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Innovation, technical change and patents in the development process: A long term view

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Innovation, technical change and patents in the development process: A long term view

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1. Introduction: Technological Learning and Economic Development

The key feature of the historical process of economic development is the "great transformation" (Polanyi, 1944) whereby the traditional organization of economic activities gives way to the systematic adoption and development of new production processes, new products and new organizational forms characterized by the prevalence of modern industries, and knowledge-intensive services. The great transformation consists first and foremost of the accumulation of various forms of knowledge and novel capabilities at the level of both individuals and organizations.

As Chris Freeman (2008) emphasizes, the pattern of development or stagnation of a national system of innovation and production is the result of co-evolutionary processes linking together several domains, including the adoption and development of new technologies, the organization of production and markets, and the changes in political and legal institutions (more on this in Cimoli, Dosi and Stiglitz, 2009). An essential aspect of "catching up" by developing countries (Abramowitz, 1986) is the emulation of technological leaders (on the notion cf. Reinert, 2007 and 2009) and the rapid accumulation by individuals and organizations of the knowledge and capabilities needed in order to sustain processes of technical learning. This process is initially imitative. It consists of the acquisition of scientific and technological knowledge as codified in the relevant literature. It also involves the acquisition of individual and organizational skills based upon various forms of experiential learning, and problem-solving knowledge embodied in organizational practices. Indeed, the latter kind of capabilities to a good extent shapes the ability to absorb the former type of knowledge. Therefore, it is particularly important to reflect upon the context within which such capabilities can develop.

The rates and patterns of development of such capabilities are fundamentally shaped by the opportunities that indigenous organizations have to enter and operate in particular markets and technology areas. In part, these opportunities reflect the intrinsic ease of imitation of technological and production knowledge. However the ways actors exploit these opportunities are sensitive to a broad array of policies and the existence of supporting institutions, including those governing the modes though which individuals and organizations can claim the legal rights to the exclusive exploitation of their knowledge. In brief, knowledge accumulation is also influenced – in ways and to degrees that have to be determined – by the *governance of intellectual property rights (IPRs).* The purpose of this work is to offer an assessment of such influences in the long term, beginning with the early episodes of industrialization all the way to the present regime. Are intellectual property rights conducive to knowledge accumulation? Unconditionally? Or does the effect depend on the distance from the international technological frontier? Even at the technological frontier, does the "strength" of the IPR regime map monotonically into higher rates of innovation? And finally, what influence is the current regime likely to exert on the opportunities and incentives for contemporary countries trying to catch up?

Many of the contributions to this volume focus upon some of these questions. Here, we want to provide a broad interpretative overview. In this, the history of industrialized countries, in particular of the United States, vividly illustrate the interplay between the dynamics of technological opportunities, capabilities accumulation, and the institutions governing the knowledge-related rent seeking possibilities of individuals and organizations.

The historical record is indeed quite diverse and variegated. However if there is a robust historical fact, it is the laxity or sheer absence of intellectual property rights in nearly all instances of successful catching up. Thus, to the extent that the emulation of the technological leaders can be identified as one of the few constants across the experience of countries which successfully caught up (Reinert, 2009), we shall argue that homogenization of patent protection onto the standards of the technological leaders is a step in the wrong direction. Moreover, the emphasis given to the role of patents and other intellectual property rights as incentives for innovation draws attention away from their potentially negative consequences for processes of knowledge and capability accumulation that are typical of latecomers' industrialization.

This chapter focuses on one form of intellectual property rights – patents. We begin in Section 2 by reviewing a few theoretical arguments that economists have formulated on the effects of a system of patent protection. Our goal is not so much to offer a comprehensive survey of the literature, as to examine the economic rationale for creating or reforming patent systems in a developing economy context. We will then review the historical evidence on the roles of patents in economic development (Section 3). There we also highlight the heterogeneity that has been historically common concerning the collection of laws and institutions which go under the heading of "patent systems," and the heterogeneity across nations and over time in the characteristics of these systems. Section 4 discusses at some length changes in the IPR regime that have taken place roughly over the last third of a century in the United States. The reason for focusing on the United States is that doing so will outline the broad template of patent policy reform that has been adopted by policy makers in many other countries as a result of a varying mix of external pressures, myopia, corruption and ideological blindness. Section 5, the final part of this essay, explores the likely impact of harmonization of international patent laws - including TRIPS - on developing countries.

2. Patents and Innovation, in Theory and Practice

A common argument suggests that patents are a necessary reward for inventive activities that would not take place otherwise. However, a sizeable body of scholarship points at other functions that patents might serve, which are in some cases complementary to the incentive function, and in other cases alternative – such as the revelation of technical information. What are the theoretical motivations for such statements, and more importantly, what does the historical evidence tell us?

In addressing these questions one should also keep in mind the fundamental distinction between the effects on countries at or near the technological frontier and those on economies that lag behind it. Indeed, the very character of innovative activities taking place among firms in a developing nation differs quite generally from what one observes in technologically leading ones. Innovations in a developing economy consist predominantly of products and processes that are new to local firms, or to the national economic context, rather than to the world. The elements of novelty, whenever present, are likely to consist of minor or incremental modifications of technologies whose basic characteristics have been defined by innovators located in other countries.

Because of these features, the rate and direction of the innovative activities carried out by local firms in developing countries might very well depend on incentive structures and appropriability mechanisms that differ from those prevailing in developed countries.[1] By the same token, the role of patents toward the disclosure and diffusion of technological information takes on somewhat different characteristics when viewed from the perspective of developing countries.

Theory

Patents as incentives for innovation

The conventional view, according to which patents are indispensable elements of the incentive structure for private profit-motivated search, is rooted in the view of knowledge as a *pure public good*. Accordingly, intellectual property rights such as patents are needed in order to create the condition of excludability that is necessary if private actors are to engage in costly innovative efforts.[2] Such theoretical orientation conflicts, as we shall see, with a substantial body of empirical evidence, and conflicts with the characterization of technological knowledge and of learning processes briefly sketched above.

There are at least two main shortcomings of the knowledge-as-public-good framework. First, the proposition that patents are necessary in order to promote inventive effort presumes that in the absence of such rights, the technological knowledge produced by the inventor would be freely available for use by third parties. On the contrary, this would not apply whenever innovative activities build upon and produce technological knowledge that is partly tacit, and rely upon capabilities that reside in complex organizational routines. Under these circumstances, knowledge related to a specific firm's innovation is not, as a rule, freely available to third parties in the absence of legal rights of exclusive control.

Second, even if, in an abstract sense, knowledge related to a specific innovation were to be made publicly available, it does not follow that every firm could use such knowledge. The use of non-excludable knowledge for the purposes of imitating or adapting an innovative technology would still depend on the initial capabilities of the imitating organization. When such capabilities are inadequate, the mere availability of knowledge is not sufficient for imitation to take place. Conversely, an organization with strong technological capabilities could not only use the publicly available knowledge, but also engage in "inventing around" the legal rights that were to be created in order to make the original invention excludable.

[1] To be sure, we do not mean to argue here that the appropriability regime is the only, or even the most important, determinant of the rate and direction of innovative activities : more in Dosi, Marengo and Pasquali (2006) and Dosi and Nelson (2010) .

[2] Incidentally note that such an assumption is core within most neo-Schumpeterian models of growth, while the limited ability to appropriate returns to innovation is often offered as the reason why the rate of technological progress is slow in some industries.

These two observations imply that in general, the appropriability regime governing the incentives for innovation cannot be reduced to the availability and character of patent rights on inventions. To the extent that relevant technological knowledge is opaque to third parties, the latter's capacity to imitate and compete away the innovator's rents would be only limited. Conversely, patents can be expected to be a more important aspect of the appropriability regime whenever the relevant technological knowledge is not or cannot be protected well by virtue of its complex and tacit nature or through secrecy, and whenever the capabilities of rival firms are adequate to exploit available information (even incomplete) about the innovation in order to imitate.

The foregoing considerations apply to both "frontier" countries and countries that are catching up. From the perspective of developing countries, however, it is necessary to consider further the effect of a national patent system that recognizes the rights of foreign inventors upon the incentive for indigenous innovation. The potential restrictions created by patent rights on the diffusion and use of existing foreign-generated knowledge may well delay cumulative processes of domestic innovation and of technological learning. These obstacles can be particularly important for those firms, like most indigenous firms in a developing economy, whose technological capabilities are fragile and less likely to be capable of sustaining learning through efforts to invent around existing patents.

Patents, disclosure, and diffusion

A second purported function of patents – not perfectly overlapping with the former – concerns the effects on disclosure of technological information. We note at the outset that the modern patent system was originally born as institutional device meant *to help disclosure, not as an incentive to innovate*.[3] According to the conventional view, patent rights were offered as consideration for the disclosure of inventions that might otherwise be kept secret. Whether or not this theory is correct, virtually all existing patent systems impose a disclosure requirement on inventors and applicants. Thus, technological information will be made available through the patent system independently of the inventors' motivations for inventing and applying for a patent.

The collective economic benefits of disclosure fall into three distinct areas. First, patent disclosure could produce social benefits in the form of reducing investments in duplicative R&D. Second, the information disclosed by patents could trigger or facilitate follow-on inventive activity, or promote a broader diffusion of the technology.

That patent disclosure can promote a greater diffusion of the underlying technology, for example by licensing agreements or other forms of market-mediated technology transfer. Thirdly, patents might be argued to promote the *diffusion* of technological knowledge through licensing agreements or other forms of market-mediated technology transfer. For example, as argued by Arora, Fosfuri, and Gambardella (2001), patents may encourage technology specialist firms to license their technologies in technology markets rather than trying to integrate downstream into the product markets (an issue that was also raised by Teece, 1986, when arguing that a

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[3] As early as the 16th century, the Venice republic was granting patents under the compulsory rule that innovators and skilled artisans from abroad were granted a temporary monopoly in exchange for their transfer of largely tacit knowledge to local artisans and firms.

necessary even if not sufficient condition for firms to profit from innovation via licensing is a tight appropriability regime).

Empirical Evidence

A detailed assessment of the impact of different patent regimes is offered in the chapter by Jaffe and Hu (see also Jaffe, 1998 and 2000; Merges and Nelson, 1992 and 1994; and the considerations in Dosi, Marengo and Pasquali, 2006). Here let us just sketch out some broad regularities and patterns.

Patents and incentives for R&D

While patents and other intellectual property rights are most relevant to discussion of private actors, we start by noting that most researchers at universities and public laboratories have traditionally done their work, which on occasion may result in a significant technological advance, without expectation of benefiting directly from it financially. Some inventors invent because of the challenge of it, and the sense of fulfillment that comes with solving a difficult problem. And, more importantly, in contemporary societies most scientific knowledge – of both the 'pure' and 'applied' nature – has been generated within a regime of *open science*. The fundamental vision underlying and supporting such a view of publicly supported open science throughout a good part of the 20th century entailed (i) a sociology of the scientific community largely relying on self-governance and peer evaluation, (ii) a shared culture of scientists emphasizing the importance of motivational factors other than economic ones and (iii) an ethos of disclosure of search results driven by 'winner takes all' precedence rules.[4] In Nelson (2006), David and Hall (2006), and Dosi, Llerena, Sylos Labini (2006), one discusses the dangers coming from the erosion of Open Science institutions. Advances in pure and applied sciences act as a fundamental fuel for technological advances – albeit with significant variation across technologies, sectors and stages of development of each technological paradigm.

However, the major share of inventive activities finalized to economically exploitable technologies that go on in contemporary capitalist societies is done in profit-seeking organizations with the hope and expectation of being economically rewarded if that work is successful.

The issue of how important monopolistic departures from competitive (zero profit) conditions are for incentives to innovate *even in developed countries* remains an open one, at least in theory. [5] What is the evidence on some monotonic relation between (actual and expected) returns from innovation, on the one hand, and innovative efforts, on the other?

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[4] On those points following the classic statements in Bush (1945), Polanyi (1962) and Merton (1973), see the more recent appraisals in Dasgupta and David (1994); David (2004); Nelson (2004) and the conflicting views presented in Geuna et al. (2003).

[5] Note that the possible 'trade-off' discussed here is distinct from the purported, and somewhat elusive ('Schumpeterian'), trade-off referred to in the literature between propensity to innovate and market structure: more on the theoretical side in Nelson and Winter (1982), and on the empirical evidence Cohen and Levin (1989) and Soete (1979), among others.

One source of evidence in order to answer the question are the works on inter-sectoral differences in the rates of innovation. Do they stem from corresponding differences in the degrees of appropriability in general, and effectiveness of patents in particular?

Most studies on the nature and sources of technological opportunities suggest that this is unlikely to be the primary determinant of observed inter-sectoral differences (cf. Dosi and Nelson, 2010, for a critical survey). Rather, the evidence suggests that the highly uneven rates of progress among industries are shaped by differences in the strength and richness of technological opportunities.

More generally let us suggest that the widespread view that the key to increasing technological progress is in strengthening appropriability conditions, mainly through making patents stronger and wider, is deeply misconceived. Obviously, inventors and innovators must have a reasonable expectation of being able to profit from their work, where it is technologically successful and happens to meet market demands. However, in most industries this already is the case. And there is little systematic evidence that stronger patents will significantly increase the rate of technological progress. (More in Mazzoleni and Nelson, 1998a and b; Jaffe, 2000; Granstrand, 1999; Dosi, Marengo, and Pasquali, 2006; and the growing literature cited therein). In fact, in many instances the opposite may well be the case.

We have noted that in most fields of technology, progress is cumulative, with yesterday's efforts (both the failures and the successes) setting the stage for today's efforts and achievements. If those who do R&D today are cut off from being able to draw from and build on what was achieved yesterday, progress may be hindered significantly. Historical examples, such as those presented in Merges and Nelson (1994) on the Selden patent around the use of a light gasoline in an internal combustion engine to power an automobile, or the Wright brothers patent on an efficient stabilizing and steering system for flying machines, are good cases to the point, showing how the patent regime may have hindered the subsequent development of automobiles and aircrafts due to the time and resources consumed by lawsuits against the patents themselves. The current debate on property rights in biotechnology suggests similar problems, whereby granting very broad claims on patents might have a detrimental effect on the rate of technical change, insofar as they preclude the exploration of alternative applications of the patented inventions.

This is particularly the case when inventions concerning fundamental techniques or knowledge are concerned. One example is the Leder-Stewart "Oncomouse" – a mouse genetically engineered to be predisposed towards getting cancer (Murray et al., 2008). This is clearly a fundamental research tool. To the extent that such techniques and knowledge are critical for further research which proceeds cumulatively on the basis of the original invention, patents could hamper further developments (Murray et al. 2008).[6]

In general, today's efforts to advance a technology often need to draw from a number of earlier discoveries and advances that build on each other. Under these

[6] It is not possible to discuss here the underlying theoretical debates: let us just mention that they range from 'patent races' equilibrium models (cf. the discussion in Stoneman, 1995) to much more empirically insightful 'markets for technologies' analyses (Arora, Fosfuri and Gambardella, 2001), all the way to evolutionary models of appropriability (Winter, 1993).

circumstances patents can be a hindrance rather than an incentive to innovate. (More in Merges and Nelson, 1994; and Heller and Eisenberg, 1998). If different parties patent past and present components of technological systems, there can be an *anti-commons* problem (the term was coined by Heller and Eisenberg). While in the standard commons problem (such as an open pasture), the lack of proprietary rights is argued to lead to over-utilization and depletion of common goods, in instances like biotechnology the risk may be that excessive fragmentation of IPRs among too many owners may well slow down research activities because owners can block each other. Further empirical evidence on the negative effects of strong patent protection on technological progress is in Mazzoleni and Nelson (1998a); and at a more theoretical level, see the insightful discussion in Winter (1993) showing how tight appropriability regimes in evolutionary environments might deter technical progress (cf. also the formal explorations in Marengo et al., 2009).

Conversely, well before the contemporary movement of 'open source' software, one is able to document cases in which groups of competing firms or private investors (possibly because of some awareness of the anti-commons problem) have preferred to avoid claiming patents on purpose. Instead they prefer to operate in a weak IPR regime (involving the free disclosure of inventions to one another) somewhat similar to that of open science: see Allen (1983) and Nuvolari (2004) on blast furnaces and the Cornish pumping engine, respectively. Interestingly, these cases of 'collective invention' have been able to yield rapid rates of technical change. Similar phenomena of free revelation of innovation appear also in the communities of users innovators: see von Hippel (2005).

The *second* set of questions regards the characteristics of the regimes stimulating and guiding technological advance in a field of activity. That is, *how* inventors appropriate returns. The conventional wisdom long has been that patent protection is the key to being able to appropriate them. However, a series of studies (Mansfield et al., 1981; Levin et al., 1987; Cohen et al., 2002; among others) has shown that in many industries patents are not the most important mechanism enabling inventors to appropriate returns. Thus Levin et al. (1987) reporting on the "Yale survey", find that for most industries

> Lead time and learning curve advantages, combined with complementary marketing efforts, appear to be the principal mechanisms of appropriating returns to product innovations (p. 33).

Patenting often appears to be a complementary mechanism for appropriating returns to product innovation, but not the principal one in most industries. For process innovations (used by the innovator itself), secrecy often is important, patents seldom so.

Pharmaceuticals is the only industry where the majority of respondents rated patents more highly than other mechanisms. Other industries where patents are relatively important include organic chemicals and plastics. What is special about pharmaceuticals and chemicals? While this hasn't been completely resolved, the conjecture is that the ability to clearly define property rights through chemical nomenclature is key. This makes it easy to enforce (and difficult to invalidate) patents on new molecules. At the same time the very revelation of the composition of a molecule tells a lot about the nature of the technology one want to protect. By contrast, in many industries "inventing around" patents is easier. On the flip side of this, the survey also found (similar to Mansfield, et al., 1981) that in most industries the impact of patents on the costs of imitation is negligible, with pharmaceutical and chemical industries as outliers. These findings were largely confirmed by a follow-on study done a decade later by Wesley Cohen at the time at Carnegie Mellon University (thus, "the CMU survey"): cf. Cohen et al. (2002).

Similar results are seen in a complementary study of the Japanese patent system (Cohen, Goto, et al., 2002), where the authors find that patents are of comparable effectiveness as in the U.S., and find similar differences across industry in use and effectiveness of patents. One sharp difference between the U.S and Japanese systems is on disclosure, discussed in some more detail below.

Comparing the results from the Yale and CMU surveys, one striking finding is that while patenting in "complex product" industries soared between the 1980s and 1990s (Kortum and Lerner, 1999), the effectiveness of patents in "complex" product industries was basically unchanged. Recent work suggests this "patent paradox" reflects a growth of patenting to use for defensive purposes in these industries – not to appropriate returns from R&D, but rather to use as bargaining chips in negotiations, or to ward off threats of infringement from others (Hall and Ziedonis, 2001). This finds direct support in the CMU responses, where respondents from complex product industries identified "strategic" purposes rather than the appropriation of returns from R&D as their primary motives for patenting. Accumulation of large patent portfolios, even those of dubious validity, is central to this strategy (Sampat, 2009). In this respect, patenting in complex product industries - which, note, dominates developed country patenting - reflects a sort of socially suboptimal "red queen" dynamic : the industry (and society) would be better off in the absence of patents, but given all others are patenting, a firm is pushed to patent and increasingly so in order to match the competitors who feel compelled to the same.

David Teece (1986) and a rich subsequent literature (cf. the Special Issue of *Research Policy*, 2006, taking stock on the advancements since his original insights) have analyzed the differences between inventions for which strong patents can be obtained and enforced, and inventions where patents cannot be obtained or are weak, in the firm strategies needed for reaping returns to innovation. A basic and rather general finding is that in many cases, building the organizational capabilities to implement and complement new technology enables returns to R&D to be high, even when patents are weak. (Note also that this all discussion has been focused on how individual firms are able to "profit from technological innovation," not on the influence of the latter strategies upon the rates of innovation). The bottom line is that, despite the fact that patents were effective in only a small share of the industries considered in the study by Levin et al. (1987), some three-quarters of the industries surveyed reported the existence of at least one effective method of protecting process innovation, and more than ninety percent of' the industries reported the same regarding product innovations (Levin et al. 1987). These results have been confirmed by a series of other subsequent studies conducted for other countries (see for example the PACE study for the European Union cf. Arundel, van de Paal and Soete, 1995).

If there are major conclusions in this broad area of investigation, they are that, *first*, there is no evidence on any monotonic relation between degrees of appropriability and propensity to undertake innovative search, above some (minimal) appropriability threshold; *second*, appropriability mechanisms currently in place are well sufficient (in fact, possibly overabundant); *third* the different rates of innovation across sectors and technological paradigms can hardly be explained by variations in the effectiveness of appropriability mechanisms, and, *fourth*¸ even less so by differences in the effectiveness if IPR protection.

Disclosure

What about the "disclosure" role of patents? Evidence from the Carnegie Mellon survey suggests that patent documents appear to be a poor source of information for firms. This may not be surprising, given the *tacit* components of technology discussed above. At least in the U.S., another potential explanation for the limited disclosure function of patents is that many firms discourage their employees from reading patents, given much stronger penalties facing willful (not accidental) infringers (Frommer, 2009). However, recent work comparing the U.S and Japan, based on the Carnegie Mellon Survey, suggests that the disclosure function is much stronger in Japan. This may reflect that, when the CMU survey was conducted, American patent applications were not published until granting, limiting the volume and speed of potential disclosure through patent documents. Moreover, Cohen et al. (2002) suggest that the existence of pre-grant opposition system in Japan created stronger incentives than in the U.S. to read competitors' patent documents.

In general, the empirical literature on innovation has repeatedly found that patents are *not* an important source of technological information, the most important exception being again related to firms in the pharmaceutical sector. While comparable empirical evidence from the viewpoint of innovation in developing countries is not available, it is possible to argue that the potential usefulness of patent disclosures for the purpose of preventing duplicative R&D does not seem to matter much for economies whose firms' innovative efforts are minimal, or whenever the development of technological capabilities is the main goal of firm-level R&D activities.

Although things might have been different in the past, the significance of *national* patents as a source of information about foreign technology appears today to be low, and diminishing. Thanks to the worldwide proliferation of digital databases of patent applications or grants originating from major national patent systems, access to the technological information disclosed by foreign patents is relatively easy, and it is implausible that such access would become substantially easier and cheaper thanks to the existence of a national patent system. While in some cases language barriers might still be of some importance, and thus make national patents useful for the purpose of knowledge dissemination, they are likely to be only a second-order problem relative to the obstacles that limited technological capabilities pose to making use of foreign patent disclosures. Accordingly, even if a national patent system were to be established in the putative developing economy, the technological information disclosed by patents could still largely be irrelevant for the promotion of follow-on innovation if the level of technological capabilities among indigenous firms is insufficient.

2. Patents and Development: Historical Perspectives

The story of industrialization, has at its center the accumulation of technological capabilities by individuals and organizations as argued at much greater length in Cimoli, Dosi and Stiglitz (2009). In that, the ease of imitation of technological and production knowledge depends on both characteristics of the knowledge itself and on the imitators' capacity for learning from available sources of knowledge. Historically, in basically all episodes of successful industrialization the process has been fuelled by many public Visible Hands promoting the development of pools of indigenous competence in various scientific and technological fields, fostering the emergence and growth of new corporate actors, and affecting directly and indirectly the allocation of resources. The creation of academic institutions has contributed to the formation of an indigenous supply of human capital that could adequately support firms' efforts at assimilating existing technologies. Likewise, early efforts at increasing the rate of absorption of existing technologies and the development of technical problem-solving capabilities can be traced to various forms of public intervention, including the creation of public research institutions (Mazzoleni and Nelson, 2009) and various other forms of 'institutional engineering' involving often the active public sponsoring of selected firms, and also the creation of state-owned ones (more in Cimoli, Dosi and Stiglitz, 2009).

It is quite clear that these public interventions were aimed at promoting or accelerating processes of technological learning that would have been otherwise absent or would have occurred more slowly, attempting as they were to alter the existing patterns of comparative advantage. It is important to notice that IPRs historically had little or no influence on these developments. Not only were they irrelevant as an incentive to the accumulation of production and technological capabilities, they also proved to be only a weak constraint on access to the relevant sources of scientific and technological knowledge. An important reason for this is that a great deal of learning efforts could concentrate on the commons of scientific and technical knowledge that had been prospering thanks to the institutions of open science and the limited duration of private property rights on old technologies. It is also the case that relatively weak patent rights available to inventors in developing economies facilitated in most cases indigenous efforts at negotiating licensing agreement over technologies of interest.

Several features of the experiences of late industrializing countries in the second half of the 20th century are by and large shared by countries that either pushed or caught up with the technological frontier during the First and Second Industrial Revolutions. Thus, the British patent system (formally in existence since 1624) has been argued convincingly to have played a marginal role in providing incentives for the advances in scientific and technical knowledge that took place during the Industrial Revolution (Mokyr, 2009; David, 2004). Indeed, the legitimacy of the patent monopoly came under considerable criticism from various social groups across much of Europe during the second half of the nineteenth century (MacLeod, 1996). It was during this time period that the Netherlands abolished its domestic patent system (1869), only to reinstate it under international pressure in 1912. The Dutch example and that of Switzerland - where creation of patent rights for mechanical inventions only occurred in 1888, and that for chemical inventions in 1907- have been central to Petra Moser's investigation on the role of patents as an incentive to nineteenth century inventive activity. Moser (2005) concludes her analysis by arguing that patents appear to have influenced the direction of inventive efforts, rather than their rate of innovation itself .

It has been argued that Swiss and Dutch inventors could still be responding to the incentives provided by patent rights, to the extent that they could secure patents rights in countries where patents were available to inventors and where their inventions could find a commercial application. While this is an important observation, it is also important to emphasize that until the principle of "national treatment" was sanctioned in the Paris Convention of 1893, many patent systems discriminated in practice if not in the letter of the law against foreign inventors. Mowery's (2009) review of the evolution of the US patent system during the nineteenth century identifies several ways in which foreign inventors' protection was weakened, ranging from higher patenting fees to the denial of patent protection for imported inventions. In general, countries catching up to the frontier have historically relied upon weak protection of intellectual property as a way to secure better conditions of access to technology and other forms of knowledge for their citizens.

Recent work surveying a range of development episodes, from the U.S. to the Nordic countries to Japan, Korea, Israel, Brazil, and India (Odagiri et al., 2009) shows that most successful development and technological "catch up" have historically occurred under relatively lax patent regimes, and that countries have a long history of calibrating their patent systems to serve broader socio-economic goals. For example, numerous countries (including Japan, Korea, and, later, China) had so-called petty patents while they were developing. By requiring lower novelty, these systems aimed at encouraging imitation, adaptation, and diffusion.

Many countries, including Italy, Switzerland, India and Brazil, have at one time or another, barred pharmaceutical product patents. Moreover, with some rare exceptions, patents and intellectual property rights have not historically been the binding constraints to catching up.

A major exception to the general non-importance of patents is in pharmaceuticals, where numerous countries have at least on occasion *limited* the types of patents allowed, with real consequences. Note also that often these limitations were not typically aimed at promoting development of capabilities by indigenous firms; instead, they were primarily for health policy reasons, to limit monopoly pricing on drugs. We observed above that patents are particularly important in pharmaceuticals. In some countries, including Israel and India, the lack of pharmaceutical product patents appears to have been key to the emergence of now-thriving generic industries. But also in these cases, elimination of patents was not the only important factor: government investments in human capital and public sector laboratories for example, were also important in each. In India, creation of an economic environment conducive to dynamic learning was also important (Sampat, 2009). Thus, *even if necessary*, lack of product patents is not sufficient for development of indigenous pharmaceutical industries.

Heterogeneity

Another theme from the historical record is heterogeneity. While discussions of the economic impact of patents - including ours above - tend to characterize patent systems in a dichotomous way (e.g. strong vs. weak), patent systems themselves are composed of numerous characteristics. Moreover there has historically been considerable variation across countries, and within countries over time, across a number of these dimensions.

One dimension is patentable subject matter: what types of things or inventions are eligible for patent protection? Within any national system of patent protection, the definition of patentable subject matter is almost certain to have been altered since the time when patent rights were first recognized. These changes - typically the result of legislative reforms, but, depending on the circumstances, also of changing judicial interpretation of existing laws - have been motivated partly by the need to address the inherent novelty of specific technologies, and partly by national and international factors influencing patent policy decisions. In the U.S., for example, the definition of patentable subject matter in the Patent Act of 1793 included "*any new and useful art, machine, manufacture or composition of matter and any new and useful improvement on any art, machine, manufacture or composition of matter*." While this definition has survived more or less intact through many rounds of patent reform, questions concerning the scope of patentable subject matter have been answered in different ways over time both in the U.S. patent case law and in the practice of the US patent office, as illustrated by the evolving views over the patentability of living things, software, and business methods (we shall come back to the issue below).

Note also that while the U.S. has adhered generally to a broad characterization of patentable subject matter, many patent systems have featured specific restrictions for certain classes of inventions, including the bans on pharmaceutical patents discussed above.

A related, but different, dimension is patent standards. Today, patent standards determine how new an invention has to be, relative to information already known ("the prior art"), to warrant patent protection. Accordingly, contemporary patent offices are charged typically with determining the "inventive step," "novelty" and "non-obviousness" of patent applications in making these determinations. But the standards for doing so have changed over time (Barton, 2003), and continue to be debated in developed countries .

In the abstract, it is unclear where to put the strict boundaries between "strong" or "weak" patent systems. It is clear however that the definition of patent standards has made it possible in several historical instances to weaken the protection available to foreign inventors. Consider for example how the 1836 U.S. patent reform created a statutory bar against the granting of patents on inventions for which a foreign patent had been granted. This statutory bar was revised the first time in 1839 so that inventors could apply for a patent in the U.S. within six months of the grant of a patent abroad, provided that the inventions had not been introduced to public and common use before the application. The bar was revised again in 1870 so that inventors could apply for a patent in the U.S. for an invention covered by a foreign patent provided that the invention had not been introduced to the public and common use in the US for more than two years before the date of application. This modification of the statutory bar against patenting of inventions patented abroad was accompanied by provisions setting the expiration of the US patent to be the earliest expiration date among the corresponding foreign patents.[7]

These standards of patentability preserved - albeit in a different form - the discrimination against foreign inventions that earlier US patent statutes realized more directly. Older statutes (e.g., the Patent Act of 1793, and subsequent revisions) denied the right to apply for a patent to foreigners who did not reside in the US, or had not resided in the US for at least two years. Patentability standards related to the citizenship or residence status of inventors were first abolished in 1836, at the time when the statutory bar against patenting of inventions patented abroad was introduced. Moreover, the 1836

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[7] These terms were modified again in 1903, in accordance with the Paris Convention on the Protection of Industrial Property of 1883, of which the U.S. became a member in 1887.

Patent Act created a discriminatory pricing structure, whereby foreigners and British inventors paid application fees equal to, respectively, ten and nearly seventeen times those required of US applicants. It should be noted that during this time period, the British patent laws established novelty exclusively on the basis of the publication or public use or knowledge of the invention in the UK.

Other important dimensions are the length or duration of patent terms and the scope of protection. As for many other features, the duration of patent terms has been the subject of numerous revisions in virtually every country. Many early patent statutes only declared a maximum term of protection, vesting into the appropriate government officers or agents the authority to determine the appropriate duration for any single patent. In others, the patent applicant had to select the term of patent protection among various possibilities, and pay the appropriate fees. While the trend has been toward lengthening the patent terms as a matter of statutory rights, and setting a standard term applicable to all inventions, in practice statutory patent terms (e.g., twenty years from filing) need not map to "effective" patent lives, or the number of years of market exclusivity actually provided by patents. This can be the case because market entry may not commence until well after patent terms begins (e.g., in pharmaceuticals), or because product life cycles are short enough that the whole patent term rarely binds (e.g. in semiconductors), or because "inventing around" patents is possible in some industries/contexts, as discussed above. Maintenance fee and renewal schedules also affect the economic duration of patents, as do a variety of practices concerned with the extension of patent terms on any given invention (e.g., the British patent on the Watt steam engine) and with the "ever-greening" of patent portfolios. As is the case for patent standards, policy choices about the length of patent terms defy easy characterization in terms of the "strength" of patent protection.

Similar ambiguities apply with respect to yet another dimension of patent systems, namely the range of later products that would be deemed to infringe a patented invention, or patent scope (Merges and Nelson, 1990). How close does a later use of a patented invention have to be for it to be considered infringing? How broadly should claims in a patent application be read? These determinations affect the extent to which patents can block later entrants.

Related to this, the enforcement regime also matters. Laws and the enforcement policies of the relevant governments determine what sorts of infringement are allowed *de jure* (e.g. is reverse engineering during the patent term permitted? How about for research use?), or *de facto* (Is it easy to sue infringers? Do the courts impose significant penalties for infringement?).

Laws and regulations on compulsory licensing - when the government allows others to produce products without consent of patent owners - are also part of the enforcement regime. It should be noted that compulsory licensing provisions and rules about the revocation of patent right due to the patentee's failure to work the patent in the country of issue have been commonplace in the patent statutes of most countries. These provisions served clearly the purpose of weakening the strength of protection offered to foreign inventors. Indeed, the compulsory working provisions introduced by the UK in the Patents and Design Act of 1907 marked the first time that British patent law implemented a measure clearly hostile to the interests of foreign inventors. Interestingly, it was possibly the first time that the British system of innovation *and appropriation* felt threatened by German and American innovators.

4. The contemporary scene

Since the 1980s, there has been a radical reshaping in the management and the structure of IP regimes at the global level. Let us get into some details since the regime changes bear important ramifications in terms of international IPR rules and constraints. The changes have been occurring in a context where trade liberalization has been coupled with pressures - sometimes at gunpoint- to strengthen intellectual property rights on an international scale. In this regard, the changes in intellectual property regimes concern two different, although related, domains.

First, there has been a quite significant modification of prevailing norms deriving from jurisprudential rulings within the US system that has influenced the *Weltgeist* in many other countries – developing and developed ones. Second, there is the increasing relevance of intellectual property in multilateral and bilateral trade negotiations and in international disputes between countries. In this respect, the adoption of the TRIPS agreement marked a milestone in the big push towards the homogenization of a (*quite high*) minimum standard of IP protection.

A new set of incentives in the US IP laws and the "American preference"

Beginning in the 1980s, intellectual property protection has been (deliberately) intensified in the United States through various channels including: extension of patentable subject matter, extended time protection, and the growth of the range of subjects who pursue and exercise intellectual property rights over their inventions. Subsequent to these changes, there has been an upsurge in patenting activity (which, however, hardly reveals a corresponding upsurge in innovative activities: more in the chapter by Jaffe and Hu). A deep analysis of these issues goes beyond the scope of this chapter[8], it suffices here to recall two major changes: a) the extension of patent subject matter, and b) the Bayh-Dole Act.

<u>The extension of patentable subject matter</u>

We have already mentioned the historical definition of a patentable matter in the US. However , nowadays, the most probable answer to the question, "Can I patent that?" is likely to be yes, as Hunt (2001) argues in his critical paper on the introduction of patents for business methods in the US economy. The relaxation of patentability criteria, due to some Supreme Court rulings, led to an extension of the patentable subject matter. In fact, US firms increasingly use patents to protect physical inventions as well as more abstract ones, such as computer programs or business models and methods[9].

According to US jurisprudential tradition, laws of nature, and hence mathematical formulas, could not be the subjects of a patent (cf. *Gottschalk vs Benson*, 1972). However, in 1981 the *Diamond vs. Diehr* Supreme Court decision paved the way for computer software and business methods' patentability by asserting that "a claim drawn

[8] There is a remarkable body of literature analyzing the changes in IP laws and court rulings, and the boom in patenting activity. See Kortum and Lerner, 1999; Hunt, 2001; Gallini, 2002, among others.
[9] The Amazon's "one click" patent granted in 1999 by the USPTO is a clear example.

to subject matter otherwise statutory does not become non-statutory simply because it uses a mathematical formula, computer program or digital computer."

The Court of Appeals for the Federal Circuit (CAFC), instituted in 1982, also played a decisive role in the extension of patentable subject matter through several jurisprudential rulings that reversed the prevailing doctrine. The *State Street Bank and Trust vs Signature Financial Group* (1998) CAFC decision allowed the patentability of business methods when the claimed invention satisfies the requirements of novelty, utility and non-obviousness. This decision also made the utility requirement more lenient.

Through a re-interpretation of patentable subject matter and of previous rulings, the *State Street vs Signature* decision reversed the prevailing doctrine and allowed patenting of algorithms as long as they are "applied in a useful way", i.e. as long as they produce "a useful, concrete and tangible result." According to this decision, registrants seeking patent protection for business methods or algorithms are not required to disclose their computer methods[10]. Contrary to the previous Supreme Court ruling, a mathematical formula and a programmed digital computer *are* currently patentable subject matter under the chapter 35, p. 101 of the US Code[11]. This tendency favors the engendering of what has been called the "patent thicket" with its likely negative potential effects on future rates of innovations, especially with respect to incremental innovations. For example, in the software industry, in which each application might be built upon a series of hundreds of patented algorithms (Shapiro, 2001).

The extension of the patentable domain also involved living entities. The 1980 *Diamond vs Chakrabarty* Supreme Court decision stated that "a live, human made micro-organism is patentable subject matter," [12] paving the way for a series of rulings which led to the patentability of partial genes sequences (ESTs[13]), including genes crucial to treating illnesses (Orsi, 2002). Another decision worth mentioning is *Re Brana* 1995. This ruling established the presumption of utility and reversed the jurisprudence that supported the circumspect practice of the USPTO in granting patents in this field. *Re Brana* recognizes the validity on patent claims on discoveries not yet made or not yet materialized.

In the US patent law, 'utility' is an essential criterion for patentability. 'Utility' refers to the industrial and commercial advances, 'useful arts,' enabled by the invention. Relaxing the meaning of 'utility' transforms non-patentable subject matters into patentable ones. Again, the *Re Brana* Court decision is remarkable. Partial sequences of ESTs were classified as useful due to their potential contribution to future advances in knowledge, and this sufficed for these entities' patentability, despite their value as research tools[14]. Disavowing a previous Supreme Court ruling that explicitly warned

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[10] Smets-Solanes (2000) presents evidence on several cases of patented business models that do not disclose the computer processes and algorithms involved.

[11] Regarding software patentability, see Liotard (2002), Samuelson (1998) and Mergès (2001). See the Besen and Raskind (1991) survey on IP, as well.

[12] In Europe, in spite of the 1998 EU Directive, this process of extension of the new right regarding living entities met serious opposition

[13] *Expressed Sequence Tags* or "partial sequences" of genes. The utilization of this process constitutes an advance in the methods that can be used to identify complete sequences of genes.

[14] It is worth noting that this evolution of the American law would have been impossible *per se* under the Continental European law, according to which a key distinction separates "discoveries" (pertaining to knowledge) and "inventions" (pertaining to applied arts), the latter being the only patentable subject matter.

against inhibiting future research by restricting access to knowledge, *Re Brana* allowed patent applicants the right to make extensive claims with reference to "virtual" inventions, i.e. inventions that have not yet been made and that cannot be predicted. Patents were transformed from a "reward" granted to the inventor in exchange for the disclosure of the invention into a veritable hunting license[15]. Patents might thus result in a *monopolistic right of exploration* granted to the patent holder even before any invention has been made and *a fortiori* disclosed.

Subsequent rulings and Supreme Court decisions engendered a new patent regime that creates conditions for transforming research advantages into competitive advantages, guaranteeing an upstream protection of the "research product," which results in the right to exclude rival firms from benefiting from "basic" discoveries (Coriat and Orsi, 2002). The resulting fear is that the system is moving toward the dissipation of fruits of the traditional "open science" paradigm (Dasgupta and David, 1994). The new regime covers areas such as software and living entities, generic key inputs, research tools and raw materials possibly instrumental in an undefined number of "downstream" applications . In a context in which innovations are often cumulative in nature, the progressive enclosure[16] of technical knowledge, which in turn underlies subsequent advancements in science and innovation, may induce the "lock-out" of potential innovators. In turn, this may offer unjustified monopoly power to small, technology-intensive "niche" firms with no physical processing or distribution capacity.

Indeed the changes in the US IP laws and jurisprudence boils down to a *de facto* industrial policy, intended to preserve competitive advantages and rents especially in a few sectors – such as the entertainment industry and biotech.

<u>The Bayh-Dole Act</u>

The inclusion of provisions that allow granting patents through *exclusive licenses* only to US manufacturing firms, as it is stated in section 204 of the Bayh-Dole Act, which sets the conditions for the "American industry preference," responds to the same *de facto* industrial policy strategy. In 1980, the US Congress adopted the Bayh-Dole Act, which is embedded in title 35, chapter 18, of the US Code under the label of "patent rights in inventions made with federal assistance." This Act set the principles for patenting inventions realized by institutions receiving federal funds for R&D, and introduced two basic changes in the US IP regime: i) it established a new principle that gives to institutions (universities and public research laboratories) receiving public funding the right to patent their discoveries and ii) it affirmed the right to license the exploitation of those patents as *exclusive rights* to private firms, and/or to engage in "joint ventures" with them. The literature has already extensively analyzed the impact of this act on the rate and direction of innovative activities. Scholars have stressed the fact that the enactment of the Bayh-Dole Act established a new IP regime that threatens the

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We should, however, further specify that even under the American law, the observed changes were neither grounded in objective fact nor even foreseeable. On this point, see the discussion in Orsi (2002).

[15] This is despite the fact that the Supreme Court had specifically warned that "*a patent is not a hunting license*" in its *Brenner vs. Manson* ruling. (on this point, see Orsi, 2002; and Eisenberg, 1995).

[16] The idea that the new IP regime can be analyzed as a new "enclosure" movement is at the heart of a series of works and studies first introduced by Boyle. (See among others Boyle, 2003)

previously dominant open science principle[17]. The possibility of granting exclusive licenses on research findings obtained by the main centers of scientific knowledge, such as universities and public laboratories, creates a basis for appropriating basic knowledge, which should, by definition, constitute the knowledge base available to all national innovation system agents. Dasgupta and David (1994) emphasize the fact that this appropriation of knowledge is achieved through a series of "bilateral monopolies" that universities and public laboratories share with private for-profit organizations, thus contributing to the commoditization of research outcomes (Eisenberg, 2000; Orsi, 2002).[18]

In fact, the new regime also bears implications with respect to the ways in which patenting is justified. As noted in Mazzoleni and Nelson (1998a), the "incentive theory" has to fade away since the invention is made with federal financial assistance: hence inventors receive an *a priori* reward. Conversely, shifts in the US patent system introduced a different (and new) type of incentive: the inducement to transfer from public research to marketable products, favoring the appropriation of research results to firms that have not been engaged in fundamental research. Firms are induced, through the benefit of exclusive licenses, to commercialize outcomes of publicly funded research even before those outcomes are obtained. In this respect, Mazzoleni and Nelson (1998a) discuss an "induced commercialization theory." Patents no longer reward the inventor *ex post* – instead, the *ex-ante* reward transmogrifies the patent's status from an exploitation right to an exploration right.

The extension of patents' domain and the 1980 Bayh-Dole Act modified the academy-enterprise links in knowledge generation and diffusion. In the decade since its passage, academic institutions patenting grew dramatically. Increasingly, the outputs of publicly funded research both published and patented, and their dissemination governed by market mechanisms. The Bayh-Dole Act reversed the previous presumption that free access to basic research outcomes was granted equally to all firms (that profited differently from the available knowledge pool depending on their specific assets and capabilities).

International proxies for IPR protection

The multidimensional characteristics of the patent system have been addressed by numerous efforts at developing summary national measures for the strength of patent protection. Such measures provide a relatively simple basis for international comparisons and for the analysis of the determinants of patent rights, or at the very least, of the latter's correlations with various indicators of national economic development.

The construction of national indices of patent protection - exemplified by the widely cited work of Ginarte and Park (1997) - provides quantitative support to the proposition that the distribution of countries according to the strength of patent protection displays considerable and persistent heterogeneity. For a sample of 110 countries, Ginarte

[17] See Mowery at al. 2004; Mazzoleni and Nelson, 2002; Mowery et al., 1999 and Dasgupta and David, 1994 for broadly converging analyses regarding the effects of the introduction of the Bayh-Dole Act in the US IP regime.

[18] In this regard, we note that an important source of royalty income for universities has been represented by patents that were licensed non-exclusively, a practice that amounts to a tax on the use of the underlying knowledge.

and Park (1997) found that both the mean and the variance of the national indices increased during every five-year period between 1960 and 1990. In light of the observed correlation between GDP per capita and strength of patent protection, this phenomenon can be obviously linked to the absence of convergence across countries in terms of their GDP per capita.

5. … and along comes TRIPS

TRIPs must be seen in this context. Passed in response to lobbyists from developed countries, TRIPs compels upward harmonization of patent laws. A detailed discussion of the legal changes required by TRIPs is beyond the scope of this paper (and indeed, beyond the competence of the authors). The main changes relative to the status quo discussed above are the minimum patent terms of twenty years from filing, restrictions on the ability to bar industrial patents, non-discrimination (or the requirement that domestic and foreign innovators be treated equivalently), and a set of requirements that patent laws be enforced.

By the turn of the century, most developing countries were compelled to introduce TRIPs-compliant patent laws. Countries that did not previously offer patent protection on pharmaceutical products had time until 2005 to do so, although they were required to comply with a "mailbox" provision such that patents could be filed in the country as early as 2000, even if the patent grant could not occur for at least another five years. Finally, a range of "least developed" countries were permitted to delay the timing of TRIPs implementation until 2006; this was extended to 2016 via the Doha Declaration.

There has been, interestingly, considerable variation in the timing of TRIPs implementation. Some developing countries passed legislation to adopt TRIPs- compliant patent laws well before their deadlines (e.g., Argentina, Costa Rica, the Dominican Republic, Korea), often as a result of previous or concurrent bilateral pressures (Correa, 2007). Others took full advantage of transition periods (e.g., Belize, Egypt, the Philippines) (Deere, 2009). Even a number of the least developed countries have adopted sooner than necessary (e.g. Cambodia, Chad, and Guinea).Given the importance of technological learning for catching up, and the general lack of patent protection for developing countries historically, these changes are striking. For example, the following table (reproduced from Deere, 2009, Appendix 3) suggests the widespread impact of two major changes to developing country patent laws resulting from TRIPs – the upward convergence of patent terms and the requirements that pharmaceutical patents be granted:

Country	Term of patent protection		Exemption from patent protection for pharmaceutical products	
	1988 (years)	2007 (years)	In relevant law (1988)	In relevant law (2007)
Least developed countries				
Bangladesh	16[c,a]	16[c,a]	X	X
Benin	10[a,d]	20	X	–
Burkina Faso	10[a]	20	X	–
Burundi	20[a]	20	–	–
Cambodia	–	20	–	X
Central Afr. Rep.	10[a,d]	20	X	–
Chad	10[a,d]	20	X	–
Ghana	10[a]	20	X	–
Mali	10[a,d]	20	X	–
Mauritania	10[a,d]	20	X	–
Nepal	7[e]	7[e]	X	X
Niger	10[a,d]	20	X	–
Rwanda	20[a]	20	–	–
Sierra Leone	20[a,*]	20	–	–
Swaziland	20[a,*]	20	–	–
Togo	10[a,d]	20	X	–
Uganda	20[a,*]	15	–	–
Tanzania	20[a,*]	20	–	–
Developing countries				
Argentina	5, 10, 15[c]	20	X	–
Bolivia	15[c]	20	X	–
Botswana	20[a,*]	20	–	–
Brazil	15[a]	20	X	–
Cameroon	10[a]	20	–	–
Chile	15	20	–	–
China	15[a]	20	X	–
Colombia	5[c,d]	20	X	–
Congo	10[a,d]	20	–	–
Costa Rica	12	20	#	–
Côte d'Ivoire	10[a,d]	20	–	–
Cuba	10[a,d]	20	X	–
Dominican Republic	5, 10, 15[c]	20	–	–

(cont.)

Country	Term of patent protection		Exemption from patent protection for pharmaceutical products	
	1988 (years)	2007 (years)	In relevant law (1988)	In relevant law (2007)
Ecuador	5[c,d]	20	X	–
Egypt	15[a,d]	20	X	–
Gabon	10[a,d]	20	–	–
India	14[b]	20	X	–
Jordan	16[a]	20	–	–
Kenya	20[a,*]	20	–	–
Malaysia	15[c]	20	–	–
Mauritius	14[a,d]	20	–	–
Mexico	14[c]	20	X	–
Morocco	20[a]	20	X	–
Nigeria	20[a]	20	–	–
Pakistan	16[c,d]	20	–	–
Peru	5[c,d]	20	X	–
Philippines	17[c]	20	–	–
Senegal	10[a,d]	20	–	–
South Africa	20[a]	20	–	–
South Korea	15[a,d]	20	X	–
Sri Lanka	15[c]	20	–	–
Thailand	15[a]	20	X	–
Trinidad & Tobago	14[c]	20	–	–
Tunisia	5, 10, 15, 20[a]	20	X	–
Uruguay	15[c]	20	X	–
Venezuela	5, 10[c]	20	X	–
Zimbabwe	20[a]	20	X	–

Source: Data for 1998 draws from Dutfield (2000). The 2006 data was compiled by author based on the WTO Secretariat's Trade Policy Review reports on members.

[a] From filing date.

These changes are dramatic. While it is too soon to assess their impact, for the various reasons discussed above, they are unlikely to have significant impact on domestic innovation (cf. Lerner, 2002; Lanjouw and Cockburn, 2001). Indeed, even in pharmaceuticals where patents tend to be more important, Qian (2007) finds little evidence that domestic patent laws matter for the rate of innovation. And recent work on the Indian pharmaceutical industry suggests that while the importance of R&D in the Indian drug industry has been increasing post-TRIPs, this has little to do with TRIPs per se.

Instead, the changes are likely to shift composition of patenting in developing countries towards developed country and multinational firms, who will no doubt try to use the patents to extract rents from developing country consumers, and perhaps foreclose on developing country firms' own learning and production activities. A particular concern in India is that the new patent regime will limit production of low cost HIV-AIDS drugs by Indian generic firms, long known in public health circles as "pharmacy to the developing world" (Sampat, 2009).

There is also variation in content of the laws. Some countries have taken significant advantage of TRIPs-flexibilities and room for maneuver. Some of these flexibilities were inherent in TRIPs, others required clarification from the WTO Declaration on TRIPs and Public Health, which affirmed the rights of countries to enact laws to prevent "evergreening" and to issue compulsory licenses to protect the public health, among other options. Thus many developing countries have limited patents on "new uses" of existing compounds (Musungu and Oh, 2006). Most controversially, Section 3(d) of India's patent law has strong restrictions on patents on "incremental" innovations (Sampat, 2010). Several other developing countries, including Malaysia, Indonesia, and Bangladesh, are considering similar provisions.

Developed countries expected TRIPs to generate a world with patent laws mirroring the US and EPO. The "counter harmonization" movement (Kapczynski, 2009) and aggressive exercise of TRIPs flexibilities by many important countries has tempered that hope, particularly in the pharmaceutical sector where patents are most important. So far, these have been interpreted as perfectly consistent with TRIPs by the WTO.

Perhaps not surprisingly, these developments have galvanized developed countries to push again for stronger measures, now through bilateral measures. Today, the US and other industrialized countries are aggressively pushing so-called "TRIPs-plus" changes in patent laws via bilateral trade agreements. The changes developed countries are lobbying for include long data exclusivity periods (which would protect innovations even where patent standards are not met), and removal on restrictions to patentable subject matter (e.g., new uses). These bilateral initiatives thus aim to ratchet up IPRs, and close the doors that TRIPs left open.

However, TRIPs flexibilities do not return us to the status quo ante: there is no doubt that most countries' patent laws are on average considerably "stronger" now than they were a decade ago. Moreover, patent laws are effectively implemented by patent examiners (Drahos, 2002). In developing countries, these examiners tend to rely heavily on their developed country counterparts for their training, search manuals, and databases (Drahos, 2002; Kapczynski, 2009). In this context, there are questions whether there is de facto institutional isomorphism, with developing country examiners following the lead of the US and EPO on the same applications, rather than enforcing the nuances of their own (more restrictive) patent laws (Kapczynski, 2009; Drahos, 2002).

Conclusions

The punch line of our discussion on the historical relations between IPR and development is that the impact of the former has been often irrelevant. Conversely, there is no convincing evidence showing that any country's development prospects are hurt by the weakness of the domestic system of IPR protection. These lessons from the historical experience inform our speculations on the consequences of the recent changes in the international IPR regime. As the discussion above suggests, the main impacts are likely to be in pharmaceuticals and chemicals. Given the limited effectiveness of patents in other fields, they may serve as nuisances and obstacles, but are unlikely to be the binding constraint on development efforts. Another reason they will have more impact in pharmaceuticals is that the difference from the pre-TRIPs era is most pronounced in that field, given the widespread restriction on product patents *ex ante*.

As discussed above, and as other contributions to this project emphasize, there are also various flexibilities, and room for interpretation, included in TRIPs, in pharmaceuticals as elsewhere. In pharmaceuticals, restrictions on patenting incremental innovations are non-trivial, since these patent dominate the pharmaceutical patent landscape in the U.S. (Kapczynski, 2009) and Europe (EC Commission Report, 2009).Thus even in the wake of considerable harmonization, there is also room to maneuver - even in pharmaceuticals. The push for “TRIPs-plus” measures is a reaction to these. To the extent that we are right about the importance of public knowledge for capability accumulation and access in developing countries, these changes toward a even tighter IPR system should be resisted. More generally, the numerous developing countries that have not yet implemented post-TRIPs patent laws should closely monitor and learn from the experiences of those that have.

Paraphrasing the conclusions of a well known review of the patent system authored by Edith Penrose (1951), we conclude by arguing that if minimum international standards of intellectual property protection did not exist, it would be difficult to make a conclusive case for introducing them. On the contrary, we believe that the findings of the empirical and theoretical literature on patents support a strong case for reforming the regime of intellectual property protection and for backing off from the global convergence toward the standards of protection that prevail in the U.S. and other advanced economies. Such reform would be in the interest not only of technological catching up efforts by developing countries, but also in the interest of innovation in developed ones. In this respect the various chapters that follows offer important insights for institutional and policy changes.

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