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Innovation and Intellectual Property

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Abstract

List of abbreviations

EPO	European Patent Office
FDI	Foreigh direct investment
IC	Intellectual capital
ICT	Infocom technology
IP	Intellectual property
IPR	Intellectual property rights
LDC	Less developed country
PCT	Patent Cooperation Treaty
WIPO	World Intellectual Property Organization
S&T	Science and technology
R&D	Research and development
M&A	Merger and acquisition
GPS	Global positioning system
ERA	European Research Area
EU	European Union

1 Introduction

(To be compressed if needed.)
Defining innovation in the customary way as something new proven to be useful – be it technical, organizational, financial, institutional, cultural or whatever under the sun – clearly makes innovation the basis for progress or evolution in all areas of human endeavor. It then becomes of central concern to find ways to call forth a flow of innovations in proper amounts, neither too few for desirable progress, nor too many for smooth adaptations. However, economic systems, regardless of type, have difficulties to generate a proper flow of innovations. It is simply difficult to tailor proper incentives through institutional means to individuals, who are capable and willing to move ahead as creators and innovators, and find a scheme for sharing the accruing advantages of the innovations between innovators and others. Sometimes early mover advantages are so weak compared to late mover advantages that prospective innovators are better off awaiting the moves of others, resulting in a waiting game. Sometimes it is the other way around so individuals engage in a race to become first with an innovation. The resulting racing game could then even be more costly in total, than the total advantages of the innovation.

Competition could be seen as both friend and foe to innovation from a society's point of view although necessity and curiosity would also induce innovations in the absence of competition, and e.g. make a Robinson Crusoe an innovator. Innovations moreover mostly require cooperation so prospects and advantages (rewards) have to be shared from that point of view in a cooperative game. Incentive structures at the same time differ among individuals, some preferring monetary rewards, some fame and social recognition, some satisfaction from achievement and so forth.

There are various ways or strategies for early as well as late movers to reap or appropriate the benefits from innovations. The innovator, being in fact the first mover, can create a lead time to late movers by being secretive about the innovations, relatively faster in its exploitation and more skilful in subsequent development (upgrading), production and marketing to various users of the innovation, and in forging durable links with them for sharing advantages.

There are also various ways or institutional means for a society to try to foster flows of innovations in rates and directions thought to be proper. Thus a society could provide means for social recognition and/or financial rewards in form of ceremonies, prizes, grants, subsidies, procurement contracts, property rights etc.[1] Most societies or cultures, primitive as well as advanced, also employ such means, e.g. for social recognition of creators and innovations. At the same time there are usually means for checking, if not punishing, the kind of deviant behavior associated with innovations and creative work. Despite this ambivalence most cultures seem to basically welcome innovations. One could even venture to say that evolution may have created means to reward innovators by giving them early mover advantages through higher chances of dating and mating success. Evolution may be smarter than we tend to think.

The use of property rights to induce innovations of various kinds is perhaps the oldest institutional arrangement that is particular to innovation as a social phenomenon. It is then customary to refer to these rights as intellectual property rights (IPRs), comprising 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 with fragmented historical developments, hardly constituting what could be called an IPR system.[2]

The purpose of this chapter is first to further the understanding and discussion about the foundations of IP and IPRs and their historical origins and development. This is of course as interesting as it is challenging in itself, but such discussions may also in the end be useful in the turmoil of present debates about various IPR issues. The chapter attempts to involve various relevant but perhaps so far ignorant disciplines about IP. As such, the first part of the chapter is a cross-disciplinary voyage in a deep sea and admittedly somewhat adventurous. It will first travel through various contexts, searching for IP notions, and then give a

[1] See David (1993) for a review of three major types of institutional means – patronage, public prizes, (grants, subsidies), procurement and property rights (the three "Ps").

[2] It is not even natural to view these rights as property rights. It was not until the 19th century that this view became common.

history account of IP developments. Understanding of fundamentals and their implications is crucial to understanding the nature and origins of issues and dilemmas in the flourishing current debates of IP, be they on cyberspace or bio, or on university-industry collaborations or static-dynamic competition.

A second purpose of the chapter is to put IPRs in the context of contemporary innovation in a new type of economy. A number of specific issues and challenges to contemporary IPR systems and IP regimes will then be probed more in depth, such as the anti-common and IP assembly problem; the trade-off between incentives and transaction costs; and the impact of weak (e.g. open) IP regimes on dynamic competition and industry evolution, the impact of patent information (the disclosure effect) and the use of IPRs in business strategies.

The chapter concludes with a brief outlook on the future. A number of continuing clashes around the IPR systems can be expected. One conjecture is that it is not in cyberspace the decisive clashes will occur but in "biospace".

2 Previous IP studies

(to be compressed if needed)

2.1 Theoretical literature

A relatively small but recently growing number of studies of the economic theory of the patent system have emerged since the 1960s. A seminal work in this category is Arrow (1962) who presented a basic model of invention, R&D innovation and imitation. Arrow argues that there is a tendency in industry to underinvest in R&D from society's point of view, due to problems for a firm to appropriate the economic benefits of its R&D. Patent protection would be one out of several alternative means for coping with this, at least to some extent. Arrow also addresses alternative means in particular contracts as being superior in certain situations. Wrights (1983) compares patents, prizes and contracts in a probabilistic setting and characterizes the optimal choice of invention incentive as a function of elasticity of supply of research and probability of success of research. David (1993) elaborates qualitatively on various alternative means for correcting for a tendency to underinvest in R&D, means he classifies under the headings of

property (i.e.IPRs), procurement (contracts) and patronage (publicly financed grants, subsidies and prizes).

The whole issue of alternatives (substitutes or complements) to IPRs of underinvestment in innovation and diffusion is of course fundamentally important and has generated long-standing, wide-reaching and deep controversies. Despite this, there is not much conclusive research available on the issue, partly because economic research on IP has been scarce, partly and perhaps mostly worthy of attack, although prone to fighting back.

The principal way a patent affects invention and innovation is through its effects on the rate of imitation. In the Arrow type of patent modelling, the innovator's profits dwindle completely by competition when imitation occurs. Thus a delay in imitation through patent protection would be a stimulus for firms to invest in R&D, at the expense to society of the possible over-pricing of products by the monopolistic patent holder.

Nordhaus (1969), which is also a truly seminal work on the economic theory of patents, makes a thorough theoretical analysis of the cost and benefits to the firm and to society of the patent system in the Arrow type of framework and Nordhaus postulates the optimal length of patent protection time from society's point of view. By increasing the length of patent protection, incentives for generating innovations are increased (i.e. dynamic efficiency is increased), while producing a longer period of monopolistic inefficiencies, (i.e. static efficiency is decreased).

More recent work in the 1990's have shifted from focusing on the optimal length of a patent towards the optimal breadth or scope of a patent as well as optimal combinations of length and breadth. For works in this vein see especially Klemperer (1990) and Gilbert and Shapiro (1990). The scope of a patent is far more difficult to parameterize, however. There have been various approaches, for example, the scope of a patent could be represented by the patentor's ability to raise price (Gilbert and Shapiro 1990), the probability of infringement, the impact on close product substitutes (Klemperer 1990), the number of side classifications of a patent (Lerner 1994), and the invent around costs. The latter two approaches have the advantage that they do not rely as much on observations or estimates of post-innovation conditions. However, in general patent scope is a very complex

issue, both theoretically and empirically as amply demonstrated in the widely cited work by Merges and Nelson (1990), a joint legal-economic analysis.

Another shift in focus in the theoretical literature is from considering a one-stage innovation process towards a multi-stage innovation process. Building partly on Barzel (1968), Kitch (1977) introduced a new perspective on the role of patent rights, viewing them (in analogy with prospect rights in mineral extraction) not as rewards but as prospect rights, which were handed out at an early stage in the innovation process . Kitch's work has been highly cited but also criticized (see e.g. Beck 1983).

There is still another shift in thought from considering only a single innovation towards considering multiple innovations that build or interact upon each other. As is often the case empirically and as studied by Mansfield, a patent loses value because new and better subsequent inventions appear before the patent expires. At the same time a strong patent influences the patentability and profitability of subsequent inventions (see e.g. Scotchmer (1991) and Aghion and Howitt (1998, Ch. 14).

Game-theoretical modelling of patent races among competitors has also become popular. In many respects stylized patent races offer a theoretically appealing application for game theory. More importantly this literature throws light on how competitive races impact incentives for R&D and innovation. An important result is that races in R&D and innovation, including patent races, and strong early mover advantages may lead to overinvestment, or at least not underinvestment on the aggregate. This perspective contrasts with the original Arrow framework and goes back to Barzel (1963) and Scherer (1966, 1967). For further study, see e.g. Reinganum (1982), Fudenberg et al. (1983), Tirole (1988), Dasgupta (1988) and Dasgupta and David (1987).

There are many policy variables for a patent system other than patent length and breadth (e.g. regarding disclosure of patent information). More and more of these other features of a patent system have become subjected to theoretical economic analysis. See e.g. Ordover (1991) on how different features affect diffusion of technical information.

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). Tables 1-2 give a summary of economic rationales for a patent system.

Table 1. Economic rationales for a patent system

Received theories economic	**Other (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 incentive to innovate & diffuse** Focus: Impact on dynamic competition through ”continuous” and entangled 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 **Patents as governance mode** Focus: Property rights allocation as mode of organizing for decentralized management and markets Concerns: • Cumulation of rights • Dispersion of rights • Interdependence of rights • Management efficiencies, e.g. in terms of coordination and communication costs • Optimal decentralized “tariffs” or ”taxation” (through prices or damages) • Market efficiencies, e.g. in terms of transaction costs

Table 2. Principal advantages and disadvantages of the patent system

Level	Advantages	Disadvantages
Nation (society, consumers)	Stimulates rate of invention by providing an incentive for investment in R&D (also for reinvestment and for invent-around work)	Risk of monopolistic in-efficiencies (including risk of hampered commercialization of new technologies)[3)]
	Stimulates rate of commercialization (rate of innovation) through investment in general	Administrative costs for setting up and running the system
	Stimulates rate of diffusion and technology transfer through disclosure, marketing and licensing	Risk of R&D and investment distortion
	Provides an artificial metric (yardstick) of invention	Risk of over-investment in duplicative R&D and/or substitute inventions
Company[1)]	Offers restricted, transferable monopoly rights	Requires controlled disclosure[4)]
	Provides bargaining power and a basis for buying or selling an identified piece of technology	Monopolistic over-pricing (incl. cost for acquiring technology) and/or barriers to entry induced by competitors
	Provides information about technology and industry competitors	Patenting costs, direct and indirect (including e.g. litigation costs)
	Provides motivation for employees and yardsticks for technology management	
Individual[2)]	Provides a basis for award negotiation of a contract or start-up of a company	Requires controlled disclosure[4)]
	Provides a means for recognition	Monopolistic behaviour of holders of possibly interfering or complementary patents
	Provides information on technology	Patenting costs

Notes:

1) These advantages and disadvantages are of course related to a company's advantages and disadvantages of taking out patents, as described above and in Chapter 7, but they do not exactly match because the pros and cons here concern the patent system as a whole, compared to a hypothetical situation with no such system at all. Moreover, seeking to take out a patent is voluntary (as is keeping it in force, once it is granted) and a company perceives advantages of so doing in comparison with the alternative of not doing so while still having a patent system in place.

2) Typically an inventor (engineer or scientist), either autonomous or employed.

3) The commercialization of new technologies can be hampered by the dispersion of several necessary patents (and IPRs in general) among actors who cannot agree.

[4] No pre-publication is allowed (i.e. before a patent application is filed) and full post-publication is enforced.

Finally there are some (but much fewer) economic analyses of IPRs other than patents. For trade secrets, see Cheung (1982), Friedman et al. (1991), for designs see BIE (1995), and for copyrights, see e.g. Palmer (1986), and Towse (1997). The issue of patentability vs copyrightability of algorithms, databases and computer software in general has generated a great deal of literature in recent decades, theoretical and empirical, and perhaps more legal than economic. See e.g. Chisum (1986), OTA (1992), NRC (1993), Reichman and Samuelson (1997) and the issue of Columbia Law Review, Dec. 1994.

2.2 Empirical literature

When turning to empirical studies, important studies have been made by Mansfield and others on the considerable gap between the very high social returns to innovation and the private returns to innovation, as well as the importance of the rate of imitation behind these gaps. These studies indicate empirically that underinvestment in private R&D is likely because of imitation. This in turn indicates the need for something resembling a patent system. However, the studies also show that imitation is a costly and time-consuming process, affected by many more factors than just patents (see Scherer 1980, Mansfield et al. 1981). The question then is how effective the patent system actually is in practice and what would happen if it was changed or even abolished.

A classical and wide-reaching study of patenting practices in UK industry is presented by Taylor and Silberston (1973). This study also provides some data on the impact of patent lifetimes on R&D budgeting. Their main findings, based on interviews with 27 UK firms, indicate that without effective patent protection R&D budgets would be cut marginally (by 5 per cent or less), except in certain specialty chemicals, where R&D would be cut by 25 per cent, and in pharmaceuticals, where R&D would be cut by 64 per cent. These findings can be contrasted with the empirical results in Granstrand (1999), showing that large Japanese corporations (jointly covering more than 50% of Japan's industrial R&D

budgets) would be cut by 38%, with 59% in chemical industry, 40% in electrical and 5.5% in mechanical industry.

Mansfield (1986) sheds further light on the impact of an abolition of the patent system on the rate of invention and innovation, as estimated by US firms. In essence, the study shows that the effect would be a very small decline in most industries. As almost always in these types of studies, the exceptions are pharmaceuticals and chemicals for which the patent system is essential. However, Mansfield shows that despite this outcome the firms make frequent use of the patent system. This ”patenting paradox” requires further explanation. Since the propensity to patent was found not to have declined in the US from 1960 to 1980, the observed decline must be due to a decline in the number of patentable inventions. Because this number is related to the amount of R&D investments, a decline in patenting without a corresponding decline in R&D investments could be due to the (temporary) presence of diminishing returns to R&D. These issues have been extensively studied by Griliches, Hall and others, see Griliches (1984, 1989, 1990) and Hall (1994). The main conclusion from those studies is that there are important but complex links between the benefits of patents, R&D and innovation over time. These links are possible to study and much remains to be done.

The propensity to utilize the patent system, i.e. to prefer to patent an invention in face of alternatives, has attracted a number of empirical studies, see e.g. Scherer (1983) and Arundel and Kabla (1998).

The well-known Yale study by Levin, Nelson and others (see e.g. Levin 1986, Levin et al. 1987, and Klevorick et al. 1995) investigated, through a survey of hundreds of R&D managers in more than a hundred industries, the strong sector-specific variations in appropriability conditions and the role of patents in different industrial sectors. Briefly expressed, markets are imperfect and so are patents and patent systems. Thus innovations will continue to appear even without patents, and patents will not be sufficient to recap the benefits from innovation in general. The Yale study has been followed up by an expanded international study (the Carnegie-Mellon study), showing a.o. differences between use of patents, secrecy, lead times and other alternative means for a firm’s appropriation of rents

(see e.g. Cohen et al. 2003). A large empirical study of IP strategies in Japanese large firms is also reported in Granstrand (1999).

Regarding the economic value of patents, much important work has been done by Scherer, see for example Scherer (1998) and Harhoff et al. !997, 2003). The distribution of patent values is generally found to be very skew, sometimes possessing no finite mean and variance.

As mentioned, the empirical studies of patents have grown rapidly since the 1980s. Several factors have spurred this growth. The increased availability of large, electronic data bases concerning patents and R&D and the availability of computers have enabled and lowered the cost of many types of analyses. As is well known to investigators (e.g. Schmookler), a manual analysis of the rich and varied mass of patent documents is a Herculean task. Moreover, increased international technology-based competition and the emergence of a pro-patent era in the 1980s has generally spurred the interest in patents among both practitioners and scholars. For works on the emergence of the pro-patent era, see Coriat and Orsi (2002), Jaffe (2000), and Granstrand (1999).

2.3 Legal and economic controversies

In relation to the significance of IP, traditionally perceived as minor, few areas appear to have such a long history of heated controversies, seemingly never cooling off but temporarily. There is a sequence of legal controversies, as well as a sequence of economic controversies. These sequences are connected in principle but not always in practice, but compounded by the professional interests of lawyers and economists, two professions with a of being both critical and criticized.

In brief and hopefully uncontroversial terms the main types of controversies are as follows. Basic legal controversies fall into jurisprudence and roughly concern the three conceptual components of IPRs. Are they or should they be rights in the first place? Couldn't a liability approach do better? Do they have to be exclusive and/or temporary rights? And if a right, what kind of right? A right with deontological (natural, moral) or consequentialist justifications? And if consequential, should they be utilitarian or teleological? All these questions have a larger and longer history of debate in jurisprudence than just for intellectual

property. For the IP area the main controversy of the nature of the right was between the natural rights movement, especially strong in 18th century France but with roots to e.g. John Locke, and the utilitarian movement, which eventually prevailed, especially in the US. (See further Granstrand 1999.)

Second, are they or should they be property rights? Couldn't privileges or concessions do better? It wasn't until the 19th century that the property right approach started to prevail and then partly for political reasons among patent advocates against opponents in the free trade movement in order to facilitate acceptance of patent rights, being easier to accept as property rights among liberals and others than as concessions in form of (output) monopoly privileges (se further Machlup 1958 and Kaufer 1989). Royal or ruler privileges (patent rights being originally granted as such) had in turn been heavily criticized in a.o. 16th and 17th century in England and dismantled, however leaving patent rights as concessions, essentially allowing for monopoly privileges. Thus, patent rights came to shift from trade law into the body of property law. Thereby, the monopoly nature of the right shifted from output markets to input markets (see below).

Third, is there or should there be a special type of intellectual or immaterial property right distinct from a physical property right or could the IPR body of law piggy-back on the latter? This is currently an issue in cyberspace, where industry tries to draw legal strength to IPRs from analogies with and language from e.g. real estate and physical property law (see Radin 2003). Again deliberate piggy-backing on property law is used by interested parties in order to strengthen the IPR system.

In addition to these controversial issues there is a host of other legal ones, some strongly rooted in jurisprudence, like the common or different nature of different types of IPRs (patents, copyrights, trade secrets, trade marks etc.), or what is protectable subject matter (genes, personal information etc.), some less so, like international harmonization.

As for more economic controversies, there has been a pulsating debate over the centuries about the pros and cons of the patent system, but the debate has been conducted in a kind of "invisible college," indeed not very visible to the economics profession at large, nor to the legal profession at large. The leading

economists have had fairly little to say about the patent system, and even less about other IPRs, their rationales, functioning and possible reforms. This is somewhat paradoxical in view of the long history of the patent system as an economic institution, actually preceding industrialization as well as preceding both the modern firm and the modern nation-state as economic institutions. It is also paradoxical in view of the worldwide spread of the patent system with its basic ideas remaining much the same, although with many national variations over time. The adoption of a patent system or an IPR system in a nation was not a trivial matter.

What did the leading economists in the past have to say about the patent system? To answer this is a research task in itself, and only a few observations can be offered here.[3] Adam Smith in *The Wealth of Nations* barely touched upon the patent system. Charles Babbage, who made a significant but little recognized pioneering contribution to economics of industry and technology,[4] was largely pro-patent but did not have much to say either about it in his 1832 book *On The Economy of Machinery and Manufactures* except than to complain about its costs and difficulties to defend English patents in court (Babbage 1832, pp. 359-361).

There has been a tendency concerning patent issues to divide analysts into advocates and outright critics (rather than reformers) with fairly polarized pro- and anti-patent standpoints. This has much to do with the monopoly feature of patents, and the general hostility among economists as well as others (including Aristotele) against monopolies. Smith, Bentham, Mill, Say, Walras, and von Mises accepted patents as exemptions from monopoly prohibitions, while Marshall, Hayek, Robbins, and Taussig were generally sceptical towards patents. A most outspoken critic in the 20th century was Sir Arnold Plant (see Machlup 1958).

Marx, of course, was critical of the patent system as part of his general criticism of private property and technological change under capitalism, but he did not devote much attention to it. Schumpeter is generally seen as the founding father of economics of technology and innovation, with his pioneering emphasis on the decisive role of innovations and entrepreneurs in economic dynamics.

[3] The best exposé still up to date is made in Machlup (1958).

However, he did not pay much attention to the impact of a patent system upon the stream of inventions, and he did not draw the possible conclusion that an economic institution like the patent system would be largely ineffective in stimulating inventive activities if these were exogenous to the economy. In later works Schumpeter gave far more thought to the rise of large corporations, their industrial R&D, the endogenization of technological change and the importance of monopolistic positions (the "old Schumpeter" view on inventions). Yet it is perhaps fair to say that, while he scrutinized the advantages of monopolies for R&D and innovations, he did not take a corresponding interest in the patent system, or the IPR system as a whole, as a way of fostering a certain breed of temporary monopolies that were advantageous to innovations.

Needless to say, many economists before World War II had emphasized the role in economic development of knowledge or information (Marshall, Hayek, etc.), but the role of the IPR system for its production and distribution was largely unexamined. This started to change after World War II, with increasing industrial and military R&D and a gradual recognition among economists of the role of R&D. Fritz Machlup wrote a major review in Machlup (1958) and (1980). Jacob Schmookler made careful empirical studies of patenting and started to use patents as economic indicators (see e.g. Schmookler 1966). Kenneth Arrow made an important analysis in Arrow (1962) of the tendency in a society to underinvest in R&D, for which the patent system was one possible corrective by raising the private rate of return on inventions. Edwin Mansfield later showed empirically that the economic returns on inventions were greater to society than to inventors on average across industry, although with large variations. Early theoretical works by Frederic Scherer analyzed e.g. R&D rivalry and patent races. William Nordhaus produced a major theoretical analysis along neo-classical lines, addressing e.g. the socially optimal patent protection time (Nordhaus 1969).

Further empirical and theoretical works have then been made at an accelerating pace since the 1970s. Through the works published after World War II, the theoretical and empirical foundations of the patent system have been considerably strengthened and some of its surrounding economic ideas have

[4] See Stigler (1991), Rosenberg (1994) and Granstrand (1994, Ch. 1) for accounts of Babbage's contribution to economics.

become more rigorously spelled out, analyzed and recognized. Still much research remains to be done. Entirely new economic ideas for designing an incentive system for innovations have also to be analyzed (see e.g. Kingston 1987, 1990, 1993, 1997, Thurow 1997 and the whole issue of Columbia Law Review, Dec. 1994 with Samuelson et at. 1994 and Reichmann 1994). In addition, comprehensive economic evaluations of the patent system with its many actual and potential decision variables (e.g. regarding patent length, strength, breadth, priority, licensing, differentiation, etc.) for a policy-maker have scarcely been performed and agreed upon. Our state of knowledge about the patent system can still be characterized as it was in the 1950s (Machlup 1958, p. 80):

> "If one does not know whether a system 'as a whole' (in contrast to certain features of it) is good or bad, the safest policy conclusion is to 'muddle through' – either with it, if one has long lived with it, or without it, if one has lived without it. If we did not have a patent system, it would be irresponsible, on the basis of our present knowledge of its economic consequences, to recommend instituting one. But since we have had a patent system for a long time, it would be irresponsible, on the basis of our present knowledge, to recommend abolishing it."

Possibly it is reasonable to place the burden of proof upon the reformer as Machlup indicates. But there is also a burden of disproof of misplaced notions. Such misplaced notions have grown around the patent system in the historical absence of sufficient attention to it. Two misplaced notions are of particular importance. The first one is the notion that a patent directly gives the patent rights holder a monopoly on output markets. In the history of economics, patents have always been linked to the much broader discussion of monopoly issues. The temporary nature of a patent-based monopoly has then generally been sufficiently recognized, but not the fact that it is basically a monopoly on an input factor market, not on an output product market. The patent rights holder can only exclude others from accessing the technology as a certain input, just as the owner of a certain raw material source can exclude others from accessing it. Sometimes an opinion of the patent system, or even an analysis of it, rests on the assumption

that the monopoly position on the input side is readily converted to a product market monopoly. A strong output market monopoly may result from strong patent positions, of course, and there are lots of historic examples of this.[5] However, an output monopoly does not automatically obtain from an input monopoly for two reasons. First, substitute input factors may be available or be made available, including substitute technologies, sometimes due to activities for inventing around the patent. Only when a patent is necessary for a product in a given market (that is the patent is effectively blocking others from entering the market) an input monopoly could be effectively converted to an output monopoly. If e.g. the scope of the patent granted is broad, the patent may become strategic. Moreover, the monopolistic power of patents depends on patent length and patent scope (or breadth), both of which could be adjusted by policies or intervention by authorities. Second, complementary input factors are needed to launch an innovative new product, including other complementary technologies, whether or not protected by patents. Products, and production processes as well for that matter, also tend to become increasingly multi-technological in character, i.e., new generations of products and processes need an increasing range of technologies over time to be implemented. This means that there tend to be more patents as well as more patent rights holders involved in each new product, increasing the difficulty for each one to achieve a sufficiently monopolistic position on the output market and thus forcing them into licensing, cross-licensing, pooling or other technology-swapping arrangements.[6]

The second misplaced notion is that a patent is entirely anti-competitive. This is not true, even if the input monopoly is perfectly converted to an output monopoly. A patent-based monopoly restricts short-run price competition for a certain product, but at the same time stimulates the generation of new products and processes that typically increase performance-based competition or Schumpeterian competition in the longer run. Thus, a patent is partly anti-competitive, partly pro-competitive. Therefore a trade-off must be made, but not a

[5] There are several large US corporations that serve as classic examples, e.g. RCA and General Electric.

[6] E.g. as of 1993 there were over 2000 patents relevant to the European mobile communication system GSM. Of these, over thirty were so-called standard blocking patents (i.e., they applied directly to a decisive feature of a standard in the system).

trade-off between the purposes of patent legislation and the purposes of anti-trust legislation, perceived of as incompatible before the 1980s, but instead a trade-off between different means to accomplish common purposes. Such a (belated) reinterpretation of the patent system also took place within the US Antitrust Division under its newly appointed head William Baxter in the early 1980s, based in fact on "new" ideas and movements in economics, which emerged mainly in Chicago a few decades earlier.

In conclusion, one may claim that the relatively little attention historically paid in economics to the patent system paved the way for some possibly costly confusion about its impact on static vs. dynamic efficiency, and concerning its input rather than output monopolistic nature. Still there is wide open space for old and new controversies of IPRs to live on without cooling off. A significant one concerns strategic use of the IPR system by incumbents and by advanced nations, building barriers to entry and catch-up. Another concerns the possible overprotection from combining legal, technological and managerial means. Still another concerns the overprivatization of certain subject matters, and the proper line between private and public property. An overriding concern is how the IPR-system compares to alternative means for the adequate provision of information and innovation. Given the scarcity of knowledge on this one is prone to agree with Fritz Machlup half a century later. An overview of main legal and economic controversies are shown in Table 3.

Table 3. Main IPR controversies (mainly about patents)

Century	Controversial issue
16th	- (?)
17th	Royal privilege vs. government concession
18th	Natural rights vs. utilitarian rights
19th	Free trade vs. protectionism and monopoly privileges
	Adoption/establishment of patent system
	International harmonization
20th	Compulsory licensing
	Weakening of patents
	Over/under-reward
	Distortion of R&D, R&D resource allocation and competition
	Tailoring vs. one-size-fits-all
	Overprotection (overreward, market power) through joined legal (IPR), technological (ICT) and managerial (strategy) means
	LDC discrimination
	Protectable subject matter
	Overshoot of pro-patent era
	Sui generis rights
	IPRs vs. alternative means (prizes, procurement, taxes, grants, consertia etc.)
	Litigation costs and alternative dispute resolution methods
	Open vs. closed IP regimes
	IP in cyberspace
	Piracy and counterfeiting (IP criminalization)
21th	IP in "biospace"?
	More?

3 History of the IPR system

(To be compressed if needed)

Here the historical evolution of IPR systems will be briefly outlined with a focus on its early period up til the first codification of a patent law in Venice 1474 (which is a common starting point for history accounts of IP law). This account is a chronological complement to the preceding account of early IP notions across different contexts. There are several excellent IPR history accounts providing a richer history, for example by David (1993) on patents, copyrights and trade secrets; Penrose (1951), Machlup (1958), Kaufer (1989) MacLeod (1988), and the special issue of the journal Technology and Culture 1991 on patents; Plant (1974), Rose (1993), Goldstein (1994) and Kretschmer (1997) on copyrights; Coleman (1992) on trade secrets; and Diamond (1983) and Wilkins (1992) on trademarks.

As discussed above, IP notions have evolved from the dawn of history, especially oriented around secrets, although identity-related symbols are also of early origin.[7] IP for gaining trade-related advantages was less important in prehistoric times, but secrets and symbols as means to gain and preserve power were important, especially in political, military and religious settings. Ancient cultures, as in Egypt and Greece, were not known to have had any patent-like institutions for technical inventions, nor did the Roman Empire (Kaufer, 1989, p.1).[8] But there are clear indications of other forms of IP in these cultures, see Table 4. Particularly noteworthy is the use of trademarks and a patent like system for ”food chemistry” in the Greek colony Sybaris on the East coast of the Italian peninsula.[9]

[7] These symbols correspond to trademarks, but could also be seen as related to designs and copyrights since they involved visual expressions. Copyright of written material requires a written language, of course.

[8] Roman property law was strongly centered around physical property and physical possession.

[9] Athenaeus in “Deipnosophistae”, book XII, p. 521 tells the following:
“The Sybarites”, Phylarchus says, “after drifting into luxury passed a law that….if any caterer or cook invented a dish of his own which was especially choice, it was his privilege that no one else but the inventor himself should adopt the use of it before the lapse of a year, in order that the first man to invent a dish might possess the right of manufacture during that period, so as to encourage others to excel in eager competition with similar inventions.” (As cited in Charles Burton Gulick's translation, Vol. I-VII, London/New York 1927-41, in Vol. V, p. 349).

Table 4 Chronological overview of early major events in IPR development

Year(s)	Event
3,200 BC	Potter marks found on fired clay pots, including jars buried in tombs of the First Dynasty Egyptian kings, providing a precursor to trademark protection. Stone seals or cylinder seals bearing such marks were used from about this time onward in both the Near East and Greece.
700-500 BC	Chefs in Sybaris, a Greek colony in southern Italy known for luxurious living, were granted one-year monopolies on the preparation of an unusual or outstanding dish. This right applied to no other art or science.
Ca 350 BC	One of the first recorded unauthorized copying events occurred when Hermodorus copied Plato´s speeches and without passing them off as his own, he took them abroad to sell for his own profit. An early "bootleg" incident.[10]
100 BC	Trademarks used in Rome on an everyday basis to mark products such as cloth, lamps, glass vessels, cheese, and medicine.
40 – 100 AD	the roman poet Marcus Valerius Martialis were so upset when others used his poems without reciting his name that he equalled it to kidnapping for which in latin is the word "plagium" (plagiarism).[11]
Ca 100 AD	An acknowledgement of intellectual work and effort in the Roman empire is visible in the legal institute of specificatio. Specificatio was a method of acquiring ownership by the creation of a new thing out of someone else's materials. If someone created a marble statue out of someone else´s marble the statue could be considered a "nova species" (a new thing) whereby the statue came to belong to the creator.[12]
337 AD	Roman emperor Constantine decrees that artisans of certain critical trades are exempt from all civil duties. Chariot makers, engineers, and locksmiths are especially favoured.
483	Roman emperor Zeno decrees that no monopoly can be granted to clothing or food, even if the monopoly was previously required by order of an emperor.
1297	A Venetian decree allows physicians to retain within their guild the secret for preparing new and novel medicines.
1323	Johannes Teuthonicus is granted a patent-like privilege by the Venetian government for a grain-mill
1324	Edward II (England) grants letters of protection to skilled German miners to induce them to come to England.

[10] Copyright Theft, John Gurnsey, Aldershot 1995.

[11] Lärobok i Immaterialrätt (in Swedish), p. 25, Levin, M,Koktvedgaard, M, Norstedts Juridik, 2000.

[12] Textbook on Roman Law,Andrew Borkowski LLB, Blackstone Press Ltd, 1994.

1331 John Kempe of Flanders receives a royal grant (patent) for the purpose of building a clothing industry in England. The policy is later extended to other skilled trades.

1332 The Venetian Grand Council establishes a special fund for a foreign constructor of windmills.

1353 An English statute enables a foreign merchant to obtain restitution for lost goods if his mark proved ownership.

1416 Franciscus Petri in Venice received a letters patent for building and maintaining a waterworks.[13]

1450 Johann Gutenberg develops the printing press.

1451 The newly acquired ease of copying written materials creates the necessity for copyright protection.

1452 Earliest recorded trademark litigation; a widow of a London bladesmith is awarded a particular mark that formerly belonged to her husband.

1469 Johann von Speyr receives the first printing privilege in Venice which duration was five years.[14]

1474 Venice enacts the first codified patent ordinance. Inventors were permitted 20-year monopolies. Infringers would be fined 300 ducats.[15]

1584 The first judicial recogniction of trademarks stems from the common law system in England beginning with the "Sandforth´s case", where it was stated that a mark deserved protection at common law to indicate source or origin of goods.[16]

1624 The first legislation of patent law that to a large extent resembles our present, were the Statute of Monopolies.[17]

1709 The first legislation of copyright law that to a large extent resembles ours were the Statute of St Anne. This legislation were influenced from older common law concepts that were formed during the 15th century.

1712-1737 Legal protection of design rights for textile patterns were afforded in France to silk weavers.[18]

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[13] Lärobok i Immaterialrätt (in Swedish), p. 26, Levin, M,Koktvedgaard, M, Norstedts Juridik, 2000.

[14] Urheberrecht, Kohler, Stuttgart 1907,pp.34.

[15] Patentskyddets omfattning, Godenhielm (in Swedish), Helsingfors, 1994, pp2.

[16] How Early Did Anglo-American Trademark Law Begin? An Answer to Schechter´s Conundrum, Keith, M. Stolte, 8 Fordham I.P., Media & Ent L.J. 505 (1998).

[17] Lärobok i Immaterialrätt (in Swedish), p. 26, Levin, M,Koktvedgaard, M, Norstedts Juridik, 2000.

[18] Lärobok i Immaterialrätt (in Swedish), p. 270, Levin, M,Koktvedgaard, M, Norstedts Juridik, 2000.

1751	In line with the French enlightenment movement, the French encyclopédia was first printed, containing many never before published trade secrets from different guilds. [19]
1790	America´s first patent and statute, The Patent Act, was signed into law on April 10, 1790 by President George Washington.[20] The same year the Copyright Act was also enacted by the U.S. Congress.

As trade and technology developed in the Middle Ages, IP notions developed. A need to protect technological advantages by other means than secrecy arose. For example, a ruler could feel overly dependent on the secret-based ”natural” monopolistic power of professional guilds and societies, as well as on that of an individual artisan such as a clever weapons smith. Furthermore, skilful artisans could take their professional secrets with them into the grave. The idea of remunerating the disclosure of secrets, which is an ancient practice in itself, became increasingly important as technical know-how gained importance. It is likely that various types of compensations were considered: prizes, grants, patent privileges, etc. What probably made a patent-like privilege particularly attractive to a ruler 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 existed, the privilege holder was remunerated by the ruler but in such a way that the ruler, i.e. the privilege granter, did not have to fully and directly pay for it.[21] A patent privilege also carried the advantage that the remuneration was tied to the actual working of a device and the demand for that device. This advantage could be achieved by a prize system as well, but then the ruler had to finance the prize. The disadvantage of a patent system from the patent holder’s point of view was that a patent privilege implied a remuneration ex post, i.e. in connection with commercial success, based in turn on technical success,

[19] The business of enlightenment: a publishing history of the Encyclopédie,1775 – 1800. Cambridge Mass.1979.

[20] Fundamentals of United States Intellectual Property Law: Copyright, Patent and Trademark, Sheldon W.Halpern, Craig A. Nard, Kenneth L. Port, Kluwer Law 1999.

[21] Thus, a patent privilege, in a way, functioned as a privilege 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.

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 ruler. 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 promoting inventions that provided an attractive mode of financing for the privilege granter.

A patent-like system also emerged in connection with ore mining sites as described by Kaufer (1989, pp. 2-4). In that context, the priority rule ”first to invent” emerged, with the term ”invention” then having a meaning closer to ”discovery” in present-day language.[22] According to Kaufer, there had been a long common-law tradition in mining areas in the European Alps of granting property rights to those who were ”first to invent” an ore site.[23] 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 (”Wasserkuenste” or ”water arts”). Patent-like privileges were then granted to originators and financiers of these devices by extending mining law principles. Often remuneration took the form of rights to a certain share of the mine’s output, again an attractive mode of financing.[24]

In the 14th and 15th centuries the Republic of Venice was engaged in mining and ”water arts” as well. Kaufer (1989, p. 304) as well as David (1993, p. 46) reports on how several engineers were granted special patent-like privileges by the Venetian government. The first known example is Johannes Teuthonicus in 1323 for a grain mill. Another example is Jacobus de Valperga, who received a special privilege in Venice in 1460 for a water pump. The privilege prevented

[22] The ”first to invent” rule means that the one who first makes an invention has priority to the rights attached to it. This property concept is analogous to the physical property concept based on the first possession of a physical thing. However, the difficulty of establishing who is the first possessor of an intellectual thing, i.e. who is the idea’s creator, has led to the alternative priority rule that the one who registers an invention, i.e. files a patent application, gets priority to any rights granted. The latter rule prevails in Europe and Japan, while the USA has stuck to the former rule.

[23] This is an example of how property concepts were extended from the physical to the intellectual world.

[24] As mining in one way or another is among mankind’s earliest technological and economic endeavours in various parts of the world, similar legal practices could conceivably have occurred in other places and possibly earlier as well. For example, silver mining become important in ancient Greece. (See Austin and Vidal-Naguet 1980, pp. 310-313.) However, it is unclear whether there were any incentive schemes used to generate and/or deploy new techniques, such as schemes for bringing in skilled workers and inventors.

anyone from imitating Jacobus' pump without his permission as long as Jacobus lived. On the other hand, there was a compulsory licensing provision requiring Jacobus to grant licenses to anyone who offered reasonable royalties. At this time, Venice had two types of privileges, invention privileges and trade privileges. Jacobus' privilege was an invention privilege that gave protection from unlicensed imitation, while a trade privilege gave protection from competition.

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 preamble of the 1474 code stated:[25]

> "We have among us men of great genius, apt to invent and discover ingenious devices".... "Now, if provisions were made for the works and devices discovered by such persons, so that others who may see them could not build them and take the inventor's honour away, more men would then apply their genius, would discover, and would build devices of great utility to our commonwealth."

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. This first patent law had a slow start, something that happened later with the first patent laws of other nations as well, e.g. in Japan. However, these laws signified the emergence of a new era: what we can call the patent era, or rather the *national patent era*, since the patent system was a national or local phenomenon pertaining only to single city-states or countries. The rest of the history of the patent system is more widely known. Table 5 summarizes the history, divided into different eras.

[25] As translated in Gilfillan (1964, p.11) and cited in Kaufer (1989, p. 5), who also provide a fuller text in original Italian.

Table 5. Eras in the history of patents and IP [1)]

Era	Characteristics
1. Non-patent era Ancient cultures (Egypt, Greece, etc.)	Emergence of science separated from technology Emergence of cultural and industrial arts Secrecy and symbols emerging as recognized IP No patent-like rights or institutions for technical inventions
2. Pre-patent era Middle Ages to Renaissance	Emergence of universities Secrecy, copyright and symbols (artisan/trade marks/names) as dominant IP, also collectively organized Emerging schemes to grant privileges and remunerate disclosure Extensions of mining laws to inventions
3. National patent era Late 15th - late 18th century	Breakthrough of natural sciences Local codifications of patent laws (Venice 1474, England 1623, etc.) Regulation of privileges Conscious stimulation of technical progress at national level, linked to economic policies (e.g. mercantilistic)
4. Multinational patent era Late 18th - late 19th century	Emergence of modern nation-states Industrialization Continued international diffusion of the patent system Local anti-patent movements Emerging international patent relations (e.g. disputes)
5. International patent era Late 19th - late 20th century	Emerging industrial and military R&D International coordination of the patent system (Paris Convention 1883, WIPO, PCT, EPO etc.) Separate IP regimes in socialist countries and LDCs
6. The pro-patent and emerging IC era Late 20th century - ?	IC surpasses physical capital for many entities Intensified international competition Global activism for IP from industrialized countries, especially from the US Almost worldwide adoption of the patent system Increased international patenting
7. The global patent and IC era ?	Global harmonization and integration of IP Emergence of supra-national and global patents, IP offices and clearing procedures?
8. The social reform patent era?	Clashes in cyber-space? Clashes in bio-space?

Notes:
[1)] Discerning eras, epochs or stages in a historical stream of events may be a useful sorting device but it always involves some arbitrariness, even if good criteria are used. (Here the degrees of codification and geographical diffusion of the patent system are used as primary criteria for distinguishing different eras.) Also, beneath the events that surface in an era is often an undercurrent of events that lead up to a later era.

In the 20th century, industrial and military R&D emerged, entailing very different modes and settings for inventive work. The individual inventor, who was the original target for patent laws, gradually has become relatively less important. Inventions increasingly require large resources, and industrial firms and the military establishment have become the prime movers of technology, in both the East and West. Similarly, cultural arts have become big business, with more professional artists than ever. Socialist countries with planned economies have set up separate IP regimes. Economic and industrial differences between various categories of countries have increased and become alarmingly large, creating tension among institutions, including national IP regimes in developed and developing countries. Two global wars have transformed the world, including its various institutional frameworks. Science and technology have progressed and accumulated tremendously at an increasing pace. Still the IP system and its essential ideas have survived and continued to diffuse internationally, not least after the downfall of the Soviet Union and the corresponding planned-economy systems.[26] This resilience of ideas and persistent adoption of a fairly well preserved and long-standing institution such as the IP system is indeed surprising. Its current context has changed radically since 15th-century Venice and 17th-century England, while its basic features of being a temporary monopoly reward for certain inventions for a certain length of time etc. have changed comparatively little.[27] There are naturally numerous variants of patent laws in different periods and places, but as a whole the patent system has become a dominant institutional design. In fact the similarities among IP laws in various countries are more surprising than their differences (which are numerous at a finer level of detail). There has also been a convergence, both of national patent systems and of IP regimes, although slow and with many substantial differences remaining.[28]

[26] The various IP components (patents, copyrights, trade secrets, trademarks, etc.) have had separate histories, which were weakly interrelated until recent decades and hardly constituted an "IP System" other than in a loose sense. Nevertheless, or rather because of this, the similarities between different IPR types and their underlying criteria are more surprising than their differences.

[27] Note e.g. the small difference between 14 years of protection in 17th-century England and 17 years of protection 350 years later in the USA and parts of Europe (now changed to 20 years).

[28] Ideas for radical reform of the patent system have been far from missing, however.

Table 6. Chronological overview of major events in US post-war IPR development

1949	Patents so frequently declared invalid when litigated that Supreme Court Justice Jackson remarks, "the only patent that is valid is one which this Court has not been able to get its hands on." (Jungerson v. Ostby & Barton Co.)
1952	The present (as of 2003) US Patent Law is passed. Revisions have occurred continually as needed.
1979	Both the US Senate and President Jimmy Carter desire to strengthen enforcement of domestic patents.
1980	US Supreme Court declares man-made microorganisms to be patentable (Chakrabarty case). Bayh-Dole Act enacted, enabling universities to patents inventions from federally funded research.
1980	US Copyright Law amended patent1[29]
1980s	Jury trials become much more common in patent litigation.
1981	The US Justice Department revises its antitrust enforcement activity to make it easier for patents not to violate antitrust statutes.
1981	Diehr case (computer program)[30]
1982	CAFC is established.[31] In quick order, the court changes the validity of litigated patents from 30% to 89%, thus initiating an era in which patents are of much greater interest to industry.
1982	CAFC3) established
1983	Patent Commissioners' trilateral conference started
1985	WIPO Harmonization conference
	USITC litigations increased
1985	The Young Report delivered to President Reagan
1986	TI semiconductor patent litigation initiated at USITC4). Kilby patent granted.[32] GATT TRIPs started
1988	US Trade Act (Special 301)
	US Tariff Act 337 amended
1989	The Structural Impediments Initiative (SII) talks initiated between the USA and Japan remove structural impediments to trade between the two nations, and include intellectual property protection.
1989	Japan on Watch List of Special 301 (cont.)

[29] The patentability of a bacteria genetically engineered by A.M. Chakrabarty was finally decided by US Supreme Court, overruling USPO's rejection of the patent application. This decision opened the possibility to grant patents for living organisms. The Supreme Court also stated in a dictum that "anything under then sun that is made by man" can be patented.

[30] A US Supreme Court decision, which through its interpretation by USPO opened the possibility to grant patents to computer software.

[31] CAFC = Court of Appeals for the Federal Circuit.

[32] Texas Instruments claimed eight Japanese and one Korean company infringed on 10 of their patents for DRAMs (see Warchofsky 1994).

Table 6. Chronological overview of major events in US post-war IPR development (cont.)

1992	US Patent Law reform report Honeywell won patent litigation against Minolta
1993	GATT TRIPs completed
1994	World's industrialized nations agree to harmonize aspects of their intellectual property protection under the auspices of GATT, known as TRIPS.
1994	US-Japan Patent Commissioners' Understanding signed
1994	After years of favourable court decisions, all software is now clearly patentable.
1995	GATT-related TRIPS agreement causes USA to amend its patent laws to expand the patent term from 17 to 20 years, allow inventive activity abroad to be considered by the patent office, and permit the filing of provisional patent applications.
1995	CAFC holds that patent claims are a matter of law to be decided by the judge and not a matter of fact to be decided by the jury. The ruling expands the ability of the court to review patent holdings and makes patent trials by jury less desirable. The ruling is slated for review by the US Supreme Court in 1996.
1998	The CAFC rules in State Street Bank and Trust v. Signature Financial Group that "since the 1952 Patent Act, business methods have been, and should have been, subject to the same legal requirements for patentability as applied to any other process or method.".

4 Emergence of the pro-IP era

The anti-patent era of the 19th century more or less ended in the 1870s. Political and economical forces largely defeated the anti-patent movement. However this did not produce a marked reversal into a pro-patent era. Patent legislation carried weight, 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). Several government committees and reports on patents, trademarks, etc. appeared as well before and after World War

II, but the pro-patent era of the 20th century did not originate in the US until the 1980s.

There seem to be four streams of events in the USA, somewhat disjointed initially, leading up to the pro-patent era. The first concerned the creation in 1982 of a federal court of appeals, namely the Court of Appeals for the Federal Circuit (CAFC), specifically to hear patent appeals in lieu of the other circuit courts of appeal.[33] This type of specialized court had been contemplated for a long time in patent circles.[34] As the complexities in patent disputes grew, the pressures for a specialized court of appeals mounted and finally resulted in the creation of the CAFC in 1982, which by and large was generated within pro-patent circles in law and industry. The origins of the CAFC were much less dramatic than the consequences, the magnitude and repercussions of which had not been anticipated. The CAFC started to act in a pro-patent manner in stark contrast to what US courts had done previously, as was to some extent expected. The validity of patents was upheld far more often (as if they were "born valid"), and patent damages were largely increased.[35] (See further e.g. Banner 1986, Cox 1986, Shapiro 1990.) All in all, the economic value of patents to patent rights holders increased.

A second stream of events behind the emergence of the pro-patent era was linked to a change of attitude within the Antitrust Division of the US Department of Justice in the early 1980s under its new Director, William Baxter. Traditionally the Antitrust Division had been hostile to IP legislation and IP licensing (illustrated by the famous "nine no-nos" of patent licensing), interpreting patents as monopolies that limited the static efficiency of price competition. Attitudes now changed in reference to upgrading the incentive aspects of patents to promote dynamic competition through R&D-based new products and processes and limiting the disincentive to R&D investments created by unauthorized imitation and "free-riding". This was presented as a shift from a narrow scope of static economic analysis towards a broader dynamic analysis of the economics of

[33] See further the Federal Courts Improvement Act of 1982 and Dreyfuss (1989).

[34] A proposal can e.g. be found in recommendations of the US Senate Committee TNEC from the 1940s, see Folk (1942, pp. 281-295).

[35] There have been several fact-finding studies of the outcome of patent court cases, including those of the CAFC, see e.g. Hofer (1986), and Scherer (1991).

technology, but still within the stated mission of the division to serve the interests of United States consumers.[36]

This change in attitude could be traced back to ideas and perspectives emerging in the 1960s among economists, especially within the emerging field of law and economics.[37] The shift in anti-trust policy in the early 1980s in the USA is a good (but perhaps too uncommon) example of how changes in scholarly thinking have had a direct impact on policies.

The third stream of events emanated from large US corporations, with the chairman of Pfizer, Edmund Pratt, and the chairman of IBM, John Opel, as two leading representatives among several other industrialists.[38] Through a series of initiatives and reports, channelled through various committees, councils and task forces, US big industry pressed for stronger IP protection and enforcement against infringers and counterfeiters domestically and abroad. US industry also pressed for a "trade-based approach" to improve IP protection by including IP matters in US trade negotiations and in the GATT framework of international trade negotiations, for which a number of "trade-related aspects of IPRs" (TRIPs) were formulated. In general, these initiatives and pressures were part of a larger movement to increase the competitiveness of US industry for which it had become increasingly clear that technology was a key asset that had to be protected. Individual US corporations such as Texas Instruments and Motorola then started in the mid-1980s to become aggressive litigators against both domestic and foreign, especially Japanese, infringers. The economic value of patents rose accordingly due to the changes in court behaviour and anti-trust attitudes.[39]

A fourth stream of events, merging with the other streams behind the pro-patent era, emanated from US Government, especially the Reagan administration. This political stream of events as well as the stream of events in industry was embedded in the general movement in the 1980s to preserve US industrial

[36] See speeches and articles by Dep. Director Roger Andewelt, e.g. Andewelt (1986).

[37] Prof. William Baxter, personal communications. See also Baxter (1966).

[38] For a good account of the lobbying activities of Pfizer executives and others regarding IP, see the Harvard Business School case No. 9-392-073, titled "Pfizer: Global Protection of Intellectual Property".

[39] A number of law suits against infringers were brought, as well as many out of court agreements. Royalty rates for licenses were moreover increased. In general, these events signified the outbreak of the so called patent war between USA and Japan. See Warchofsky (1994).

competitiveness. This movement in turn was essentially triggered by the successful catch-up process in Japan and Asian NICs and the perception in the USA that these countries were free-riding on US technology as they made significant inroads into US markets and the US trade deficits grew to astounding heights. At the same time, there were signs in the early 1980s that US (civilian) R&D investments were insufficiently growing with little or no increase in patenting and that foreign corporations, especially from Japan, were increasing their patenting in the USA.[40] New forms of federal and state support to stimulate industrial R&D were installed, for example, a new R&D tax deduction scheme, engineering research associations, R&D consortia and schemes for university-industry collaboration (including the so-called Bayh-Dole act of 1980, enabling universities to patent inventions from federally funded research, see Henderson et al. 1995).

In the 1980s, the Patents, Copyrights and Trademarks Sub-committee was recreated (in 1982), and the Congress became much more active on IP matters. Presidential commissions and task forces on IP were created, and US diplomats and delegates criss-crossed the globe advocating the protection of US IP (see e.g. Oman 1986 and Simon 1986).

Proposals for reform asked for longer patent protection time, shorter handling of cases in the USPTO and in courts, more reciprocity towards foreign countries, and increased enforceability against infringers and counterfeiters, especially in NICs and developing countries. The international trade aspects of intellectual property rights were proposed to take place primarily within the GATT framework, an arena in which the USA had more leeway than in the UN framework (with WIPO, UNCTAD etc.) or the framework of other international institutions designed for IP protection, which moreover were perceived by the USA as too weak. (See also Cordray 1994.)

In conclusion, the four streams of events described above merged and resulted in the advent of the pro-patent era in the USA, signs of which were clear in the mid-1980s. The CAFC and the change in anti-trust policies were largely domestic matters, which paved the way for effective enforcement of the existing

[40] In fact, the share of foreigners' patenting in the USA rose from 22% in 1967 to 40% in 1980 (Evenson in Griliches 1984, p. 92). See also Quigg (1986).

US IP legislation. Entirely new IP legislation was hardly decisive for bringing about the pro-patent era, however.[41] The industry lobbyists were of decisive importance in conjunction with the US Government and the tie-in of IP issues to broader political issues of US industrial competitiveness and trade relations. In these respects, there were similarities with how the anti-patent movements were defeated in Europe in the 1860s and 1870s (see Kaufer 1989, p. 9).

The trade-based approach to IP legislation was, to a considerable extent, successful (from the US point of view), especially since the US Congress created leverage for US trade negotiators through a number of changes in US trade laws.[42] The pro-patent era, set in motion in the USA, gained ground internationally for various reasons. This was especially due to the shared interests among technology-based MNCs, not only in the USA but also in Europe and especially in Japan. In the late 1990s there were no signs of a reversal of the pro-patent era, on the contrary. This may be seen as a reflection of the growing strength of more fundamental forces in the international economy. Table 6 summarizes the events.

5 Role of IPRs in national innovation systems

Almost the only point of consensus regarding the role of the IPR system[43] in economic history is that its role is intrinsically difficult to assess and that there is

[41] There were a number of other important legal IP developments in the USA in the 1980s, especially broadening what was patentable matter to include mutational genetic engineering and computer programs. (See the chapters by Barton, Samuelsson, Rathman and Goldberg in NRC 1993). The US Supreme Court decision in 1980 thus held that a live, human-made micro-organism is patentable subject matter (the Diamond vs Chakrabarty case). The Supreme Court decision in 1981 led to the acceptance of the patentability of certain computer programs (the Diamond vs Diehr case), and a new subject matter – semiconductor chip mask works – were given legal protection by the Semiconductor Chip Protection Act of 1984 (the first new federal form of IP protection in over 100 years in the USA).

[42] Important new trade legislation included the Trade and Tariff Act of 1984, with a.o. Section 301 (authorizing US government to take retaliatory action against countries judged to give an inadequate IP protection) and Section 501 (authorizing the President to judge the adequacy of IP protection in granting tariff preferences to a country) combining to a stick and carrot approach. The Omnibus Trade and Competitiveness Act of 1988 moved further along these lines, e.g. with a "Special 301", requiring USTR to watch, identify and investigate foreign states denying adequate IP protection to US firms.

[43] It may be argued that the collection of IPRs, as we know it, is not, and never has been, legally coherent enough to be called a "system" and to be studied as an entity with causal relations. In addition, part of the IPR system is aimed at promoting cultural progress rather than economic progress in a narrow sense, although cultural arts in themselves have largely become big business.

no persuasive evidence that the IPR system has ever played a major role. At the same time there is widespread consensus today that technical progress, the promotion of which is the direct purpose of the patent system, has probably been the major determinant behind economic progress.[44] It is then natural to turn to the history of technology for evidence of its role. However, while there are plenty of accounts of cases where patents have played major as well as minor roles in promoting as well as delaying or distorting technical progress, there are few if any studies showing the impact of the patent system upon streams of innovations and the opening up of new technological fields and industries on the aggregate. Inventors have consistently exploited the patent system, perhaps surprisingly often, but its impact on technical progress is a question that remains largely unanswered.

There were several periods and places in history without a patent system but with flourishing inventive activity. One example was in ancient Greece, which in fact, at a closer look, showed an impressive rate of technical progress (see e.g. Farrington 1965 and Finley 1965). Another example is medieval China (see Needham). The economic incentives for inventive activities in these pre-industrialized times could possibly have been less important compared to other incentives than they are today. It must also be kept in mind that 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 technical progress than the commercial sector, although competition has always played a decisive role in both sectors. One should also keep in mind that inventive activities on a broad scale in a country were historically not always sought by the ruling elite. An extreme example of this was the forbidding of inventions in 18th-century Japan by the Tokugawa rulers.

A patent system (or some kind of prize system) has not always been necessary for technical progress on the whole, even in the 20th century, as evidenced by military technology as well as by planned economies (although the

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However, for the most part we will talk about the patent system, which is more narrow and legally coherent.

[44] Note that a patent is granted to a technical invention only on the merits of its technical advance, not on its economic merits (apart from a general requirement of industrial applicability of the invention), although the underlying assumption is that by so doing, economic progress will be stimulated.

rate of technical progress in planned economies has been low relative to market economies.[45]) Neither has a patent system per se been sufficient for technical progress on a large scale, historically. Patent systems, awarding temporary monopolies to inventors, were first legally codified in Venice in 1474 and England in 1623, but technical progress did not "take off" until much later in connection with industrialization in England.[46] Such an absence or delay of impact could in principle been due to the initial weakness of the patent systems and a gestation period for their operation.[47] The US patent system during its first period of existence was weak (as was the Japanese one, although for a shorter period), but when strengthened in the 1830s, it created a traceable impact upon inventive activities (Sokoloff 1988). More importantly, however, the delay or absence of impact of the patent system upon technical progress could be attributable to the absence of complementary developments as well as the presence of overriding counteracting forces, such as war.[48] It has moreover been claimed that the state of technology in ancient Greece as well as in medieval Italy was sufficient to enable industrialization (Farrington 1965). If this is so, the patent system cannot be claimed to be the missing institutional link in the developments of technology and industry.

Looking further at economic progress as represented by industrialization, it is interesting to note that most countries, including Japan, did industrialize in the presence of a patent system (see e.g. Dutton 1984. However, Germany, Holland and Switzerland did not (see e.g. Kaufer 1989, p. 45), and Schiff (1971), studying Holland and Switzerland, found no evidence that industrialization in these

[45] As pointed out earlier, a competitive market economy is necessary for a patent system to be effective as an incentive system, since it holds out the prospect of a reward in the form of a temporary monopoly on a market. However, a patent system with special licensing schemes is feasible in a planned economy, for exanple a patent system in which royalties for non-exclusive compulsory licenses are paid as a lump-sum down payment such a system comes close to a prize system.

[46] The pace of technical progress had been significant in other places and periods, e.g. in China and just after the Middle Ages, as argued in e.g. Mokyr (1990). However, in connection with industrialization, the pace of technical progress seems to have increased more than previously and has then become self-propelled and sustained in co-evolution with industry.

[47] By weakness is meant that legal protection or legal enforcement was weak enough to make the resulting incentive weak or perceived as weak. For a generally sceptic view of the role of patents in industrialization of Europe, see Landes (1969).

[48] Cf. Mokyr's point that war on the European continent delayed industrialization there (Mokyr 1990).

countries was hampered by the absence of a patent system. Thus, some countries could industrialize without a patent system.

The size and growth of a domestic market are likely to matter to technical progress, however, and perhaps more so in the absence of patents. 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". This is so, North continues, because large and growing markets would increase the private return upon innovation, other things being equal. In addition, going back to Adam Smith's arguments, large markets would 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.

Sweden, being another small country, had a late but rapid industrialization with a spur of inventive activities, giving rise to a number of large, multinational companies. (See Dahmén 1970 for a classic study with a Schumpeterian perspective.) In the formation of many of these large, invention-based MNCs, patents played a conspicuous role, perhaps even more so in protecting subsequent inventions that sustained the companies' economic development (Granstrand 1982).[49] Chandler makes a similar point about the role of patents in the sustained development of large US companies, although the role of patents in their early formative stage was found to be marginal on average (Chandler 1990). The case of large companies in the USA seems to lend some support to North's view of the importance of large markets where patent rights are absent or weak, while the case of Sweden points to the importance of strong patents in gaining access to large foreign markets when the domestic one is small.

[49] In addition, some Swedish companies could be formed on foreign technology that was by default unprotected in Sweden (like the Bell telephone invention). Some Swedish invention-based companies also by default did not patent abroad, which precluded their early internationalization. (E.g. the original company to what in the 1980s became the Nobel chemical company. Alfred Nobel himself was, however, an industrious patentor, with 355 patents at the time of his death in 1896. In addition he was a skilful, internationally minded entrepreneur, creating one of the earliest industrial MNCs in history.)

In connection with the role of IPR for the rise of large, industrial corporations, it should also be remembered that – although it is difficult to assess comprehensively – trade secrets have always played an important role. Moreover, they have often complemented patents, typically so that product technology has been protected by patents while process technology, or at least part of it, has been protected by trade secrets. Trademarks, finally, have also played an apparently important role for companies in the longer run, although not much has been studied (see however Wilkins 1992 for an excellent study).

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 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.[50] 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. It is likely, though, that new, small companies will become increasingly dependent upon the patent system as they face old, large competitors. At the same time, the large competitors are becoming less dependent upon single items of IP. Coca-Cola, for example, could probably lose its secret formula and still survive. Single patents with great blocking power could be an expensive nuisance to a large company, especially if held by inventors with no manufacturing and are thus invulnerable to retaliation through counter-blocking.[51] However, such patents would not jeopardize the business of the whole company, unless really high damages resulted from litigated infringement.[52] Small companies on the other hand could be ruined by patent litigation.

In summary, the IPR system in general, and the patent system in particular, has been neither necessary nor sufficient for technical and/or economic progress at

[50] For example, the importance of patents for the pharmaceutical industry in advanced countries is generally very high.

[51] A case in point are the patents of the renowned inventor Lemelson.

[52] This is unlikely but possible, especially since US law allows for trebled damages when infringement is found to be wilful.

country and company level historically. 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. 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 or economic progress in different periods and places. Qualifications must be made, correlations must be sought, complementary developments and counteracting forces as well as alternatives to patents must be taken into account, and so on for a deeper understanding. However, not many studies have done this thoroughly (see Dutton 1984).

In the present stage of knowledge, there seems to be some consensus that says 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, for which it proved functional (David 1993). This was true for, among others, Italy, England, the USA, Japan and Switzerland. 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, international trade and agreement interdependencies and so on.[53] Neither can one infer that a patent system initially designed for catch-up would be dysfunctional for sustaining a technological lead gained thereby. 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.[54]

[53] Mansfield (1994, 1995) and Lee and Mansfield (1996) has 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.

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

If the patent system has historically played a secondary, perhaps even marginal, role in the economic history of countries once they have industrialized and created a base of up-to-date industrial companies, why have the basic features of the patent system survived for so long? A common answer is that, although the patent system has often been found deficient, it has been better than nothing, and there has been no better incentive system for technical progress in the commercial sector. To this answer one may add that institutional inertia has over centuries gradually been built into the patent system worldwide, not least in current times as the formerly large, planned economies in Russia and China have started to adopt it.[55] The appearance of any new institutional innovations, yet to be conceived of, competing with the patent system as an incentive system is thereby hampered. Such a barrier to an institutional innovation is analogous to a barrier to technological innovation with one difference: technological innovations may be protected by patents, while institutional innovations may not.[56]

6 Role of 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 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[57].

[55] IP legislation was enacted in the Soviet Union in 1931, providing a copyright certificate and an inventor certificate. Inventors holding a certificate were entitled to remuneration from organizations using their inventions, but this was more like an inventor reward scheme.

New patent and trademark laws of the Russian Federation were adopted in 1992. These laws protect a wider spectrum of IP and are of Western type with a.o. a private rather than state property concept. Still in 1997, however, Russia does not have an effective patent system (Alimpiev and Sokolov 1997).

[56] One can point to a prize system, such as the Nobel prize in economics, as a possible incentive system for generating institutional innovations (or rather inventions) in the economy. Hopefully, such a prize system provides sufficient incentives for economic inventions and research about the IPR institution, for which there seems to be a need in society.

[57] 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

Second, the IPR system does not appear to have significantly fostered the emergence of ICTs at least not in its early stages up til the pro-patent era. 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 IPR regime. (Mowery 1999) The same could be said about the emergence of Internet under 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). Thus, although ICTs has 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 emergence of several ICT industries. [58] In other words, absence rather than presence of strong IPRs were arguably important in the early stages of sectorial innovation systems based on ICTs.[59]

Third, the emergence of a much stronger IPR regime since the 1980s (the pro-patent era) has by and large been concomitant with the much grander emergence of intellectual capitalism, the roots and trends of which stretch much further back in history. The strengthening of the IPR regime may very well have strengthened some features of intellectual capitalism 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-patent era was as much, if not more, a consequence of intellectual capitalism as a cause of it. In any case a strong IPR regime is a feature

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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.

[58] 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).

[59] The role of strong patents in other sectorial 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 2000).

of the new economy with a concomitant expansion of IPRs by volume, type and value and strategic attention paid to them.

7 IPR systems (patents in particular) and industrial structures

As mentioned 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 after WW2 under a fairly lax IP regime[60]. 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[61]. One could expect to find such examples in areas with particularly low ratios of imitation to innovation costs, times and risks in the absence of strong patent systems. Such low ratios are likely in large scale R&D areas. However, emerging industries often operate on smaller R&D scales, also under growth prospects and incentive structures less sensitive to free-rider problems and waiting games. If they operate on large R&D scales (e.g. aerospace), other institutional means than a strong patent system have 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 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 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 stand-alone growth. (To be completed if needed)

8 Role of IPRs in corporate innovation systems

The actual role of IPRs for industrial R&D, innovation and diffusion has been debated for centuries, with little consensus emerging. The role of trade-marks and trade-secrets is conspicuous, even decisive for the formation and growth of a firm

[60] 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. Well-functioning technology markets for patent and know-how licensing have then also been important (Arora et.al.).

[61] The standard examples being within pharmaceuticals and chemicals.

(see Wilkins for trademarks). The role of patents has been fairly small on average, at least up til the pro-patent era, except for certain industries where IPRs are essential, pharmaceuticals and specialty chemicals in particular. The inter-industry differences are large, however (Levin et al., Mansfield, Scherer etc.). There has also been a patenting paradox in the sense that firms take out patents even if they see them as fairly unimportant (Mansfield). Nevertheless some studies have established that patents do play a role as intended for R&D investments, see Table 7 for an example.

Table 7. Sensitivity of the R&D investments of large Japanese corporations to patent protection time (in 1992)

Question	Chemical (n=9)	Electrical (n=10)	Mechanical (n=5)	Total (n=24)
What would the effect be on your company's total R&D budget as a rough percentage, if the maximum patent protection time were:				
(a) Increased by 3 years	+8.5	+2.8	+0.3	+4.8
(b) Decreased to 10 years	-21.2	-3.7	-0.3	-10.7
(c) Decreased to 0 years (i.e., patent protection ceases)	-59.2	-40.0	-5.5	-38.2

Source: Granstrand (1999)

The rapid rise of the pro-patent era and the rapid recognition in industry of IP as being of strategic importance has created a need to integrate IP in business strategies. Figure 1 gives an overview how IP could be linked to various types of strategies in a company.

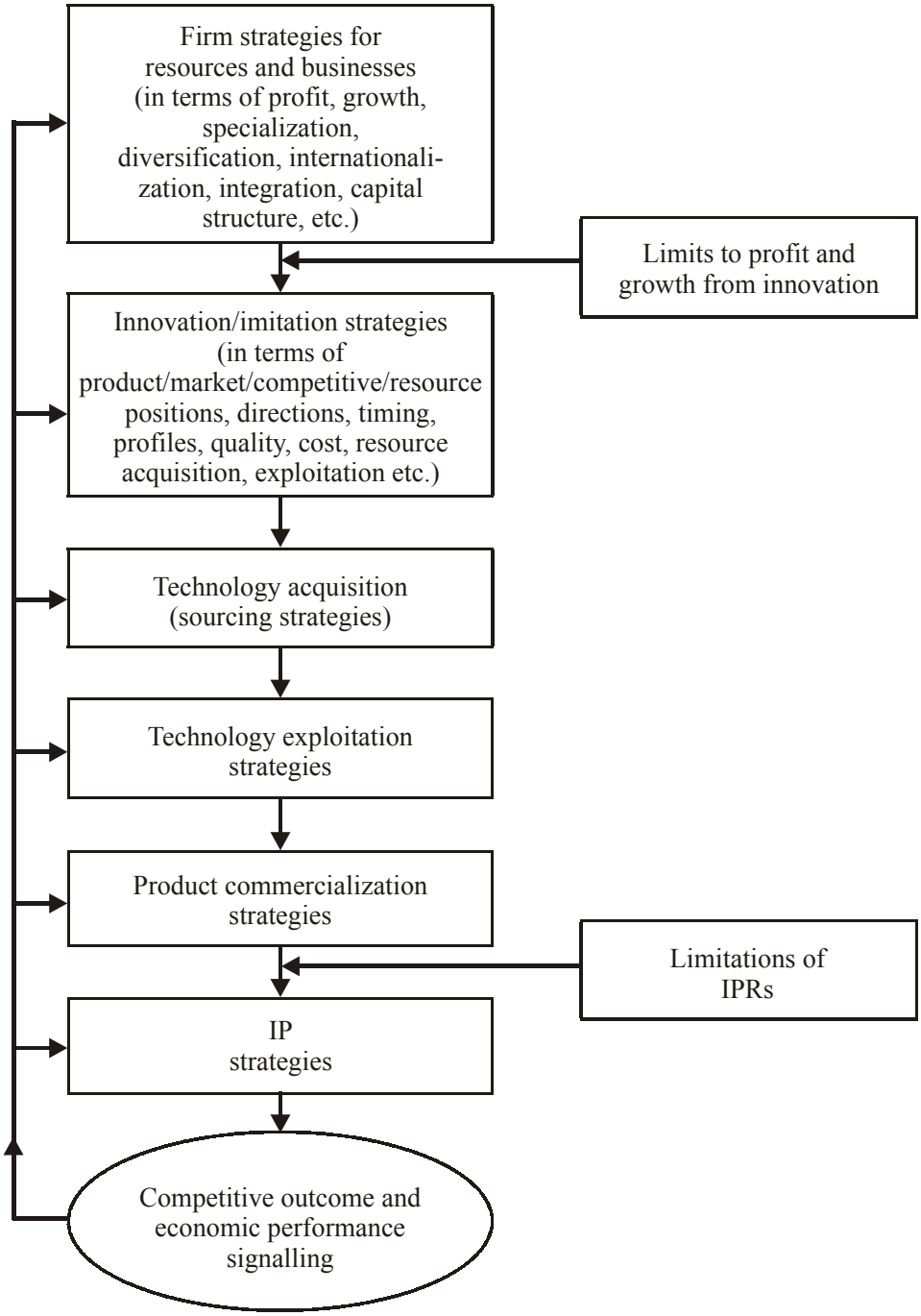

Figure 1 Types of strategies for the technology based firm

It is then important to note that a company has a number of strategies that could be used mostly as complements but sometimes as substitutes to patents, e.g. in commercialising a new product, as shown in Table 8 (to be updated with Cohen et.al.)

Table 8. Means for commercializing new product technologies

(Scale: No importance = 0,1,2,3,4 = Major importance)

Means	Japan[1)]	Sweden[1)]	US[2)]
(a) Taking out patents to deter imitators (or to collect royalties)	3.3	1.9	2.0
(b) Exercising secrecy	2.4	2.0	1.7
(c) Creating market lead times	2.7	2.4	2.9
(d) Creating production cost reductions	2.9	2.7	2.7
(e) Creating superior marketing	2.7	3.0	3.1
(f) Creating switching costs at user end	1.9	1.7	n.a.

Notes:

1) Current sample of 24 large corporations. Perceptions for 1992.

2) As reported in Levin et al. (1987). Perceptions for mid-1980s, rescaled to the scale used in the current study.

Source: Granstrand (1999)

Table 8 gives a very partial picture of the strategic use of IPRs, however. Table 9 shows how various IPRs could be matched to various elements in a business system, resulting in what could be called multi-protection or use of total IP strategies.

Table 9. Analyzing the business system for multiprotection and total IP strategies

Business element/component		IP type (example)
1	Business idea	Trade secret
2	Business plan/model/method	Trade secret, patent
3	Product technology (equipment, materials etc)	Patents, utility models, licenses, trade secrets, trademark, design
4	Production/process technology	Patents, trade secrets, licenses
5	R&D results	Trade secrets, patents, database rights, licenses
6	Component technology	Maskwork protection, patents, trademark, defensive publishing
7	Complementary products	Patents, trade secrets, database rights, copyright
8	Substitute technologies	Patents, licenses
9	Systems configuration	Open information, defensive publishing, copy letting
10	Software, orgware, data	Patents, copyright, trade secrets, database rights
11	Auxiliary services	Trademarks, trade secrets
12	Distribution technology	Patents, utility models, trade secrets
13	Marketing concepts	Copyright, open PR information, patents, trademarks, designs
14	Packaging design	Designs, trademarks
15	Company and business names, logos, slogans and symbols (“company aesthetics”)	Trademarks, copyright, designs

9 Role of IPRs in university innovation systems

The continuous "roll-over" of human knowledge from older to younger generations constitutes a large investment for mankind. 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, 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 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 is it to the better or worse for society?
Scholars and policy-makers world-wide are beginning to have a closer look at this phenomenon, its causes and consequences, and especially now in the U.S, having on top the leading and most competitive and markets oriented universities.[62]

Some likely consequences and to some extent already ongoing trends for universities are then:

a) Internationalization and emergence of multi-national universities (MNUs) in international competition and cooperation with eachother.

b) Concentration among the leading, fully diversified universities, complemented by smaller local or niche universities, leading to a two-tier structure.

c) Strategic alliances will increase.

[62] See e.g. Rosenberg and Nelson (1994), Rosenberg (2000) and Nelson (2003).

d) Corporate universities and competitive profit-seeking education companies will rise.

e) Quasi-integration into R&D services, consultancy, spin-off venturing and other education and research related services, creating new forms of competition as well as cooperation in university-industry relations.

f) A more business oriented type of university management will emerge, creating tensions with the traditional institutional role and culture.

g) Universities will increasingly appropriate benefits through active IPR + TLD policies.

h) New information and communication technologies will radically restructure the university system, with corporate universities and commercial education companies as lead users.

In summary, the general trend is towards universities becoming economic institutions involving both higher education and science. In this process university innovation systems are being built up, especially involving especially science, engineering and medical faculties, and including seed capital, venture development units, special facilities for financing and commercialization, offices, science parks, incubators for start-ups, technology licensing, liaison offices, support units for services (accounting, legal etc.), innovation 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, enabling US universities to patent inventions from federally funded research (see further the chapter by David Mowery in this volume). 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. This is quite distinct from the IP regime in industry, being more oriented around technology, secrecy, patents and other registered IPRs. Table 10 illustrates some of these differences.

Table 10. 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

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. Certainly citing fulfils 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 technological progress. Much can be said and debated about the differences and relations between science and technology.[63] However, technically speaking there is nothing in principle that prevents science and technology from having more similar IP regimes. One could e.g. have a patent-like system in science as easily as one could have a prize or grant or inventor reward system in technology.[64] The information in a ”scientific patent” could be freely used, respecting citation practices, until it is commercially exploited in some specified sense, similar to patents in technology.[65]

[63] See especially the works by D. de Solla Price and N. Rosenberg, being two leading 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) and Eisenberg (1987) for how it may clash with the IP regime in technology and industry. The distinction between science and technology is becoming blurred, however, (see e.g. Narin and Noma 1985). The division of intellectual labour between universities and companies is also less clear , with companies doing basic research (see e.g. Rosenberg 1989) and universities taking out patents (see e.g. Bertha 1996).

[64] The latter was in place in e.g. the former Soviet Union. Note that for a patent system to be effective as an economic incentive some kind of competitive market economy is necessary. However, since patents give several types of advantages to individuals and firms, patenting may also occur in monopolistic industries. For example, patenting has been frequent in the telecommunications service sector in the USA, Europe and Japan in the 20th century, although the sector has mainly consisted of national telecom service monopolies, regulated by the government.

[65] To illustrate further, it is quite conceivable (whether practical or not) to have an international system of ”publication offices”, examining scientific publications in more standardized ways, following explicitly defined criteria.

Thus, science may be called open only in a specific sense and certainly open science is not synonymous with IP free science. Moreover, the IP regimes in science and technology are fairly similar at a more fundamental level.

However, the differences between universities and industry are vast in general, not only regarding IP handling. There is a complementary division of labor between them to which the 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 under high uncertainty of generic knowledge (innovation) with transaction free diffusion is more efficient than using patents, which then would generate high transaction costs.

University patenting and the Bayh-Dole Act has been subjected to considerable concern and research in recent years in the US. There is also 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.[66]

10 Role of IPRs in military innovation systems

For a long time roughly half of the world's 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. The “appropriation” and control of military S&T has formed a special military IPR 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). Military and civilian technology, R&D, industrial activities, IPR 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, 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.

The likely implications of this is increasing R&D collaborations across nations, sectors, forms and civilian - military borders; industrial restructuring (divestments, joint venture 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 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 likely 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

[66] For further reading, see XYZ.

and use of IPRs are then perceived as crucial, necessitating the nurturing of an IPR culture and IPR investments in the traditional military industry.

11 Role of patent information disclosure

If the role of patents as incentives is ambiguous if not small in techno-economic development, the role of patents as disclosures of information is even more ambiguous but perhaps at the same time large. Certainly a strong motive historically for handing out patent-like privileges was to disclose and diffuse secrets, e.g. held by skilled artisans and guilds[67] 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.[68]

The idea of disclosure as the inventor's payment (apart from fees) for patent rights has 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 industries and countries in disseminating new technologies, e.g. in Japan. (Klemperer, Granstrand, Cohen et.al.).

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 (Granstrand).[69]

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[67] 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.

[68] 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.

[69] Regular conferences and exhibitions are held (e.g. Epidos) with a flurry of 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.

There is also a growing number of estimates showing that the amount of unused technologies and patents is considerable (Westney, Cohen et.al., BTC, Granstrand), 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.). 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 coordinating 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. 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 results that something works in the first place rather than how it works (cf. the A-bomb) are more efficiently disseminated through patent information as well as through publications than negative results, i.e. that some approach does not work. Although such negative results are often disseminated in informal communications within professional communities (Rogers, von Hippel), 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. To achieve this some special incentive system would be needed for publishing (disclosing) negative R&D results, being novel and non-obvious but lacking inventive step.

Finally, it is natural to compare the inventive and disclosure effects in patentable and non-patentable areas. This has not to my knowledge been done systematically so only a few remarks will be made here. In comparing say engineering sciences and social sciences and their different IP regimes one may observe a higher total R&D, private R&D and private R&D share in engineering sciences. This depends on many factors and can certainly not be attributed to the presence of incentives in form of patents, more or less unique to engineering

sciences.[70] As to disclosure, one could expect more coordination, inducing a.o. less duplication, in social science R&D, presumably operating in a more open IP regime. However, this is not entirely clear, e.g. in view of the proliferation of fairly duplicative concepts (also in innovation research). On the other hand there are many different reasons behind duplicative R&D and many means for reducing it in both engineering and social sciences which have to be taken into account in a comparison (For example, knowledge "codification" in form of artifacts may perhaps reduce knowledge duplication).

12 Challenges to the IPR institution

12.1 Fitness problems

The IPR institution has not lacked sceptics (like Marshall and Hayek), critics (like Sir Arnold Plant and Lester Thurow), and reformers (like Barton 1999, 2000, Kingston 1994, Samuelson, Reichman et al. 1994) during its many years of existence. Consequently there are a number of old challenges like international harmonization, rationalization of IPR organizations, high litigation costs, alternative dispute resolution schemes, monopolistic abuses, protectionist abuses and effectiveness relative to alternative incentive schemes and means of appropriation. These challenges are still valid, and mostly increasingly, so as the IPR institution has become more important under intellectual capitalism with an expansion of IPRs by number and types and by economic value. Here I will focus on some challenges that seem to have emerged as particularly relevant or somewhat newly recognized without any attempt to be exhaustive. Most likely there are further challenges ahead, still to be recognized.

Before going into the new or reinforced challenges to the IPR institution in the new economy, it may be worthwhile to observe that there is no fundamental change in the legal characteristics of knowledge, as summarized below. Rather the economic characteristics have changed proportions due to new technologies. Excludability may be less costly, the cost of distribution may be less etc. Appropriability conditions may then have improved.[71]

[70] A very small but growing number of US patents could be found outside engineering.

[71] Whether alternative incentive schemes such as prizes, grants and contracts have improved is left aside here (see e.g. David 1993, Wright 1983, NAE 1999).

Concern over intellectual property rights counteracting their purpose and hampering technological progress and entrepreneurship is increasingly justified because of the sheer growth, cumulation and interaction of new technologies and IPRs. The changing character of technology creates misfits between technology and the legal framework designed to foster it. This could be called the *technology fitness problem*. It is an inherent tendency that changes in legislation lag behind changes in technology, legislation being by tradition and design more reactive and reluctant to *sui generis* approaches than pro-active and anticipatory when facing uncertainty. However, lags between new technologies and new legislation created to adequately deal with these technologies tend to become more common and conceivably more costly to society. Contemporary technology is advancing fast, perhaps faster than ever in absolute terms, with an entire array of new technologies emerging. Some of these new technologies challenge fundamental concepts in the intellectual property system, and it is not clear at the outset whether and how they could be given intellectual property protection under the current intellectual property regime. Well-known examples are software and biotechnology. Less well known examples involve new surgical methods, new teaching methods, new business methods or even new athletic techniques.[72].As the cost and/or prospective value of new technologies and inventions increase, the push for intellectual property protection will increase.

A challenge is how to make the IPR system better fit different industries or, more generally, how to make the IPR system better fit the need to stimulate production and distribution of information and knowledge in different industries in light of available incentive systems and appropriability conditions. This could be called the *industry fitness problem*. Tailoring of the IPR system to fit the situation in different industries has been suggested from time to time (see Thurow 1997 for a recent example). A certain amount of tailoring does occur (e.g. through

[72] New business methods have become patentable in the US after a court decision in the so called State Street Bank case in 1998. By now prominent examples are Amazon's patent ("Internet-based Customer Referral System", issued as US Patent on Febr. 22, 2000) and Priceline's generic auction patent ("Method and Apparatus for a Cryptographically Assisted Commercial Network System Designed to Facilitate Buyer-Driven Conditional Purchase Offers", issued as US Patent on Aug. 11, 1998). This type of patents have stirred up a debate about what should be patentable subject matter, standards of patentability, proper scope of patent protection and proper cost/benefits of patent office operations (see e.g. Merges 1999). Some critics claiming that such obvious but

confinement of patentable subject matter, prolonged patent protection term in pharmaceuticals or industry-specific adjustment of patent scope) but has traditionally been done only to a limited extent. However, such tailoring is costly and despite the fact that misfits are costly as well, significant industry tailoring is likely to be difficult and exceedingly costly. This is so primarily because of the complex and dynamic nature of the increasingly many-to-many correspondence between products and technologies. That is the emergence of multi-product (generic, general purpose) technologies and multi-technology products (see below).

Another challenge is how to interface or harmonize different intellectual property regimes. Different co-existing intellectual property regimes have evolved over time, linked to different sectors of society and their institutions, organizations, norms, etc. (See e.g. David 1993 and Dasgupta and David, 1994.) Science and universities constitute one, technology and industry another, military and government another, culture and artists a fourth and perhaps also religion and churches. These intellectual property regimes are partly overlapping and interdependent, of course, but increasingly so as technology and economic concerns continue to penetrate modern societies. Clashes between intellectual property regimes thus more frequently occur e.g. in industry/university collaborations. Pressures thereby arise to align different intellectual property regimes with each other, and to find regime designs that are in some sense preferable on the whole. In this context one may also note that not only universities, US ones in particular, have become economic institutions, (see Rosenberg and Nelson 1994 and Nelson 1996) but in many cases, public knowledge institutions have also become more business and proprietary knowledge oriented, offering yet another indication of intellectual capitalism.

In this context the question must be asked whether there exists a single superior IP regime or a superior mix of complementary IP regimes for different economic and quasi-economic sectors of society, which tend to gather creative and knowledge-producing people with different motivation structures and

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generic inventions, requiring almost no R&D, could jeopardize the development of e-commerce. The debate has also reached the general public (see Gleich 2000).

different propensities to be incentivized by standard utilitarian-based IPRs. This could be called the *IP regime fitness problem.*

12.2 The IP assembly problem

A most challenging problem for the intellectual property system is what can be called the *IP assembly problem*. New technologies are interacting with each other and with old technologies in more complex and interdependent ways. As a result, products and services become not only increasingly based on new technologies, but increasingly based on many different technologies. That is, products and services become more multi-technological, or "mul-tech" for short, which is different from becoming "hi–tech" in the sense of using some advanced, new technology. At the same time more generic (or "general purpose") technologies appear, so in this sense, technologies become more multi-product also. All in all, the cross-links between new products and technologies proliferate. This means that patents and businesses become more cross-linked and interdependent with each new business becoming reliant on an increasing number of patents and each new patent having an impact on an increasing range of businesses on average.

Moreover, the sources of new technologies proliferate as more firms and nations invest in R&D and firms also increasingly internationalize their sourcing and exploitation of new technologies. Thereby the number of firm to firm encounters increases as both factor input and product output markets become more global. The IP assembly problem is further aggravated by the recent trend in some fields, notably biotechnology, to grant patent and other IPR protection (e.g. database protection) to research tools, i.e. inputs to the R&D process itself rather than to the downstream production process.

Thus, in a new technology as well as in a product market, there will be not only more agents on average, but increasingly interdependent agents in a mixture of cooperation and competition ("coopetition" or "competeration"). Technology trade, e.g. through licensing and cross licensing, then becomes increasingly necessary. This is because intellectual property rights to sustain a business become increasingly fragmented among players who are ready to enforce or

otherwise exploit their rights, thereby creating transaction costs and possibly dynamic efficiency losses through a web of hold-up problems.[73]

The factors mentioned so far put increasing demands on the well functioning of technology markets, which is actually at the same time facilitated by the IPR-system by design. What further complicates the functioning of technology markets is strategic firm behavior in using and abusing the intellectual property system. Some inventors and small firms without manufacturing act as "patent extortionists". Large corporations aggressively build up patent portfolios and employ various patent strategies. They, moreover, combine them with various other intellectual property rights into a kind of multi-protection, and thereby build up bargaining and retaliation power. Intellectual property management skills also develop in general. As IP-based bargaining powers are accumulated in industry, asymmetries in bargaining powers become more likely to appear – between new and old firms, between small and large firms, and between companies adapted to strong and weak intellectual property regimes in different sectors and countries. These asymmetries in bargaining powers create increasing risks in innovation and entrepreneurship, risks that become more and more difficult to absorb, especially for small manufacturing firms. (New kinds of insurances are being tried but with expensive premiums.)

Thus, the intellectual property system may slow down, misdirect or hold up innovation and diffusion, although not necessarily discouraging all R&D investments. Consequently, there is, as there always has been, a mixed verdict over whether the intellectual property system promotes technological innovation and diffusion, but perhaps the doubts in the mix are increasing. The pendulum continues to swing between trust in and suspicion of the intellectual property system (cf. Kingston 2000).

13 Current trends

One may finally note that patent protection traditionally has been confined to technical inventions. This confinement has in fact not a proper economic justification. It is rather the need in various areas for additional incentive and

[73] This would then be analogous to the anti-commons problem described in Heller (1998) with department stores in Moscow being unable to assemble all the necessary rights for their operations.

disclosure effects that a patent protection can provide better than other means that should be guiding what is patentable subject matter. The US in particular is now extending what is considered to be patentable subject matter. This can therefore be economically justified but only to some extent. The granting of patents to small scale inventions in various new areas can hardly not. Rather they will increase IP assembly problems and transactions costs that outweigh benefits plus offer possibilities for over-protection of companies, industries and countries.

There are several other changes and trends regarding IPRs at the same time as there are changes and trends in the nature of innovation in general, trends and changes which are far from fully synchronized and therefore may enlarge and create misfits in the future. Table 11 indicates a number of such trends.

Table 11. Trends regarding industrial innovation and IPRs

Trends in the Nature of Industrial Innovation	Trends Regarding IPRs
• More industrialization (of culture; universities; new industries; globalization) • More dynamic competition at various levels of innovation systems • More market linked (also to growing and differentiating technology/information markets, labor markets, financial markets) • Continued transition from individual based innovation to intra-firm to inter-firm based innovation (i.e. increasing collectivization) • Growth and diversification of S&T/knowledge base for innovation • Closer/faster interaction between science, technology and commercialization with increased blurring of S&T interfaces. • More multi-technology ("mul-tech") innovations • More ICT-based R&D and innovation (CAD, CAE, AI, simulation, "e-Research" etc., also offering more means for production, distribution and appropriation of information) • Increasing privatization of S&T and S&T protectionism through use of various IPRs, technological means and management strategies for appropriation • Standards and systems nature of technologies increasingly important • Increasing use of patents (and other IPRs) on research tools and use of patent information (patents as research tools), also with new tools	• No reversal of new economy and pro-IP era • International diffusion and enforcement of IPR systems (through WTO, TRIPs) etc. • Slow harmonization and rationalization • Increasing convergence of legal foundations • Increasing critique of techno-legal overprotection and abuse of IPRs (in ICTs, bio etc.) • Increasing public concern about ethics, equity, efficiency, and effectiveness of IPRs and alternative means for provision of innovation and diffusion • Increasing IP awareness and IP use inside and outside industry (universities, artists, military R&D etc.) • New IPR challenges in ICT-based R&D (sui generic rights, security, IPR clearance, new collaborative modes, e-contracting, etc.). • Increasing problems with IP-related transaction costs (IP assembly/disassembly, litigation etc.) • Extension of protectable subject matter (science patents, business method patents, software patents etc.) • Increasing blurring of unity of invention/creation and protectable subject matter (e.g. in publishing)

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