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Intellectual Property Rights for Governance in and of Innovation Systems

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Abstract

This chapter attempts to look upon the role of IPRs in different innovation systems – national, sectoral, corporate, university and military systems – in a governance perspective. The rapid advent of the pro-IP era from the 1980s on, embedded in the more grand and gradual emergence of a new type of economy dominated by intellectual capital, has generally transformed and strengthened various IP regimes in these innovation systems, with an increasing use of patent and licensing oriented regimes.

Availability of enforceable and valuable IPRs together with more large-scale R&D and complex new technologies, calling for more inter-firm technology collaborations and various forms of technology trade (licenses, small firms, services etc.) have fostered quasi-integrated corporate innovation systems. Seen in a governance perspective the IPR approach creates governance tools but also governance problems but so do other approaches to incentivizing and coordinating innovative activities as well. A re-evaluation of various approaches is needed, focussing on both incentivizing and coordinating functions, for sustaining efficient and effective innovation systems.

Key concepts

Key concepts in this chapter are used in the following way (with approximate synonyms within parentheses):[1]

R&D will include any creative or inventive, research and development activity not only confined to what is formally accounted for or organized as R&D.

Technology is a body of knowledge about techniques and is used here in the commonly confined sense of natural science related engineering techniques.

IPRs, i.e. intellectual property rights, include patent, copyright, design, trademark, trade secret, database, animal/plant breeding and some other rights in intangible creations.

IP denotes the underlying intangible (intellectual, immaterial) resource (or asset or capitalized entity) to which an IPR is associated. The distinction between IP and an IPR is often important.

IP regime: A type of IP-based governance, oriented around particular IPR-types and their associated legislation and enforcement. Thus, one talks about strong and weak IP regimes (referring to strength of legislation and enforcement) and patent vs. trade secret regimes (referring to the particular dominant IPR type). The concept is somewhat vague or elastic but commonly used (perhaps due to its vagueness, since what is vague could be vaguely right).

Governance: An umbrella term for rule-based institutions coordinating economic and social activities, with management hierarchies and markets as two main polar type of institutions.

Innovation: Anything new and useful, where new is new to the world, i.e. new to everyone and useful is useful to someone.

System: A set of components, related (connected) to each other in some ways. Usually a system is functional in some sense with respect to some associated performance criteria. Moreover a system has boundaries across which it interacts with its environment through inputs and outputs; it has internal structures and processes, with feedbacks as an especially important type; it could be hierarchical or not and is decomposable into sub-systems. The components of systems could be almost anything – ideas, artifacts, humans, organizations.

Innovation system: A system that involves innovations. These systems usually comprise actors, artifacts, knowledge and institutions, usually with economic functions and performance criteria. They can be defined at various levels – national, regional, sectoral, corporate etc., and can be hierarchical or non-hierarchical (as in some nations and commonly at sector level). See further a special section in this chapter.

[1] More concise definitions could be given, but emphasis here is on brief and sufficiently clear descriptions.

List of abbreviations

DARPA	Defense Advanced Research Projects Agency
EPO	European Patent Office
ERA	European Research Area
EU	European Union
FDI	Foreign direct investment
GATT	General agreement on tariffs and trade
GDP	Gross domestic product
GPS	Global positioning system
IC	Intellectual capital
ICT	Information communication (Infocom) technology
IP	Intellectual property
IPO	Initial public offering
IPR	Intellectual property right
LDC	Less developed country
M&A	Merger and acquisition
MNC	Multi-national corporation
MNU	Multi-national university
OSM	Open source movement
PCT	Patent cooperation treaty
PMC	Private military corporations
PPR	Physical property right
R&D	Research and development
S&T	Science and technology
TRIPs	Trade-related intellectual property section (of GATT)
WIPO	World Intellectual Property Organization

1 Introduction

1.1 Background

Sustained progress almost by definition requires a sustainable flow of innovations, i.e. new and useful information and things. All currently known economic systems have difficulties to efficiently induce and govern such a flow and alleged signs of their dysfunctioning are likely, e.g. in terms of over- and underinvestments in R&D and innovation. As innovations moreover become larger in both scale of production and scale of use and interdependencies among them proliferate, coordination problems within and across different flows of innovations grow in addition to incentive problems. This is particularly true for technological innovations due to the cumulative and interactive nature of new technologies. In this context, the innovation systems approach has emerged as described in the sequel.

Innovators, being early movers, have to perceive sufficient advantages accruing from their innovative efforts and may deploy various means or strategies towards that end, such as creating lead times in exploration and exploitation or creating strong user ties or other barriers to imitation. Societies and organizations urging for progress in turn have various institutional means or policies to help foster innovations and innovators, such as creating incentive schemes and motivation structures through e.g. recognition, prizes, subsidies, contracts and limited rights.

The use of various rights to induce innovations of various kinds is an old institutional arrangement although the by now customary recognition of these rights as intellectual property rights (IPRs) is of more recent origin. The (growing) family of IPRs comprises old types of rights such as patents for inventions, trade secrets, copyrights, trade marks and design rights, together with newer ones such as breeding rights, maskwork rights and database rights. These rights – although subsumed under the label IPRs, suggesting some coherence – in fact comprise a very heterogeneous set of rights hardly (yet) constituting what could be called an IPR system. The various IPRs have usually long running and fairly separated histories of legal and economic developments and concomitant controversies, surrounded by relative neglect on average among the public at large, including policy-makers, managers, and the economics and law professions in general. Nevertheless, the underlying criteria for granting these rights have surprisingly many similarities in emphasizing novelty, usefulness and distinctive originality (or inventiveness).

1.2 Purpose and outline

The purpose of this chapter is to make a first attempt to elaborate on the role of IPRs in various innovation systems and then to view them in a governance perspective. In so doing not only national and sectoral innovation systems but also corporate, university and military systems will be dealt with. These latter three types of innovation systems are usually not dealt with in the innovation systems literature. As will be seen, different innovation systems at national, sectoral and corporate levels have employed different IP regimes. The regimes have also

changed over time and in recent decades in particular in connection with the emergence of a strong IP regime globally, commonly referred to as the pro-IP era, linked to the emergence of a new type of economy in which intangible assets or intellectual capital in some sense has come to dominate. In this context IPRs have increasingly become viewed not only from an incentive point of view but also in a governance perspective, i.e. how different modes of governance of innovation and diffusion (through management, markets or intermediate forms) are helped or hindered by the use of the IPR approach. In this perspective, various forms of technology trade and inter-organizational technology collaboration contracts become important. The chapter first briefly describes the property approach to governance with the intellectual property approach as a particular but increasingly important special case. Then a history account of IPRs and innovation systems is given followed by an account of theories and rationales of the patent system as a special but most important case. Finally an empirical part follows, dealing with the role of IPRs in the five types of innovation systems mentioned.

2 Evolution of the IPR system and systems of innovation

2.1 Early patent history

Notions of intellectual property have evolved from the dawn of history, especially oriented around secrets.[2] Identity-related symbols are also of early origin.[3] IP for gaining trade-related advantages was less important in prehistoric times, but secrets and symbols as means to gain and preserve power and governance structures were important, especially in political, military and religious settings.

IP notions developed as trade and technology developed in the Middle Ages and a need to finance increasingly large scale innovations arose. Remunerating the disclosure of secrets, an ancient practice in itself, became increasingly important as technical know-how and its cumulation gained importance. Various types of compensations – prizes, grants, patent privileges, etc – were considered. What probably made a patent-like privilege particularly attractive to a ruler or a governing body was its financial feature. A privilege that protected the privilege holder from competition allowed him to charge higher prices. To the extent that competitive trade developed, the privilege holder was remunerated by privilege granter, i.e. the governor in such a way that the governor, i.e. the privilege granter, did not have to risk any finance.[4] A patent privilege also carried the advantage that the remuneration was tied to the actual useful working of a device, i.e. to its

[2] One may in fact argue that some fundamental IP notions are not a culture-specific institution but more deeply biologically rooted in features of human identity formation, information processing, incentive structure and propensity to trade common to all cultures (such as protection possibility of individual secrets and dispossession impossibility of an individual's know-how). See Granstrand (1999).

[3] These symbols correspond to trademarks, but could also be seen as related to designs and copyrights since they involved visual expressions.

[4] Thus, a patent privilege, in a way, functioned as a decentralized scheme to tax consumers for a period of time. Also in modern times a strong patent system is attractive to a government in an advanced country as a policy measure since it is easy to finance. The government does not have to pay subsidies and the patent offices and court system can be largely self-financed. There need not be any losses to the government through business tax money, either. On the contrary, tax revenues might increase due to monopolistic pricing.

innovation nature, and the expressed demand for that device, i.e. its diffusion or market penetration. This advantage could be achieved by a prize system as well, but then the governing body had to finance the prize. From the patent holder's point of view, a patent privilege implied a risky remuneration ex post, i.e. in connection with commercial success, based in turn on technical success, and it financed neither any necessary investments ex ante nor any failures ex post. This disadvantage could be mitigated by a grant or a loan in combination with the patent, however, but then at the discretion of the governing body. Thus, the emergence of the patent system can be seen partly as a reaction against secrecy in a context of the rising importance of technology and trade, and as a scheme for jointly promoting inventions, innovations and their diffusion, a scheme that provided an attractive mode of financing for the privilege granter.

As mining became a more technically complex operation, e.g. going deeper into the ground, more technical devices were needed, e.g. for removing water. Patent-like privileges were then granted in Europe to originators and financiers of these devices by extending mining law principles (Kaufer 1989). Often remuneration took the form of rights to a certain share of the mine's output, again an attractive mode of financing, similar to licensing on a barter basis.

In the 14th and 15th centuries the Republic of Venice was engaged in mining and "water arts" as well. At this time Venice had two types of privileges, invention privileges and trade privileges. An invention privilege gave protection from unlicensed imitation of an invention, while a trade privilege gave protection from competition in general.[5]

In 1474 Venice promulgated a formal patent code, the first one known in history. The code incorporated various ideas practised in preceding cases. Inventions shown to be workable and useful received ten years of protection subject to compulsory licensing provisions. The 1474 patent code and its preceding practices were a way for Venice to attract engineers from the outside and stimulate orderly technical progress, although it was not the only way.

2.2 Emergence of innovation systems, the pro-IP era and a new type of economy

In the 20th century, industrial and military science based R&D emerged on a substantially larger scale as well as research universities, entailing very different modes and settings for innovations. The individual inventor, who was the original target for patent laws, gradually has become relatively less important. Innovations increasingly require large resources, and industrial firms and the military establishment have become the prime owners and movers of technology in inter-organizational settings that could be described as innovation systems, both in terms of technical (artifact) systems and actor (organizational) systems. Similarly, cultural arts and innovations (movies, concerts, books etc.) have become big business, with more professional artists and organizations than ever. Differences between countries have increased, industries have grown and diversified, science and technology have progressed and accumulated, globalization has increased etc. Still the IPR system and its essential ideas have survived and continued to diffuse

[5] These two privileges could overlap, but not necessarily. This parallels the contemporary fact that a patent right does not convey a right to trade a product based on the patent, e.g. in pharmaceuticals where government approvals are needed.

internationally, not the least after the downfall of the Soviet Union and the corresponding planned-economy systems. This resilience of ideas and persistent adoption of a fairly well preserved and long-standing institution is indeed surprising as its current context has changed radically since its distant origins, e.g. 15th-century Venice in case of patent legislation.

An anti-patent movement in the 19th century Europe more or less ended in the 1870s (see Machlup and Penrose 1950). Political and economical forces largely defeated the anti-patent movement. These forces were under the surface not directly linked to the patent system so they did not produce a marked reversal into a pro-patent era. Patent legislation continued to carry weight, and the patent system was internationally adopted and harmonized to some extent, but patent issues were by and large circling in the backwaters of business, economics and policy-making and continued to do so for a good century. In the USA a revival of certain anti-patent sentiments appeared in the inter-war years, as large corporations with strong in-house R&D emerged, some of them blatantly using the patent system to build up dominant market positions (see e.g. Folk 1942 and Scherer 1980, p. 451).

However, a pro-patent era was set in motion in the USA in the 1980s and then gained ground internationally for various reasons, also evolving into a broader pro-IP era. (See further Granstrand 1999, Jaffe 2000 and Coriat and Orsi 2002.) Since the 1990s criticism of "overshoot" has grown but with no signs of a significant reversal of the pro-IP era, on the contrary. This may be seen as a reflection of the growing strength of more fundamental forces in the international economy. The rapid emergence of a much stronger IP regime since the 1980s, has by and large been concomitant with a much grander and more gradual emergence of a new type of economy, the roots and trends of which stretch much further back in history. This economy is essentially characterized by a confluence of old capitalist institutions, more dominant than ever after the downfall of the Soviet empire and the demise of planned economies, and a new kind of dominance of intellectual capital, comprising intangible assets (knowledge, IPRs etc.) valued or weighted by various means and methods. Hence this type of economy, being new in the sense that knowledge and intellectual capital has come to dominate, has been referred to as the knowledge (learning, information) based economy or intellectual (knowledge) capitalism or simply the "new economy".[6] However, the newness derives from the new role of dominance of intellectual capital that has gradually emerged, while the old, basic capitalist institutions remain (i.e. firms, markets, property rights and profit-seeking). Thus, the notions that the new economy is entirely new and is resulting from a rapid change have to be dismissed (rapidly and entirely).

2.3 IPRs in the emergence of intellectual capitalism

What role has the IPR system then played in the emergence of intellectual capitalism? This must be left largely as an open question here, but a few observations may be done. First, the IPR system has historically been neither

[6] The concept of intellectual capital has often been defined as a residual once tangible assets are defined, just as the notion of technology once was in the decomposition of inputs in a production function. However, several efforts have been made and are underway to give more precision to the concept, not the least for accounting purposes.

necessary nor sufficient for neither technical nor economic progress, such as in the first industrial revolutions (Granstrand, 1999). This is hardly a surprising statement but is nevertheless important to keep in mind, especially since technical progress is increasingly seen as necessary for economic progress[7].

Second, although information and communication technologies (ICTs) have contributed significantly to the emergence of intellectual capitalism, IPRs do not appear to have contributed significantly to the emergence of ICTs, at least not up until the 1980s. In fact it may even be argued that lax IPR regimes were instrumental for the early emergence of several ICT industries.[8] A few examples will illustrate. The transistor was patented at Bell Labs but licensed out generously and the subsequent emergence of the semi-conductor industry was significantly spurred by public procurement and a lax IP regime (Mowery 1999). The same could be said about the emergence of Internet under the Defense Advanced Research Projects Agency (DARPA). The software industry also emerged under a lax IPR regime (Samuelson 1993). The telecom industry was largely nationally monopolized til the 1980s and 90s, with little interest in IPR. Mobile telephony also emerged until the late 1980s under a lax IPR regime (Granstrand 1999). In other words, absence rather than presence of strong IPRs were arguably important in the early stages of various sectoral innovation systems based on ICTs.[9]

Third, the relatively rapid emergence of a much stronger IP regime since the 1980s has been embedded in the much grander and more gradual emergence of intellectual capitalism as mentioned above. The strengthening of the IP regime may very well have strengthened some features of intellectual capitalism, e.g. through appreciation of IPR values, and speeded up the development of some of its components in the recent decade or so, but with our limited knowledge at present about the feedback structure involved it is only safe to say that the pro-IP era appears to be more a consequence of intellectual capitalism than a cause of it.[10] In any case a strong IP regime is a feature of the new type of economy with a concomitant expansion of IPRs by volume, type, value and strategic attention paid to them. The rapid strengthening of the old IPR institutions in the slow, gradual emergence of a new type of economy has in turn strengthened old misfits plus

[7] Of course, it is difficult to infer very much from history by relating the absence or presence of an institution such as the patent system to a lower or higher rate of technical, industrial or economic progress in different periods and places. There seems to be some consensus, however, that the patent system has played a positive role for the rate, if not the direction at large, of technical progress but only a role secondary and complementary to other developments.

[8] History in general has plenty of examples how pockets of open S&T have been instrumental for progress, at least temporarily. These pockets or pools of open S&T may be open also to the general public by design (as with open standards or the current open source movement) or by default. Commonly, they are closed or semi-closed with some kind of entry commitment (e.g. granting back of improvements or agreeing not to take certain actions).

[9] The role of strong patents in other sectoral innovation systems is also not clear, not even in those sectors where patents traditionally have been most important, that is pharmaceuticals and chemicals. (See e.g. Scherer and Weisberg 1995). The new database protection directive in Europe has also not clearly spurred a European database industry, at least not yet (see Maurer 2001).

[10] North (2005) focuses on three main interacting factors in the process of economic change – demography, growth of knowledge and institutions. The emergence of intellectual capitalism then mainly appears to be spurred by growth of knowledge and to a lesser extent by the IPR institutions, with a possible minor influence by the World War II baby boom on growth of knowledge.

created new ones for the IPR institutions, e.g. misfits between the patent system on one hand and nations at different stages of development or industries with different innovation characteristics (see further Granstrand 2004b). Nevertheless, despite mounting criticism there are no signs of a significant reversal of the pro-IP era, but rather that IP reforms of various kinds will appear as IP policies will be increasingly attended to in the national and international innovation systems.

3 Economic Rationales for a Patent System

3.1 Overview

The long history of the IPR system as an economic and also social institution has naturally produced much debate and rationalizations over the years. Only a brief summary can be given here and then with a focus on patents as an IPR of prime importance with a focus on rationales of an economic nature[11].

For a classic qualitative review of theories of the pros and cons of patents, see Machlup (1958) and for a current review (with similar classification of theories) from an economic perspective, see Mazzoleni and Nelson (1998), and from a legal perspective Gutterman (1997). The received theories build on old notions that in the absence of patents underinvestment in R&D and innovation would occur and/or that too much secrecy would occur. Thus an extra incentive to invent, disclose and innovate would be needed and that a patent right would help fill this need.[12]

However, a strong patent right tailored as a reward to an inventor who is first in some sense with an invention may also lead to excessive races with overinvestment and uncoordinated exploitation of new technologies as a result. Then it has been argued that a patent right should be tailored as a prospect right giving an exclusive right to the rights holder to further exploration in a wider area, handed out at an early stage of the exploitation process as in mineral extraction. In this way further exploitation of new technological areas could presumably be better coordinated or governed. [13]

The received theories focus on different parts or stages of the compound invention/innovation/diffusion process and on the different but related roles of IPRs as incentivizing and coordinating mechanisms. Thus the received theories altogether contain the elements in what could be said to constitute two newer integrated perspectives. One views patents as joint incentives to both exploration and exploitation through integrated innovation and diffusion processes. The other

[11] Rationales or justifications of IPRs are categorized more generally in legal philosophy into deontological and consequentialist. The former category includes moral rights and rules that are largely exogenous to the economic and legal systems – they are 'natural rights'. The latter category includes economic rationales, which in turn are often classified as teleological (fulfilling proper ends of human life) and utilitarian (fulfilling consumer utilities). Utilitarian rationales for IPRs dominate contemporary society and are focused on here. See further Granstrand (1999) and Andersen (2004).

[12] Although the notion about underinvestment is old it was not formalized until the 1960s with Arrow (1962) as a truly seminal work. Arrow discussed generic reasons behind underinvestment and alternative remedies, including patents. Later works have shown that also overinvestment may occur, even without patents.

[13] This so called prospect theory was introduced by Kitch (1971) building partly on Barzel (1968) and earlier works by Scherer and has been highly cited but also subjected to severe critique.

perspective views patents (and more generally IPRs) as a mode of coordination or governance similar (but not equivalent) to the role of property rights in tangibles.

Table 1 gives a summary of both the received economic rationales for a patent system and the newer economic perspectives on patents. Viewing patents as a joint innovation/diffusion incentive integrates received incentive oriented rationales (treating disclosure as diffusion of information) and in doing so also focuses on the interdependence and dynamics over time of the processes involved. Hereby dynamic (Schumpeterian) competition is more clearly articulated and contrasted against static competition.

3.2 The property approach viewed in a governance perspective

A general controversy (or set of controversies) concern the use of a property approach with its pros and con not only for incentivizing innovators compared to alternative approaches (tax-based subsidies, procurement contracts etc.) but also for handling coordination or governance problems in innovation and diffusion. The property approach has then been criticized for creating rather than solving coordination problems, e.g. in the common context of sequential or cumulative innovation or in the contexts of "open science" or complex technologies, then creating anti-commons problems or problems with assembling different necessary IPRs for productive use of resources.

However, information and knowledge are uncertain and highly heterogeneous entities and so are the conditions under which they are produced and diffused, justifying a combined variety of approaches to foster suitable conditions. Thus, using the property approach means decentralizing decision-making about scarce resources to agents with unique access to localized information for proper decisions, and incentivizing them to exercise their capabilities by providing them with access to a share of the extra surpluses they then generate. The latter is done by allowing the property holder to charge prices higher than marginal cost in order to help cover fixed investment costs.

Such monopolistic pricing is a drawback of the property approach, as it incurs a certain loss of consumer surplus apart from a shift of some surplus from consumers to the producer. However, in order to assess the property approach, this drawback (cost) has to be compared with corresponding drawbacks of other approaches. If the right to exercise certain monopolistic pricing is seen as a decentralized right to tax consumers, it corresponds to the right to impose a targeted sales tax administered by private agents. The administrative cost could then be fairly low in comparison with public forms of taxation, be they targeted (selective) or general.[14] Of course, taxes could be more than minimally distorting and over-taxation could occur, as it could with any form of tax. (Few people seem to disagree on this.) One real virtue as well as a drawback of the property approach is its amenability to flexible decentralization which then easily could lead to over-decentralization in the sense that too many and costly agent interdependencies will arise, resulting in too high transaction costs, eventually

[14] Just to mention one comparable alternative, consider the popular use of R&D tax credits or tax deductions for stimulating innovation, based on the idea to subsidize R&D inputs through targeted cuts in general taxes. This tax arrangement has significant limitations and hardly qualifies as a minimally distorting tax arrangement (see Mansfield 1982). It could be modified of course, e.g. to cover commercial activities as well, not just R&D, but it will still be inherently limited (see Granstrand 1998).

high enough to outweigh incentive effects and other efficiency gains. In addition, recentralization is usually more difficult (costly) than decentralization.

This view of the property approach is actually a governance view comparable to an organization-theory view, in which the handing out of private property rights is comparable to handing out or decentralizing responsibilities and accountabilities (liabilities) in an organization, applying management by objectives, dealing with principal-agent and information asymmetry problems, intervening for conflict resolution and so on[15]. There are many organizational principles, some of which are that decentralization should be aligned to the information structure, incentive structure and structure of interdependencies, and should not be carried so far that the management cost of coordination outweighs benefits, e.g. from entrepreneurial motivation and economies of scale from division of labor. To illustrate, the adoption of the so-called M-form of organization, that is, a form of organization of a firm being decentralized into product divisions, is a recognition of stronger interdependencies within product-related activities than e.g. within functionally related activities (i.e. activities within R&D, production and marketing functions). Handing out patent rights to product inventions is then comparable (but not equivalent) to adopting an M-form of decentralization. If, however, inter-product interdependencies become more costly to coordinate than intra-product ones, the M-form has been carried too far, with too many small interdependent divisions with internal transfer pricing problems (transaction costs), conflicts and costly higher management intervention (the organization's internal court system). Thus, using a property approach is largely a matter of how far decentralization should go along what organizational principles, in order not to let transaction costs and administrative expenses outweigh innovative and efficiency gains by handing out too many small interdependent property rights.

This does not imply that a proper trade-off along the centralization-decentralization continuum makes the property approach the single best solution. For this all costs and benefits of a property approach relative to other approaches have to be weighed in, and in particular for an intellectual property approach these costs and benefits are far from well understood. An IPR system is likely to be more costly to run than a physical property right (PPR) system, although its benefits may have increased as technological innovations have become more highly valued (see Landes and Posner 2003).

3.3 Patents as a governance mechanism

Viewing patents as a governance mechanism incorporates coordination aspects besides incentive aspects (and thereby has a focus related to the prospect theory). To some extent the governance perspective on patents and IPRs more generally is similar to a governance perspective on physical property rights (PPRs). However in a fundamental way IPRs differ from PPRs and the difference actually strengthens the justification of viewing IPRs in a governance perspective. The difference refers to the simple (but important) fact that, in contrast to an exchange of a physical object (resource, artifact) between two agents, an economically motivated exchange of proprietary information new to one of the agents (e.g.

[15] Cf. the discussion of the property approach vs. the liability approach in Calabresi and Melamed (1972).

through a market transaction, leaves both agents in possession of the information. As dispossession of human embodied information is impossible and information is not wearing out through usage, a long term need arises for coordinating or controlling the agents as to their use of the symmetrically possessed but asymmetrically owned information. This could be done (more or less imperfectly) through explicit or implicit contracting, e.g. through a license contract or an employment contract with a non-disclosure agreement. Thus, exploiting IPRs tend to create longer post-exchange contractual relations than for PPRs (for which exhaustion of the seller's rights occur when selling a physical object - warranties, product liabilities, etc apart).

Different forms of licensing (in a broad sense) and other forms of contracting on markets for IPRs then become essential for transfer and assembly of resources via markets in the economy. In the aftermath of the pro-IP era licensing has also grown considerably and one may even expect a "pro-licensing era" to emerge (see Granstrand 2004). Other growing phenomena are the trading of small hi-tech projects and start-up firms, which are essentially IP-based; the organizing of large inter-firm technology collaborations which are employing various complex schemes for managing IPRs; employing some form of open source or creative commons licensing in development communities; clearing houses for IPRs and digital rights management schemes in creative industries and so on. These are all phenomena that not only illustrate how IPRs are managed in different settings but also how IPRs are used to manage or govern the underlying productive operations. An example of the latter in an intra-firm setting is the use of IPRs and intellectual capital concepts to boost the asset value of a firm. Going one step further one could use a kind of distributed intellectual capital management to vitalize the entire organization of the firm to make it more efficient and innovative, just as total quality management once was used (see Granstrand 1999).

Not only patent rights but also patent information (disclosures) could provide a basis for governance. This will be dealt with next.

Table 1. Economic rationales for a patent system

Received economic theories	**Newer economic perspectives on patents**
Incentive-to-Invent theory Focus: Impact on invention and R&D Concerns: • Distortion of R&D (e.g. too much substitutes/too little complements, too little basic/too much applied, too much patentable/too little unpatentable) • Barriers to competition • Heterogeneity of industries/firms/inventors **Incentive-to-Disclose theory** Focus: Impact on secrecy Concerns: • Quality/quantity of disclosure • Impact on R&D (e.g. stimulation, coordination) • Impact on diffusion (e.g. on technology markets) **Incentive-to-Innovate theory** Focus: Impact on innovation and competition Concerns: • Incentives ex ante and ex post invention • Impact on complementary investments • Transaction costs • Invention/innovation distinction • Patent scope and duration **Prospect theory** Focus: Resource exploitation efficiency Concerns: • Coordination and duplication of R&D • Exploration • Improvement • Firm strategies	**Patents as a joint incentive to innovate and diffuse** Focus: Impact on dynamic competition through ”continuous” and entangled (interdependent) innovation and diffusion processes Concerns: • As for incentive-to-innovate • Efficiency/distortion of diffusion • Interdependence of inventions and innovations over time (e.g. in sequential innovation) • Dynamic interaction between innovation and diffusion processes **Patent rights and patent information as a governance mechanism** Focus: Property rights allocation and disclosure as a mode of incentivizing and organizing for decentralized governance through management hierarchies and markets and hybrids of these two governance modes. Concerns: • Allocation and transfer of rights • Cumulation and dispersion of rights • Interdependence of rights • Scope and duration of rights • Enforcement of rights • Governance efficiencies, e.g. in terms of coordination and communication costs, e.g. market efficiencies, e.g. in terms of transaction costs • Optimal decentralized “tariffs” or ”taxation” (through prices or damages) • Role of governance bodies and institutions (legislators, courts, patent offices, patent management, patent pools, clearing houses, anti-trust authorities etc.) • Alternative governance mechanisms

3.4 Role of patent information disclosure for governance

A strong motive historically for handing out patent-like privileges was to disclose and diffuse secrets, e.g. held by skilled artisans and guilds[16] The disclosure would thereby stimulate and coordinate the R&D of others, speed up differentiation and cumulation of results, speed up exploration of new, promising areas, help to avoid duplication, and provide for more efficient technology markets.[17]

The idea of disclosure as the inventor's payment (apart from fees) for patent rights has thus been central to the patent system from early on. Despite this apparently important role of patents, there is not much systematic evidence of its functioning and value. Recent studies have pointed at the value of patent information for companies in managing their R&D as well as for countries in disseminating new technologies, e.g. in Japan (Ordover 1991, Granstrand 1999, Cohen et.al. 2003).

A whole set of methods and services (some even patented) around patent information has also developed, spurring a whole industry of patent information analysts, especially in connection with the computerization of patent information and patent processing. The turnover of this industry is still small but growing. In addition a considerable amount of R&D and patent related work in firms in general is devoted to technology intelligence (monitoring, scanning), using patent information.[18]

There is also a growing number of estimates showing that the amount of unused technologies and patents is considerable together with a growing number of efforts by patent offices, firms, license brokers, universities etc. to increase the utilization ratio, e.g. by start-ups (tax-deductable), donations or licensing. Accurate, cheap and timely patent information is then of course crucial.

Moreover, the amount of R&D duplication is formidable. For example, EU has estimated it to be 20 BUSD/year only in Europe (Arora et al. 2001). Part of this is inherent in a competitive market economy but part is also due to reducible inefficiencies in technology markets and division of R&D labor. The governing function of patent disclosures has been comparably weak in the past, before the current pro-patent era, and before the advent of new infocom technologies for processing patent information as described above. However, despite the growth of patent information and its cheap and fast dissemination, which will increasingly help coordinate complex and expensive R&D, there are nevertheless limitations. Positive research results signalling that something is found to work are more efficiently disseminated through patent information as well as through other publications than negative research results signalling that some approach does not

[16] Note that the dual functions of patents as incentives and disclosures do not need to be integrated, i.e. a patent system could in principle be designed to offer incentives without requiring disclosure and disclosure could be achieved in other ways.

[17] There is also a dilemma of growing proportion when R&D information protected by patents becomes used by others in their R&D in a way being considered as infringement.

[18] Regular conferences and exhibitions are held (e.g. arranged by patent offices such as the Epidos conferences) around a flurry of databases and tools being developed. With more intelligent agents, AI tools for full-text analysis and joint analysis of patent and other publications, this industry could be expected to grow on commercial conditions, thereby probably reinforcing technical information asymmetries between firms and nations.

work, which is a result that is not patentable and frequently not published.[19] Although such negative results are often disseminated in informal communications within professional communities (von Hippel 1988), this type of selective, ad hoc communication is probably not reducing duplication of negative R&D results very much. Neither would patents work in coordinating duplicative failures across firms in their collective trial-and-error R&D process. To achieve this some special incentive system would be needed for publishing (disclosing) negative R&D results, being perhaps novel and non-obvious but lacking inventive step.

4 IPRs in Innovation Systems

4.1 The innovation systems approach and its rationales

Over the centuries technological innovations have become more systemic in two aspects – first their provision on average require increasingly large scale, complex, R&D, manufacturing and marketing operations and then their use and usefulness depend on an increasing number of other innovations, new as well as old, technological as well as non-technological (indicated e.g. by the increasing number of standards). Using a systems approach then becomes natural, not only as in systems engineering but in the studies of innovation as a social phenomenon.

A new and important strand of economics literature in the 1990s also adopted an explicit systems approach to the studies of innovations.[20] As a result, a number of concepts of innovation related systems were introduced, such as national, sectoral and regional innovation systems. However, although mentioned in the literature, there has been no focus so far specifically on corporate innovation systems. This is a gap in the literature on innovation systems, especially in light of the indication that companies, and large ones in particular, control a major share of the world's technology (Patel and Pavitt 1995).[21] A focus on corporate innovation systems may also offer a new approach towards understanding the nature and evolution of large, technology-based corporations, which increasingly have to develop structures and processes to generate and exploit innovations of all kinds, not only technological innovations, but also managerial, financial etc.

Universities and the military sector are two highly important sources of innovations as well. Pursuing the systems approach in innovation studies then leads to the identification of university innovation systems and military innovation

[19] The demonstration effect of showing that something works (rather than how it may work) may have strong impact on contenders (as shown by the detonation of the A-bomb). Patent applicants are required to reveal how an invention supposedly works through so called enabling disclosure but evidence that it works properly is not always necessary.

[20] If one can speak of some kind of a breakthrough for the systems approach in innovation studies occurring in the 1990s, it might be due to the surge of studies of innovations in general, the quest for meso-level concepts (like industrial clusters, development blocks, regional complexes), the general appeal of the systems approach as used in engineering and the adoption of the systems approach by key opinion leaders in economics and policy analysis.

[21] Some large corporations moreover have R&D budgets comparable in size with total industrial R&D in some small countries.

systems.[22] In general, the IP regimes in these two innovation systems have shifted in the last decades for different sets of reasons, with increased attention paid to patenting and licensing, in addition to the traditional emphasis on secrecy and copyright in military and university innovation systems respectively.

A 'corporate innovation system' is then defined as 'the set of actors, activities, resources and institutions and the causal interrelations that are in some sense important for the innovative performance of a corporation or a group of collaborating companies, including universities and other organizations'.[23] Some comments are in order. Different groups of components are specified (actors, activities, resources and institutions) to indicate important subsystems like the actor system within and around the corporation involved in innovation, including R&D labs, R&D cooperative partners etc.; the R&D, production, marketing and outsourcing systems, where R&D, production etc. are activities; the resource structure, with the system of technologies (seen as intellectual resources) in particular and the institutional structure (or system or infrastructure). The system of technologies or, in other words, the technological system is then taken in the literal sense in line with Freeman *et al.* (1982), i.e. as a set of interrelated bodies of technical knowledge, e.g. a set of complimentary or substituting product and process technologies. The technologies may be interrelated conceptually or causally, and in the latter case they are then interdependent. A technological system in this sense is then distinguished from a technical system, which essentially is a set of physical parts of products or artefacts, i.e. a 'hard' system.

By corporation, is meant any company (firm, enterprise), not necessarily a large one. A corporate innovation system extends beyond the boundaries of a specific corporation and are moreover not necessarily sub-systems of national innovation systems or sectoral innovation systems, since there are multi-national corporations as well as multi-product corporations active in many sectors. The significance of such corporations in innovation is part of the motivation for introducing the concept of corporate innovation system.

4.2 IPRs in national innovation systems

Codified IPRs have historically emerged in a national context for promoting innovations in the interests of the nation. Thus, the role of IPRs, and patents in particular in national innovation systems have a long track record, which can only briefly be described here. Given the long existence of IPRs one can expect that they then have played some kind of a functional role over the years. However, the only point of consensus regarding the role of the IPR system in economic history is that its role is intrinsically difficult to assess and that there is no persuasive

[22] As there are many diverse sources and contexts of innovations, several types of innovation systems could be identified. One could then ask what the systems approach could contribute to innovation studies beyond merely adding the empirically ambiguous term 'system' to the term 'innovation'. Available space here just allows to refer to standard virtues of the systems approach such as providing a generic language with a number of key concepts (system boundaries, structure, processes and performance, input/output relations, feedback, sub-systems, etc.), providing a systematic method of analysis and a dynamic perspective with feedback analysis as a key element, and providing (mostly) some kind of governance or control function for a purpose. These are all virtues which are difficult to illustrate in the brief expositions presented here.

[23] This definition is syntactically and semantically aligned to the common definitions of national and sectorial innovation systems as surveyed in Edqvist (1997). See further Granstrand (2000).

evidence that the IPR system has ever played a major role[24]. At the same time there is widespread consensus today that technological innovativeness, the promotion of which is the direct purpose of the patent system, has probably been the major determinant behind economic progress.[25] Innovations have flourished in several periods and places in history without a patent system, e.g. in ancient Greece and in medieval China. Also the most important factor during all periods, as persuasively emphasized by North (1981), is the military sector, which has a quite different incentive system for innovations than the commercial and cultural sectors. Moreover, some countries industrialized before they had a patent system (e.g. Germany, Holland and Switzerland[26]) while most countries, including Japan, did so after they had installed a patent system, and then with greatly varying lags.

The size and growth of a domestic market likely matters to technological innovativeness, and perhaps more so in the absence of patents, however. In connection with industrialization, North (1981, p. 165) has argued that "In the absence of property rights over innovation, the pace of technological change was most fundamentally influenced by the size of the markets", because large and growing markets would increase the private return upon innovation, other things being equal. Large markets would also allow for specialization, in turn favouring creativity. Small, industrializing countries could then look for foreign markets. If these markets in turn had a patent system, the small countries would be more likely to have to adopt a patent system themselves sooner or later, which Holland and Switzerland eventually did.

There is some consensus that the patent system has played a positive role for the rate, if not the direction at large, of technical progress but only a role secondary and complementary to other developments, particularly other institutional developments, including a general property rights system (see North 1981). A patent system, awarding temporary monopolies, was initially designed and implemented in countries mainly for their importation of new technologies and technological catch-up in various sectors, for which it proved functional (David 1993). This was true for, among others, Italy, England, the USA, Japan and Switzerland[27]. From this alone, one cannot infer that a patent system would be functional for the catch-up of the less developed countries in the contemporary world, with an immensely more internationalized economic system having MNCs, FDIs, TRIPs and other international trade and agreement interdependencies and so on.[28] One could even argue that it would be unlikely or highly costly in the pro-IP

[24] It may be argued that the collection of IPRs, as we know it, is not, and never has been, legally connected enough to be called a "system" and to be studied as an entity with causal relations.

[25] Note that a patent is granted to a technical invention primarily on the merits of its technical features, not on its economic merits (apart from a general and weak requirement of industrial applicability or usefulness of the invention), although the underlying assumption is that by so doing, economic progress will be stimulated.

[26] Schiff (1971), studying Holland and Switzerland, found no evidence that industrialization in these countries was hampered by the absence of a patent system.

[27] Japan is a particularly interesting case which shows how the IPR-system (patents in particular) could be designed and used together with various licensing schemes and technology policies to foster not only catching up but also forging ahead (see e.g. Granstrand 1999).

[28] Mansfield (1994, 1995) and Lee and Mansfield (1996) have shown that strong patent protection is functional for attracting FDIs. However, FDIs are not necessarily functional for catch-up. Scherer and Weisburst (1995) are also sceptical to whether a switch from weak to strong patent protection alone can induce a catch-up, based on a study of the adoption of patent protection for pharmaceuticals in Italy 1978.

era on the grounds that most instances of nations catching up have taken place in the absence of a strong international IP regime. Neither can one infer that a patent system initially designed for catch-up would be dysfunctional for sustaining a technological lead gained thereby. On the contrary, a patent system might even function better for the latter purpose in a world with increasingly globalizing companies and markets and a relative weakening of the nation-state.[29] The advent of the pro-patent and pro-IP era fostered by the US and later supported by other developed countries as described above is a strong case in point. Several countries have also changed from a weak to a strong IP regime once they have reached a certain stage on the "development ladder".

4.3 IPRs in sectoral innovation systems

Industrial sectors in market economies without monopolies do not have some form of centralized governance in the same way as nations and companies have (although industry associations in some countries are strong). This would have an impact on the governing role of IPRs in sectoral innovation systems, especially regarding seller diffusion of new technologies through licensing, cross-licensing and other forms of technological transfer and imitation, including patent information disclosure. The governing role of the IPR system for a given industry or sector moreover differ widely across different types of IPRs just as the role of a given IPR type differ across industries.[30] Some industries rely heavily on certain IPR types as witnessed by references to them as copyright industries or design industries or witnessed by valuations of their IPR capital stock (e.g. with very high trademark values). The large industry differences have moreover led to misfits between industries and the patent system in particular, which is fairly much the same across industries (and across most nations as well regarding patentability criteria). Thus, demands on industry tailoring of patent rights have grown, although without much impact in sight.

The large differences in the role of patents, licenses and trade secrets across sectors have been widely studied and documented (see e.g. Scherer 1980, Levin et al. 1987, Mansfield 1986, Granstrand 1999, Arora et al. 2002, Cohen et al. 2003). Less attention has been paid to the longitudinal role of IPRs for a sector, which will be briefly touched upon here.[31]

The role of a strong IP regime in emerging industries is unclear. There is some evidence that several leading edge industries based on ICTs have developed

[29] The patent system is likened to a Panda's thumb by David (1993) in describing its evolution into something quasi-functional from strange origins.

[30] Industries differ widely and so do their associated innovation systems. For an excellent recent treatise on sectoral innovation systems in general, see Malerba (2004). For instance, sectoral innovation system differ regarding the dynamics behind the changes in system boundaries (e.g. through technological convergence), feedback structure between R&D, innovation, growth and structural change, appropriation mechanisms, industry life cycle characteristics and nature of their technology base. Differences like these naturally reflect in differences in corporate innovation systems.

[31] For a good example of a longitudinal study of patenting behaviour in an industry, see Hall and Ziedonis (2001).

after the Second World War under a fairly lax IP regime[32]. (See Section 2.3). There seems moreover to be few cases where a strong IP regime has not only co-existed but clearly fostered the emergence of new leading edge industries and their rates of innovation[33]. One could expect to find such examples in areas with particularly low ratios of imitation to innovation costs and times in the absence of strong patent systems (as would be the case in chemistry). Such low ratios are likely in large scale R&D areas with high costs of innovation (e.g. in aerospace or telecom). However, emerging industries often operate on smaller R&D scales. They also tend to have good growth prospects and their incentive structures then tend to be less sensitive to free-rider problems and waiting games. If emerging industries operate on large R&D scales, other institutional means for incentivizing and coordination than a strong patent system have moreover often been used, e.g. procurement or natural monopolies.

It is rather in later stages of industry evolution with subsequent innovations on a growing R&D scale (e.g. in form of new product generations) that a strong IP regime might be particularly conducive to further developments. At the same time barriers to entry can be built up by incumbents, especially against small firms. The use of various patent portfolio strategies by large firms (both incumbents and diversifying entrants) serves this purpose. This may in turn result in a changed division of R&D labor, where small R&D firms increasingly resort to licensing and acquisitions rather than aiming for stand-alone growth. The emergence and functioning of technology markets and markets for corporate control are in turn facilitated by strong IPRs, which therefore contribute to vertical specialization and other forms of intra-sectoral division of labor.

4.4 IPRs in corporate innovation systems

Quite naturally companies are and have been embedded in various innovation systems and IP regimes pertaining to their relevant sectors and nations. As in-house R&D became institutionalized since the 19th century and the need for companies to constantly generate innovations – minor as well as major, product as well as process – became more pronounced, innovative activities became mainly internalized although with a fair amount of interaction across company boundaries with inventors, investors, institutes, users, competitors, etc.

The internal IP regime was, and still is, mainly oriented around trade secrets and also around trade marks while patents (as well as copyrights and designs) have been of minor importance traditionally[34]. Company governance through

[32] There are in addition many examples historically of how lax IP regimes (regarding patents in particular) have fostered the emergence of industries in countries trying to catch up with leading edge countries.

[33] The standard examples being within pharmaceuticals, chemicals and biotech. Other examples may be found in copyright and design industries. A counter-example might be the database industry where the (fairly) new database protection directive in Europe has not yet clearly spurred a European database industry (see Maurer 2001). New *sui generis* IPRs and IPRs tailored for a specific industry or sector offer interesting natural experiments in this respect, of course. Industries differ widely and so do their associated innovation systems.

[34] There are many accounts in business history indicating the importance of IPR for the economic progress of companies in various places and periods or stages of their development. Still, there are as many examples of companies that have succeeded without any significant IPRs as there are companies with strong patents that have failed. There are also examples of companies, mostly

management has simply not paid much attention to these latter IPRs as a rule. While private property rights in general have arguably been of decisive importance for well-functioning interaction between markets and companies, IPRs have not by and large. Even for trade secrets, their legal protection through property rights has had, and still has, a minor role compared to other means to protect them.

Internal company management moreover rather resembles a liability approach than a property approach and internal innovative activities resemble a kind of localized open source approach with layers of internal openness and external closure. A company also by design has a rapid feedback structure on several levels responding to performance signalling through external accounting as well as through managerial accounting. This has often created tension with the relatively slow and uncertain feedbacks involved in R&D and innovation, calling for institutions complementary to companies such as research universities and institutes and government procurement (e.g. by the military).

The rapid rise of the pro-patent era and the rapid recognition in industry of IP as being of economic and strategic importance has created a number of significant changes, however, in line with changes in general linked to the emergence of a new type of economy. IPRs are now increasingly used as a managerial or governance tool for influencing the pattern of trade, competition and cooperation in a larger context than just for protecting product and process innovations from price competition and as a tool for formation and exploitation of intellectual capital (IC). New types of (pure or hybrid) IC-based firms and markets also emerge. Large IPR portfolios are built up through various IPR strategies in order to create action space (in R&D, design, commercialization etc.), power in various forms of bargaining (for acquisition, financing, standard-setting, cooperation etc.) and market value (for IPOs, M&As, shareholders etc.). Strategic licensing and cross-licensing is used for standard-setting, sustaining technological leadership, oligopolistic clubbing, outsourcing, franchising etc[35]. Licensing and servicing is also increasingly becoming a primary business compared to product sales and a "pro-licensing era" might very well follow as a consequence of the pro-IP era as mentioned above. Licensing also offers a flexible contractual form for governing future transactions and customer relations, compared to spot transactions of tangibles with their exhaustion of rights[36]. This also applies to inter-organizational collaborations although a great deal of managerial or

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small, that have been forced out of business because of the IPR and litigation power of large competitors. The importance varies with country, period, industry, company and type of IPR.[34] The overall, long-run impact of the IPR system upon a stream of company formations and developments cannot be assessed across industries in our present stage of knowledge. There has also been a patenting paradox in the sense that firms take out patents even if they see them as fairly unimportant (Mansfield 1986). Nevertheless some studies have established that patents do play a role as intended for R&D investments (Taylor and Silberson 1973 and Granstrand 1999). The role of trade-marks and trade-secrets is conspicuous, however, even decisive for the formation and growth of a firm (see Wilkins 1992 for trademarks).

[35] A classic case is the "systems battle" between JVC and its VHS system and Sony and its Betamax system in which JVC pioneered in using an IP licensing scheme to build a corporate innovation system around VHS with collaborating competitors for outcompeting Sony and its Betamax system.

[36] Note the range of types of licensing contracts (exclusive, sole, simple, sub, cross, block, grant-back, compulsory, etc.). Moreover, patent licensing could be performed on line, leading to what could be dubbed "e-licensing", which in turn could be linked to "e-research".

organizational learning has to take place in this arena. Nevertheless there are various examples of how collaborating companies create different IP regimes as an important part of the governance structure[37]. The open source movement (OSM) is also a good example of a particular governance structure in and of a community of collaborators, an innovation system which is in fact very much IP-based and as such could be considered an organizational innovation (see e.g. McKelvey 2001).

All in all one can observe an increase in the use of a range of various other strategies for technology sourcing and technology exploitation than the traditional ones with in-house R&D and in-house production and marketing, corresponding to vertical integration. These other technology strategies correspond through their contractual nature to various degrees of organizational integration or market mediation. Thus one can argue that corporate innovation systems increasingly employ a quasi-integrated mode of governance, intermediate to governance through management and markets. The advent of the pro-IP era has contributed to this development in that the availability of enforceable and valuable IPRs have fostered the use of various technology market mechanisms.

4.5 IPRs in university innovation systems

The continuous "roll-over" of human knowledge from older to younger generations constitutes a large investment for mankind.[38] This knowledge investment has traditionally been affected by IP-considerations but only to a minor extent, mainly in form of secrecy (in families, churches, guilds etc.), copyrights and branding (trade marks, names etc.). The generation of knowledge new to mankind in form of scientific endeavors also constitutes a major investment, traditionally affected by IP-considerations only to a minor extent, again in form of secrecy, copyrights and branding. Universities of the Humboldt type, integrating higher education, research and science, play a major role in these two endeavors. For various reasons universities now undergo major transformations into economic institutions, leaving some of their functions as cultural institutions in jeopardy. One could even venture to say that a major industrialization of universities is taking place. In the course of this process universities gradually behave more like knowledge-based corporations (as well as the latter become somewhat more university-like in their R&D and education). What is behind this institutional process of university-industry convergence and whether it is to the better or worse for society is an open question. However, scholars and policy-makers world-wide are beginning to have a closer look at this

[37] For examples see e.g. Gawer and Cusumano (2002), and Granstrand and Lindmark (2002). Companies could and do use licensing also for some form of intra-firm governance (e.g. of foreign subsidiaries) as well but historically this has mainly been for profit transfer purposes. (For an example, see Granstrand and Fernlund 1978). Needless to say efficient internal transfer pricing is difficult to achieve for intangibles.

[38] The investment aspect is a narrow economic one. The roll-over also involves consumption. Moreover, economic aspects are far from the only relevant ones. In fact, the roll-over could be seen as a defining characteristic of culture, as described in North (2005), thereby implying that universities are cultural institutions.

process, its causes and consequences, and especially in the U.S, having on top the leading and most competitive and market oriented universities.[39]

In this transformation process university innovation systems are being built up or redesigned, especially involving science, engineering, business and medical faculties, and being provided with seed capital, venture development units, special facilities for financing and commercialization, science parks, incubators for start-ups, technology licensing and liaison offices, support units for services (accounting, legal etc.), innovation and entrepreneurial management training etc.

In this context more active and industry-like IPR-policies become adopted by university management, often with initial overexpectations of economic return and underestimations of negative consequences. A major event fostering these developments in the US and later elsewhere in the world was the Bayh-Dole Act from 1980, facilitating for US universities to patent inventions from federally funded research. However, the Bayh-Dole Act was not a decisive or triggering event but rather reinforced developments already underway (see Nelson 2003). Nevertheless, the pro-IP era in industry has extended into the university life. Not surprisingly this has led to clashes with the traditional IP regime in universities being oriented around science and eventually open scientific publications and license-free use of results, while recognizing copyrights and the role of trademarks for reputation building. This is quite distinct from the IP regime in industry and its sectoral and corporate innovation systems, being more oriented around technology, secrecy, patents and other registered IPRs. Table 2 illustrates some of these differences.

The scientific society or community has, over the centuries, developed IP notions quite different from the IP notions in the industrial-technology community. Priority for new creations is important in both scientific publishing and patenting but is decidedly more vague in science on the basis of the “first to publish” principle, rather than on the “first to file” (a patent application that is) or the “first to invent” principle as is the case with technical inventions. A publisher’s decision to “grant” a publication is based on some criteria of newness, non-obviousness and usefulness of the publication, similar to but not exactly the same as the criteria used in granting patent rights for an invention. The newness criteria and priority ground moreover foster secretive behavior prior to publication and patenting in both regimes. Scientists then use each other’s works and, in so doing, are expected to cite them as a basis for recognition and further career, funding and award possibilities (although a fair amount of “publishing around” someone else’s work takes place in science just as invent around takes place in technology, the latter being in fact encouraged by the patent system). Certainly citing fulfills other functions in academic work as well, but in this respect, citing is thus analogous to paying a royalty for using the results of someone else’s work. (Cf. Trajtenberg 1990.) However, the “payment” is made “liquid” in quite a different manner. Peer recognition for contributions that are scientifically innovative is perhaps the biggest “payment” to academics, albeit a non-monetary reward. The monetary rewards in science are partly oriented around prizes, grants and salaries. These forms of rewards are in fact alternatives to patent rights as means to promote scientific as well as technological progress.[40]

[39] See e.g. Rosenberg and Nelson (1994), Rosenberg (2000), Rosenberg (2003), Nelson (2003) and Mowery (2004).

[40] Much can be said and debated about the differences and relations between science and technology. See especially the works by D. de Solla Price and N. Rosenberg, being two leading

Table 2. Comparison of IP regimes in universities and industry

Regime feature	University publishing	Industry patenting
Priority	First to publish (First to discover/write)	First to file (First to invent)
Criteria	Newness to the field Non-obviousness	Newness to the world Non-obviousness Industrial applicability
Examination system	Publishers Journal editors and referees	Patent offices Patent examiners
Opposition system	Informal	Formal
Sanction system	Informal	Formal
Legal basis	Copyright matters codified in law, otherwise weak Professional norms	Codified in patent law
International coordination	Strong in some disciplines. No unifying framework or treaties	International treaties and cooperation
Licensing provision	General permission to use "publication pool"	Usually subject to patent holders' discretion
Remuneration system	Citations Reputation Community prizes and job offers Research grants Promotion Non-contract-based	Royalty or lump sum payments or barter Product or license sales Contract-based

Thus, science may be called open but only in a specific sense and certainly open science is not synonymous with IP free science. Moreover, the differences between universities and industry go beyond IP regimes. There is a complementary division of labor between universities and industry to which the

scholars on this topic, e.g. de Solla Price (1973) and Rosenberg (1982). For a discussion of the traditional IP regime in science, see e.g. Nelkin (1984), Merton (1988) and Long (1991), and Stephan (1996), Eisenberg (1987), Rosenberg (2003), Mowery (2004), and David (2004) for how it may clash with the IP regime in technology and industry. The distinction between science and technology and the division of intellectual labor between universities and companies is also becoming less clear as companies do more basic research and universities take out more patents.

IP regimes and other means for provision of innovations have adapted. For example, it can be argued that universities and industry provide differently adapted incentives for creative individuals and thereby utilize heterogeneous creative resources in the overall innovation system more efficiently. It can also be argued that publicly financed production of highly uncertain but generic knowledge (innovation) with transaction free diffusion is more efficient than using patents, which then would generate high transaction costs. These complementarities would be reinforced by a cumulative nature of the knowledge produced and long lead times to its economic fruition, for which the short term feedback structure of corporate innovation systems is ill-suited.

University patenting and the Bayh-Dole Act have also been subjected to considerable concern and research in recent years in the US. There is a fair amount of scepticism growing in the US about the overall economic benefits involved (not only benefits for leading universities) as clear evidence of them fail to show up, while negative side-effects do.[41]

4.6 IPRs in military innovation systems

For a long time roughly half of the world's science and technology (S&T) and R&D activities have been defence related with R&D activities performed in mostly national military-industrial complexes, led by super-powers in distinctive alliance structures. These military-industrial "complexes", as they usually have been referred to could be seen as embracing a military innovation system, in turn with similarities to a sectoral innovation system as dealt with by Malerba, but with special strong links to a national innovation system. The "appropriation" and control of military S&T has formed a special military IP regime based on secrecy and various types of controls and sanctions, quite separate from the civilian IPR-systems (regardless of type of economic system – market or planned). The performance criteria and the feedbacks from performance to resource allocation etc. have also been quite different and generally much slower and more uncertain compared to civilian innovation systems. The system boundaries have also been more well defined. Military and civilian technology, R&D, industrial activities, IP regimes and other governance structures, as well as dedicated ICT-systems, have been quite separate from each other (even within firms). For various reasons (downfall of Soviet Union, multi-polarisation of power, US hegemony, growing importance of China, terrorism, rising capital intensity in conventional warfare, rising R&D costs, new technologies, waning geographic borders and distances etc.) this situation is now subjected to far-reaching changes and trends (without completely changing the nature of military affairs, of course).

What is increasing, and already visible in the USA, are: integration of military and civilian technologies (through dual use, lead/lag reversals, scientification etc.); outsourcing of defence R&D, production and services for firms (e.g. so called PMCs – Private Military Corporations), nations and even for cross-national alliances; internationalisation and globalisation of defence R&D, defence services and defence industries; limited military/police international "ventures"; cross-national trade of military technology; R&D and production collaborations.

[41] For further reading, see Nelson (2003), Rosenberg (2003) and Fagerberg et al. (2004).

The likely implications of this is increasing R&D collaborations across nations, sectors, companies and civilian – military borders; industrial restructuring (divestments, joint ventures, M&As) and global concentration. Defence R&D as well as defence services (based on surveillance, command and control, robots, unmanned vehicles, electronic warfare, network defence etc.) will increasingly be ICT-based, but possibly with closer integration of military and civilian ICT-systems. This is especially likely in the area of security and surveillance with its vast possibilities to use ICTs for development, production and exploitation of databases. (Note the military role in developing e.g. Internet and GPS and Echelon). Awareness and use of IPRs beyond trade secrets are also increasing and likely to continue to increase in military industry.

The implications of changes like these are of course many and important, for instance for a Europe lagging in civilian and military technology, but wanting to avoid technological over-dependence on the USA. A major objective is to foster integration of European defence-related R&D, industry and services and in that connection to consider integrating defence-related R&D in European framework programs – some military, some hybrid military/civilian ones, some closed, some open to non-Europeans. Military R&D then becomes more integrated into the build-up of the European Research Area (ERA), a concept launched for a more integrated and cooperative R&D system in EU in connection with the proclaimed objective of investing at least 3% of GDP in R&D and innovation by 2010. (Cf. the notion of a European innovation system.) Awareness and use of IPRs are then perceived as crucial, necessitating the nurturing of an IP culture and IPR investments in the traditional military industry.

5 Summary and conclusions

This chapter has made a first attempt to look upon the role of IPRs in different innovation system and moreover to look upon IPRs in a governance perspective. This provides a somewhat new view of the effects of IPRs both upon incentives and coordination. Although IPRs and their associated licensing and sales provides opportunities to govern innovative activities on markets as well as in firms and in the increasingly important intermediate quasi-integrated forms of organized innovative activities, e.g. inter-firm technology collaborations, the proliferation of IPRs also create governance problems. This is particularly so after the rapid emergence of a pro-IP era embedded in the slow emergence of a new type of economy. This in and of itself calls for more attempts and research on IPRs with a governance lens.

In comparing innovation systems a number of differences and some similarities stand out. National, sectoral, corporate, university and military innovation systems are all vested systems with different and changing boundaries but they also differ in a number of other ways, e.g. regarding performance criteria (ranging over welfare, equity, survival, growth, profits, knowledge and security); feedback structure (e.g. type, speed and uncertainty of performance signalling); hierarchical connectedness (ranging from centralized management hierarchies to decentralized markets), and dominant IP regimes (ranging over trade secrets, patents, trade marks and copyrights).

At the same time there is a certain convergence, e.g. between corporate and university innovation systems and between military and civilian sectoral innovation systems. The advent of the pro-IP-era has also not only strengthened the various IP regimes but also led to shifts between them with a certain degree of convergence to patents. Various types of IP-related contracts, – licensing and collaborative agreements in particular – are also increasingly used. Changes like these could be interpreted as an emerging shift to an increasing common use of IPRs for governance in and of the innovation systems. This magnifies the need for further research.

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