of private knowledge. In this market, patents perform the same function as in traditional technology markets, with the only difference that main agents here are universities, R&D labs, spin-off firms.

Increasing cumulativeness and uncertainty in the nature of technical change and the re-shaping of legal frameworks that rule the knowledge domain towards more extensive IP protection induce firms to play with patents in additional arenas to that of the technology and the science market. These dynamics lead to the generation of what we might call *secondary markets for science and technology*. Firms might benefit from patents also beyond the monetary (or non-monetary) rents deriving form technology licensing. Firms might patent to block the entrance of competitors, to secure their dominant position in given technological trajectories, to increase their bargaining power in cross licensing or, among other reasons to protect themselves in case of infringement trials. The rationale behind the patenting behavior is mainly strategic, defensive or blocking. The value of patents is, to a major extent, a function of uncertain expectations regarding future non-deterministically foreseeable technological scenarios.

Patents enter into firms' portfolios as signal of (technological) reputation. Patents acquire a value "per-se", independently from that of the subjacent technology and in some limit cases they are not even traded. Patent might be kept within firms' portfolios waiting for the proper opportunity to be used, directly or indirectly[7]. The utility of patents goes beyond the appropriability function and they reconvert themselves into strategic assets. The willingness to patent can be assimilated to the decision to buy a lottery ticket. Even though the probability of winning is extremely low the winning prize or the value assigned by each individual to the eventual win is high enough to encourage the patenting (Scherer 2001; Lamely and Shapiro 2005). The difference in our scenario is that uncertainty concerns not only the possibility to win, but also the prize itself. When a firm patent an invention with the idea of playing in the secondary market, there is no guarantee that the invention-i.e. the patent- would be of a certain value in the future.

Moreover, the value of a patent can directly depend upon the value of other patents to which it can be linked though patent-pools, for example. This can contribute to explain why do firms carry out extensive patenting strategies even though it is widely acknowledge that patents have a highly skewed value's distribution, i.e. in every technological field there is a set of limited number of valuable patents and a huge number patents with much less value. Given high entrance barriers determined by risk propensity and high enforcement and legal costs, the secondary market is a highly concentrated one, dominated by major actors –mainly big firms, MNCs and joint-ventures- where the value of patents is increasingly disentangled from the subjacent technology and increasingly related to their potential (future) value.

There are two main attributes that identify the transactions in this secondary market: liquid and derivative. Patents are converted into liquid assets in the strategic portfolios of firms, as they are used to increase bargaining power in cross-licensing, to increase their capacity of managing legal controversies, to determine M&A between firms. A market is defined as liquid when their assets can easily circulate. This market is liquid in the sense that patents are easily tradable without requiring firms to have the necessary technological and production capacities to translate the invention into practice (at the time of transaction).

[7] = Following a survey of the EU regarding the value and the use of invention patent in Germany, France, Italy UK, Holland and Spain sleeping and blocking patents account for 18% in the case of SMEs and 40% of big firms and universities (Cesaroni and Giuri, 2005).

Patents become to a certain extent liquid because they loose the weight and the density of the technological component and they can hence circulate easily in the market without having to be necessarily entangled in any final artifact. At the same time, a given share of patents is not even traded and it is kept sleeping. Just as in derivative financial markets the value of the transaction is disentangled from the present value of the share object of transaction, in this case patents are valued according to their potential future value. The decision to patent goes beyond the expectation of incorporating the patented invention into (direct or indirect) production. Firms patent to create barriers to competitors, and to create the possibility to participate in oligopoly rents that will be generated in the future by potential additional discoveries or incremental innovations based on their patents (Levin at al. 1987; Cohen at al. 2000).

In this scenario, the traditional notion of patents as appropriability mechanisms of rents deriving from R&D efforts fades. The logic of patenting appears as disentangled from the incorporation of intangible into tangible production engendering the generation of additional markets. Patents almost "monetize" and the benefits associated with their ownership are less and less deriving from the temporary monopolistic power over the innovation, but upsurge from the strengthening of bargaining power between firms, or from the potential future appropriability of oligopoly rents generated by additional firms according to the future value of patents.

Barriers to entry in the secondary market go beyond production and technological capabilities; they derive from firms' risk-propensity and size, and the existence of needed complementary markets and institutions to make this secondary market work. Considering the explosion of patenting activity in recent times, the re-shaping of world IP systems, the challenges of new technological paradigms and firms' prevailing patenting behavior, it is straightforward derived that traditional markets for technology and the new market for science account for only for a fraction of what is going on in the patent arena. Secondary markets for knowledge where firms basically play betting on future-uncertain- outcomes, are shaping firms' patenting behavior. In this setting, costs and barriers to entry for new actors (firms and countries) are high, litigation and enforcement costs might be prohibitive, and different forces press towards concentration. However, there are spaces for new actors to position themselves into certain technological-related trajectories, but clearly this would not happen though market forces.

Concluding remarks on the implications for development

The revisiting of the economics of intellectual property, and especially patents, in the light of the paradigm-based theory of innovation and the interpretation of the contemporary dynamics in the markets for knowledge entail non-obvious implications for development theory. As regards to that, let us single out three major implications for public reasoning on long-run sustainable development, which we believe are of utmost importance to go beyond good intentions in the contemporary innovation for development discourse.

Behavioral microfoundations of innovative conducts and the role of IP rights

As regards the behavioral foundations of innovative and imitative conducts, we are quite skeptical about their reduction to linear and deliberate profit maximizing choices. "Getting the IPRs right" is far from being the solution. Also because too much of uncertainty regards what might "right" mean in terms of intellectual property regimes across countries with profound differences in technological and production capacities. Legal appropriability mechanisms, i.e. prevailing intellectual property norms, classify as *second order effect factors*, with respect to production capacities and technological capabilities embodied in socio-institutional systems in shaping innovative and imitative conducts.

Appropriability of innovation and the set of factors shaping innovative and imitative behavior of firms go far beyond patents. A wide set of inducements bound or incentive firms in their imitative and innovative search. Firms (and hence countries) may appropriate innovation rents beyond any legal attempt to do it, simply through the complexity and the embeddedness of technology and knowledge in their organizational procedures and technical know-how, or through lead-time advantages. At this point, the implications for the contemporary (fashionable) "innovation for development" are quite comprehensible. The availability of a set of diverse appropriability conditions and of a given knowledge base is not irrelevant in shaping the search for novelty and entrepreneurial endeavors in innovation. Explanations regarding the willingness of firms (and to a broader extent of countries) to explore new paradigms, to carry out experimental research or to engage in reverse-engineering or imitative efforts, the rate of introduction of new products, processes or start-up firms, require a comprehensive understanding of specific social, institutional and corporate characteristics, which go beyond the analyses of the prevailing legal framework governing access and transferability of knowledge.

Asymmetry in countries' scientific, technological and production capacities

Countries do not depart from the same line. They suffer of deep asymmetries in terms of production capacity and technological capabilities. And it is reasonable to assume that these asymmetries will tend to persist over rather long spans of time, unless tailored and sustained efforts (mainly industrial and technology policies) are taken in order to foster structural change and to induce transformations in production structures and allocation of inputs.

International distribution of innovative capabilities is at least as uneven as that regarding production capacities and specialization. If one takes patents –for example the number of patents granted to foreign in the US Patent Office- as a proxy for innovativeness, evidence suggests that the club of innovators is restricted to a bunch of countries. In the 60s, Germany, UK, France, Switzerland and accounted for almost 75% of all patents granted to non-US residents; nowadays, Japan, Germany, The Chinese Province of Taiwan, the Republic of Korea and France account for almost that same share. The new entry of the Asian economies in terms of patent intensity follows the structural changes experimented by these economies, which in different moments, radically transformed their production apparatus, increasing the share of technology intensive sectors in their manufacturing industries and catching up with the frontiers in terms of technological intensity and productivity.

Innovation dynamics and access to codified and no-codified knowledge (for example the capability to profit from information disclosed by patents) strictly depend on the positioning in international network hierarchies and on the stage of production process in which firms are engaged in. In industrialized countries, as well as in emerging economies, science and technology polices have been carried out on a continuous basis for several decades, allowing a virtuous circle between sectoral specialization, availability of technological capabilities. Moreover, a shift in public policy priorities accompanied production structure changing needs. In developing countries the story is, as it is well know, completely different. Developing countries spend scant amount of financial resources in R&D. They are usually specialized in low knowledge intensive activities, especially natural resources and labor-intensive industries, and in general their domestic innovation efforts are basically adaptive in nature and rarely encompass inventions and scientific discoveries. The US and Canada account for 41.9% of world R&D expenditure, Europe explains 28.2% and Asia accounts for 27.3%; while Latin America and the Caribbean –which accounts for 1.3% of world expenditure- Oceania -with 1.1%- and Africa –representing 0.2% of that amount- evidently play a residual role (RICYT, 2004[8]). The kind of production specialization entails different innovation efforts, hence generating a situation where it is obvious that industrialized countries are those who lead international patenting, since it results from innovation efforts[9].

Ranking countries according to their technological production capacities and to their innovative performance helps to clarify our discourse. In graph 1 we order countries along the horizontal axis according to the intensity of their technological specialization with

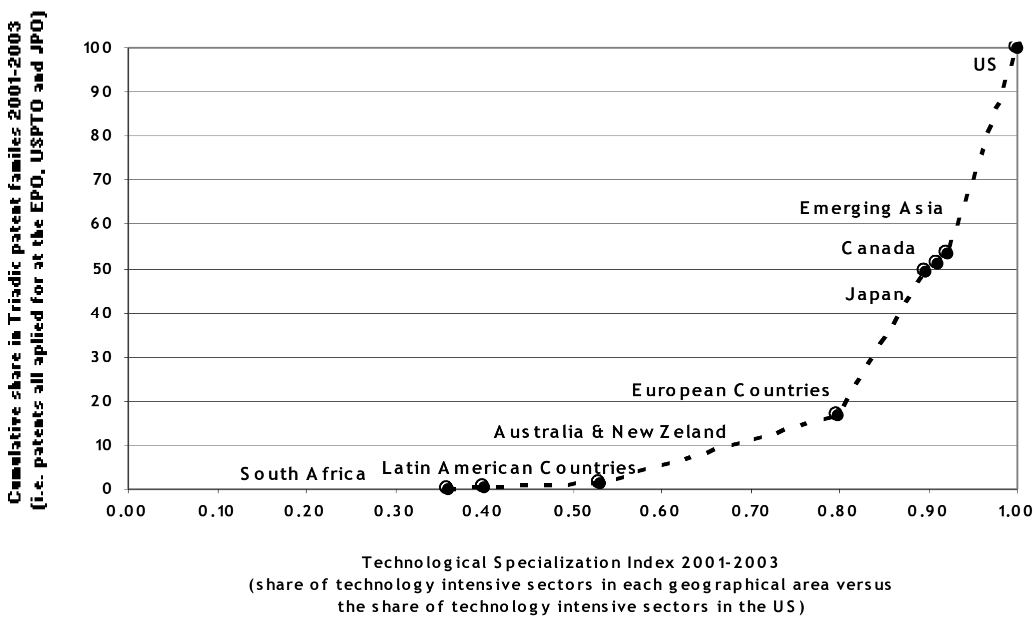
[8] Data refers to 2003 OECD, UNESCO and RICYT estimates, based on current US dollars.

[9] We recognize that this is a synthetic and limited indicator, but it suffices to flag asymmetries between production systems as that of interest in our analysis).

respect to the frontier. At the same time we measure their innovativeness; for each country (or group of countries) we plot on the vertical axis the cumulative share of patents all applied for at the three major world-patenting offices (the European, the Japanese and the North American one). The graph portrays a sort of knowledge curve showing the comparative technological intensity of production structures of countries and the relative patenting behavior.

First, we observe a clear differentiation between industrialized countries and industrializing ones. The US, the Republic of Korea, the Chinese Province of Taiwan, Japan, Canada and the European countries, all show similar technological specialization- at least in terms of share of hi-tech industries in total manufacturing; those countries all together account for more that95% of total patents all applied for at the European, Japanese and US Offices. The US, Japan, Canada, Emerging Asia and the European countries all show similar production structures as regards the share of technology intensive sectors within total manufacturing value added. Actually the share of those sectors varies between 45% for the average of European countries considered and 65% in the US. In industrializing countries, however, the share of those sectors does not go beyond 30% on average, being the rest of production concentrated in labor and natural resources intensive sectors.

Figure 1. The knowledge curve: production structure and patenting behavior



Source: own elaboration. OECD Patent Database 2006, ECLAC-Padi and OECD-Stan.

Note: Emerging Asia includes India, The Republic of South Korea and the Chinese Province of Taiwan

Second, in a parallel way, the graph shows (if one reads it through the vertical axis) the asymmetry in innovativeness -as measured by patent applications- which corresponds to and derives from the specialization pattern. Patenting results from innovation and defensive strategies that are not homogenous across sectors. Behavioral microfoundations of innovation conducts, patenting and rent appropriation through patents are strictly industry specific. Correspondingly to the relative intensity of production specialization, the US, Japan and the European countries account for the highest shares in triadic patent family[10]. South Africa, Latin America and Australia and New Zeeland, in accordance with their low-tech specialization pattern, account for a residual international patent activity. What is interesting here is to note the effect of structural change and patenting behavior. It is reasonable to assume –and empirical evidence supports this assumption- that to a high share of technology intensive sectors in production structures corresponds a more intense patent activity. Countries that recently caught up show a dramatic increase in their patenting activity, but in a comparative way they still are residual actors in the world patent game. The Republic of Korea, The Chinese Republic of Taiwan and India – to varying extents- reoriented their production structures towards technology intensive sectors and their patenting activity skyrocketed, when and if they are going to erode the position of mayor IP players is still an open question.

Participation and exclusion in contemporary markets for knowledge

Our general point is that innovativeness, besides being partly the result of a random process naturally concerning something new and not-expected, entails a degree of stickiness shaped by scientific, technological and production capabilities. This entails serious consequences in considering the implications for developing countries of the reconfiguration of contemporary markets for knowledge.

First, in the case of the markets for technologies it is clear that developing countries lack production and technological capabilities that would enable them to participate in those markets. In the supposed division of labor, they cannot play the role of specialized technology providers. At the same time, they face serious constraints for acting as technology demanders, due to their production specialization and to their scant technological capabilities that would be necessary to decode and productively use patent information. Socio-institutional factors, infrastructure, current scientific and technological capabilities shape the arena of production possibilities in a strict way. Actually, even supposing the extreme scenario where all patent information would be freely available to developing countries it would be rather illusionary to imagine a spurring of local manufacturing firms (who would do that?).

[10] This affirmation can appear a bit tautological give that we are considering patents all applied for to the US, the European and the Japanese offices; however, the home biased effect country is not relevant for our analysis since we are interested in comparing the intensity of patent application across world countries in a general way. Calculating the share of triadic patent families for all countries exuding the US, the Europeans and Japan would not alter the order: South Africa is the country accounting for the lowest share and emerging Asia is that with the highest share.

Second, in the case of the markets for science the same discourse applies. Developing countries lack the scientific and technological capabilities to enter in this market. Beyond legal frameworks, those countries suffer of a chronic deficiency in terms of researchers and as regards the quality of infrastructure and systemic environment for science and scientific research. Obviously the current debate regarding proprietary versus open science should be of concern for developing countries, but they should avoid blaming patents as the only barrier for their scientific catch up. Public support to research and development, the recognition of the profession of researchers, capacity building in scientific research and development, investment in top quality infrastructure for research are more binding factors than patent protection for developing countries to play a role in scientific research.

Third, considering the emerging dynamics of the derivative markets for knowledge and the kind of speculative patenting behavior that is taking place, it is clear that this arena is for those major and leading innovative actors who recognize and value innovation as a strategic asset for future competitiveness. We have been saying that in these derivative markets the value of patents is increasingly disentangled form the subjacent technology. Hence, production and technological capacities are not seen as major entry barriers, but this means that main barriers here are the capacity and the capability to carry out a strategic management of intellectual property, which stems from and exceeds production and technical capacities. Without those capacities it is hard to participate in these markets; agents might not even recognize the rationale for them. The explosion of patenting activity deriving from competitive behaviors of agents coping with uncertain future outcomes and extensive patenting may induce a slow down in the rate of technical change which is already alarming actors in the frontier. Think about the self-evident negative consequences of patent thickets in context of incremental innovations. These issues should be of concern in developing countries as well.

To conclude, let us state that proposing a solution for the IP and development debate is clearly far beyond the scope of this paper. Our aim here is much more modest and it would suffice for us to call the attention of those in international organizations, academies and public policy agencies concerned with the innovation for development discourse on the need to avoid converting the patent controversy in a much ado about nothing discourse. The point here is that the existence of unexploited technological opportunities, together with the relevant knowledge base and a set of appropriability conditions, concur to define the boundaries of the set of potential innovations: those which are actually explored might crucially depend socio-economic traits of production and organizational systems. Considering that technology is highly specific, that it is embedded in routines and procedures, that knowledge has a strong tacit component and that learning is a trial and error process which entail non-substitutable experiences, lead the patent controversy on blaming or blessing patents for their effect on innovative conducts to loose most of its relevance. We hope that our reasoning contributes to include the intellectual property for development discourse within the more extensive debate on appropriability and the generation of innovative knowledge, and within the perspective of public policy decisions to construct scientific, technological and production capabilities.

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