

Proper property properties of knowledge

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1. Background

The coquettish title needs motivation. Various alleged and intrinsic properties or characteristics of knowledge (including information and content) have been widely recognized and used for analyzing whether granting some kind of property rights in knowledge (i.e. intellectual property rights) would be a proper approach for the provision of useful knowledge in society.

A caveat is also in order. Ascribing properties to objects like knowledge and bodies of knowledge with technologies as a special case easily invites to static thinking about discrete entities, while production of knowledge (i.e. learning) is a dynamic and more or less continuous process. The framings of nouns and verbs simply differ.¹ Such static thinking about knowledge as discrete entities, pieces or bodies of knowledge falling into various areas of knowledge then invites to classifying in particular technologies once and for all as codified vs. tacit, cumulative vs. discrete, enabling, generic, core etc., while in fact the knowledge learnt in the technological areas considered rather dynamically changes its properties in such terms. (Panto cccc – Heraclitos.) Knowledge is both inputs and outputs in learning and changes its character continually when used and produced.

This dynamic character of knowledge in turn is important in the context of a property rights system for knowledge production. Such a system is based on a relatively stable act of legal principles for continually rolling out a web of property rights under more or less genuine uncertainty.² Such systems are not confined to IPRs but includes property rights in e.g. physical resource discoveries, e.g. of new land, ocean, space or electromagnetic spectrum resources. However, the IPR systems are subjected to specific legal uncertainty, e.g. regarding entitlement and scope (who owns what since when and with what rights?)

¹ Compare the different conceptual frameworks in technology management (i.e. managing technologies as objectified resources or assets) and R&D management (i.e. managing the activities R and D). For example, characterizing a learning process as interactive comes more naturally to mind than characterizing knowledge as interactive.

² Genuine uncertainty here is not taken to mean solely uniform probability distributions over some pre-defined sets of events but also includes uncertainty about the sets of events (the sigma-algebras) themselves, a type of uncertainty we can call sigma-uncertainty.

With this caveat in mind perhaps a more proper title of this paper would be “ Proper propertizing in learning”.

2. A note on concepts and terminology

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3. Purpose

The general purpose of this paper is to review some of these knowledge properties and see how they fit or misfit a property rights approach. This is a large research task that has to be narrowed down for this paper so only a few properties can be addressed and then in a tentative manner as a starting point for discussion. A specific purpose is to identify some properties of knowledge that make a property rights approach (IP approach) improper and some properties of knowledge that would in themselves be conducive to a property rights approach. The paper will also discuss some knowledge properties that traditionally have been required for granting IPRs in knowledge as well as some properties of knowledge that traditionally have precluded IPRs in knowledge.

Knowledge is produced under a variety of motivation and incentive structures. Here the purpose of the paper is to focus particularly on economic ones based on social and private return on investment (RoI)-considerations expressible in monetary terms. This in turn enables a direct linking or matching between relevant knowledge properties on one hand and costs and benefits in the RoI-consideration on the other. Thus inventions primarily driven by other motivations (like posthumous fame or kinship altruism) or other factors (like flashes of genius) are not considered here.

4. The IPR approach in perspective

The contemporary IPR approach is essentially a utilitarian approach although a moral (or “natural”) rights justification still exists in certain areas. IPR approach could be achieved through other approaches, however. Historically, the function of patent rights to stimulate invention (production of new knowledge), innovation and diffusion (incl. disclosure) nationally and later internationally have been more or less achieved by privileges or exemptions and the property approach is of more recent origin (see David, Kingston, Radin a.o.).³ Such functions of a patent system, be it based on privileges, exemptions (concessions) or property rights could also be achieved more or less by more legally distant institutional

³ To embed patent rights in the traditionally strong legal framework of property rights in physical (tangible) goods is likely to strengthen the legal foundations of patents. At the same time such piggy-backing is limited by intrinsic differences between physical and non/physical (intellectual) goods, giving intrinsic differences between physical property rights (PPRs) and intellectual property rights (IPRs), e.g. regarding rights based on sole possession which never can be guaranteed or obtained once lost for knowledge. Such a difference e.g. limits exhaustion of IPRs as well as it calls for controls of multiple possession through some sort of licensing contracts.

arrangements, like contracts, prizes, grants or tax deductions, each with their pros and cons in different situations.⁴

Contemporary proposals of alternatives to a property rights approach to knowledge provision include a liability approaches based on some form of entitlement and liability instead of property.⁵

Two things could be said in this context. First many of the various alternatives could be more or less converted into each other.

Second, an emerging perspective on IPR-systems as well as PPR-systems is their role in governing economic activities, i.e. how these are incentivized and coordinated *see e.g. Andersen 2006(. Important functions of a property rights system is then to provide signaling (who owns what) and more generally to provide an infrastructure for contracting. An IPR approach and a contractual approach thus become complementing rather than substitutes (see Merges 2005).

Pre/contractual signaling is important e.g. for facilitating for agents to search for and enter into contractual agreements as well as for governing any trespassing. Property rights moreover provide possibilities to arrange for residual rights in contracting plus post/contractual obligations. As with most IPRs they could be made temporary and thereby allow for making private vs. public trade/offers by parametric changes. Most IPRs are moreover optional which allows for private vs. public contracting (i.e. social contracting), as with patent disclosures. Finally, all trade presupposes property rights and IPRs facilitate contracting for trade in knowledge in contrast to barter based info exchange. The latter mostly presupposes some implicit recurrent contracting or cultural norms for communication. A current relevant but open question then is whether IPRs rightly designed and used (e.g. licensed) facilitate collaboration (cf. open source).

Important concepts or properties of knowledge for this paper are genericness, technical character, cumulateness, and interactivity of knowledge. Technology, finally, is taken in its usual sense as a body of knowledge about techniques, i.e. a body of information with technical character, i.e. technical information/knowledge.

5. Does knowledge really have public goods properties?

The commonly recognized basic defining properties of public good are non-excludability and non-rivalry in consumption. Often a low variable to fixed cost ratio is part of the definition as well although this is a matter of degrees. These three properties are generally ascribed to knowledge, which is then generally regarded as a special type of public goods. As such it is

⁴⁴ Professor Paul David posits (and prescribes) patronage plus prizes paralleling property (David 1993). Arrow (1962) particularly discusses....

⁵ For a seminal paper, see Lalabresi and M (1972). For a variant, see Reichman (19xx).

moreover often claimed that knowledge then should basically be a public property at least eventually after some time has elapsed after its production.

Here I would like first to challenge the notion that knowledge is a public good and that other properties of knowledge must be sought that justifies a claim that certain types of knowledge should eventually go into the public domain. One such property is the genericness same specific knowledge, i.e. generic or general/purpose technologies. Genericness increases the number of applications and with private property in generic knowledge the aggregate transaction costs from trading propertized generic knowledge would be substantial. The number of applications would decrease if the scope of the knowledge is narrowed but then the dispersion of rights in the corresponding knowledge area would go up which again would increase transaction costs. High transaction costs in turn make a private property approach less efficient and also less effective (as some transactions will not be realized due to deterring transaction cost).

A complicating factor is that genericness of knowledges (e.g. technologies) is not generally observable from the outset and moreover as applications of the knowledge (technology) are discovered and developed the knowledge in itself changes, although not necessarily resulting in changes of the originally defining boundaries of the knowledge in question. (Cf. how search engine technology has gradually become recognized as generic.) When genericness of a new technology is observed at an early stage private property rights in that technology is questionable. This could be the case for a new research tool or a new educational tool. (For the latter see an example in Appendix). When genericness of new knowledge is observed at a later stage after IPRs have been granted in it and are still valid, provisions must be available to remedy any escalation of transaction costs, e.g. through scope reduction (n.b. the dispersion risk) or compulsory licensing.

Thus, genericness speaks in favor of a public property approach. Genericness has also traditionally been considered in IPR legislation, but then by associating it with scientific (basic) knowledge and keeping that knowledge outside patentable subject matter, while associating technology with specific application knowledge.⁶

(The (increasing) difficulties in drawing a line between science and technology and the misconception of technology as applied science have been widely described and could be left aside here (see e.g. works by Rosenberg, de Solla Price, Nelson etc.). The traditional way of thinking about how to outline patentable subject matter does take many other knowledge properties than genericness into account and even give them higher weight in balancing the patent system.⁷ (E.g. traditionally recognized distinction is between discoveries (non/patentable) vs. inventions (patentable).)

⁶ Genericness considerations are also reflected in the use of the distinction between ideas (general) and expressions (specific) for granting copyright protection.

⁷ En passant one may note that what is proper (suitable, optimal) in designing and redesigning patent systems and any other IPR system is commonly discussed among legislators as balancing the system. This language is not as innocuous as it may appear, since the underlying metaphors are usually associated with static balancing

Regarding the public goods properties non-excludability and non-rivalry in consumption, both can be questioned as to their applicability to knowledge. Since knowledge is increasingly distributed through the use of various ICTs, there are also technological means available for targeting info receivers and excluding others (Granstrand 2000b). Even the classic example of public goods, i.e. lighthouse light signals could be used to illustrate how such electro/magnetic signals could be transmitted using non/visible frequencies, scrambling the signals, employ frequency hopping etc. so only ships with special equipment could access and interpret them. Excludability could also be achieved by non-technological means, the most fundamental being personal secretiveness, but also using special codes (languages) for selection and exclusion in human communication. In addition, one could argue that excludability achieved through technological, biological and cultural means would weaken the argument for creating legal excludability through private property rights, since that could lead to overprotection (as with copyrights on encrypted content with a disencryption ban on top).

Thus, excludability is in itself neither a necessary, nor a sufficient condition for IPRs such as patents and copyrights, property rights are assigned or licensed away to a centralized body or legal person. Still such a clearance arrangement or collaborative organization is an unstable institutional arrangement under interactive learning since a new valuable finding will create new strategies with a new value function in the cooperative game. New possibilities to form coalitions and find upsetting or even blocking strategies will emerge, and the core of the game is thereby jeopardized. The instability is moreover increased if entry and exit conditions in the collaboration are weak i.e. less costly to players. A property right approach may then offer possibilities to create entry and exit conditions that could mitigate defection but also lead to lock-outs and lock-ins and especially asymmetric lock-outs and lock-ins (i.e. cheap entry and costly exit or vice versa). In addition the motivations and incentive structures of key players differs so the value function becomes multi-dimensional, and the game is no longer cooperative.

Thus there are many virtues and vices of an IPR approach to incentivize and govern complex collaboration in interactive learning.

On the other hand, if secretiveness is too strong from a social point of view, a patent-like private property right could be used as an incentive to disclose (apart from the need to disclose in some way for enforcing a priority rule for selecting the rights holder). Thus excludability could be partially reduced through a patent right approach.

(expressed e.g. in pictures of weighing bowels held by a blindfolded goddess of justice). This in turn invites to short/term thinking about balancing, which may degenerate further into one/dimensional thinking, e.g. in terms of public vs. private interests taken as two homogenous and opposing sets of interests.

Thus knowledge cannot be regarded as public goods since it does not have the non-excludability property.⁸ However, that in itself does not imply that granting private property rights in knowledge is a proper approach.

6. Technical character

The concept of technical character (property) of certain knowledge has thus been used for excluding scientific knowledge from patentability. In addition it has been used in Europe but not in the US to exclude all other types of knowledge from being patentable. A most well-known example is software which is considered to lack technical character unless it is classified as a computer related invention linked to technical hardware or giving technical effects. The question then is whether the technical character is a proper property for confining property (patent) rights in knowledge? I will argue here that it is not. First a technical character requirement is not codified in European patent law (the EPC), nor in national patent laws like the Swedish or Nordic.

The legal language rather uses concepts like invention, (sometimes and somewhere interpreted as technical invention) industrial applicability and reproducibility.⁹

Second, the concept of technical character has crept into patent examination practice and guidelines in Europe without any foundation in economic principles or motivation in economic terms.

This does not mean that economic motives do not exist, of course. The question then is if technical knowledge is underprovided while non/technical knowledge is not and if so, if this underprovision could be reduced better through a patent system than any alternative institutional arrangement. The first of these two questions could be readily addressed here.

Arrow (1962) discusses the risk of underprovision of innovation due to the knowledge properties indivisibility, uncertainty and appropriation problems deriving from difficulties to trade knowledge (information) without revealing at least part of it (what has been referred to by others as the information paradox).¹⁰

However, Arrow equates invention with production of information in general and makes no explicit reference to technology (= technical information) or engineering or the like (although

⁸ Thus non-rivalry in consumption does not need to be addressed. Suffice to observe that in some physical sense consumption of knowledge is non-rivalrous as sharing does not diminish supply (as with fire and light as well). However, consumption of information may create rivalry about the rent streams emanating from it, although not necessarily so.

⁹ There is a long and varied etymological and legal history of these concepts, see Granstrand (2006). The same could be said about the concept of technology deriving from ancient Greek 'techne', which originally had a much broader meaning than today (see e.g. Moravesik).

¹⁰ These difficulties in turn derive from lack of second order codifiability (i.e. codification of content without revealing it) and dispossession impossibility (Granstrand 2000).

he implicitly had technological inventions in mind.¹¹ Thus his argument that underinvestment in production of information with the above/mentioned properties is valid regardless of technical character, unless the latter property is deducible from the former ones, which could readily be checked is not the case.¹² The question then turns to an empirical one, i.e. whether underinvestment is more likely and serious in technical fields than in non-technical ones. Studies by Mansfield and colleagues have in general looked at technological innovations (including medical and agricultural ones, but their results point at primary factors explaining the wedge between social and private rates of return to innovation that do not exclusively exist in technical areas.¹³

Remains to see if there are factors at play in non-technical areas that possibly could induce overinvestment and thereby outweigh any underinvestment tendencies. The theoretical literature on overinvestment generally refers to racing arguments (Barzel, Stiglitz and Dasgupta, Reinganum, David and others including also Kitch). These arguments are also valid in technical areas.¹⁴

Finally empirical literature showing over-investment in non-technical knowledge production and innovation is by and large missing (at least to my knowledge), while there is an abundance of quests for such innovations (social, cultural, managerial, organizational, financial, institutional etc.).

Thus, the conclusion is that technical character is not an exclusive feature of underprovided innovations. As a corollary lack of technical character of an invention is not a valid ground for rejecting an application for a patent right in such an invention. Thus, as a special case patent rights in software could not be rejected based on a claim that software lacks technical character.¹⁵ (In order to obtain such a patent right a number of criteria have to be fulfilled of course, notably inventive step (non-obviousness), novelty, usefulness, unity of invention and enabling disclosure).

The remaining question is whether a patent-right is after all a proper approach given alternative institutional arrangements in non-technical as well as technical areas. As is well known this question has been widely discussed over the centuries, and it is still fair to say that it is largely an open question.¹⁶ What is known is a number of properties of knowledge and conditions for its provision which have to be considered. One such property is cumulativeness.

¹¹ Personal communication.

¹² It is easy to find examples of non-technical information possessing either or all of the properties in question.

¹³ See Mansfield et al. (1972) and also Thirtle and Ruttan.

¹⁴ And perhaps then even more so. At least this literature is more or less explicitly referring to technical areas as it discusses patents, which typically at the time of writing was granted in technical areas.

¹⁵ One could claim that software has technical character after all, but that is besides the point here.

¹⁶ See Plant, Arrow, Scherer, David, Scotchmer etc.

7. Cumulative and sequential innovation

A recent theme in discussing an IPR approach, patent rights in particular, is its impact upon cumulative and sequential innovation.¹⁷ In order to probe this issue it is natural to look at a most cumulative field such as mathematics and see if patent rights in mathematical knowledge production is fostering or hampering it. Mathematics is highly cumulative in the sense that each new advance, i.e. invention, builds on some previous ones.¹⁸

Each theorem (or rather each proven proposition) is linked to original axioms through a chain of implications. The rules of proof are designed to avoid contradictions, although it is in general impossible to prove the absence of contradictions (Gödel). Thus, mathematics is built to last. However, the rate of cumulation may be slow (as with Fermat's conjecture) although it is not slowed down by empirical tests or observations (as e.g. in astrophysics). More importantly cumulation is in general not proceeding through single chains of cumulative implications but the same proposition may be reached through various implication chains. Thus, there are invent around possibilities in mathematics just as in technologies in general and these possibilities are not fully known at any point in time and typically grow as more proven propositions are produced.¹⁹ Once complex proofs will later be simplified, once specific results will later be generalized, more necessary and sufficient conditions will be found (discovered) etc. In certain areas the implication network will at times grow fast and thick (as in computational mathematics and graph theory); in other areas it is rather the opposite (as in classical geometry or number theory). Some theorems become central and some are clearly non-obvious and may require many man-years to produce.

The point here is that whatever the relative merits of a patent system are in comparison with its alternatives (prizes, patronage etc.) mere cumulateness of knowledge advances would not make it inoperable. It is conceivable that progress in certain areas would proceed only through one or very few long implication chains along which a number of blocking patents on "strategic theorems" could substantially delay progress and make invent around and research for substitutes a waste of time but that is an empirical question on which history of mathematics has little to say.

Finally, what has been said so far is not to be taken as a plea for a patent system in mathematics, far from it (due to common genericness of mathematical knowledge). The point here has been to take mathematics as an example of a highly cumulative knowledge field and to check whether cumulateness in itself is a property of knowledge making IPRs in it improper.

¹⁷ See in particular the works by Scotchmer.

¹⁸ Some would prefer to refer to a new theorem (including new algorithms) as a discovery rather than an invention. The distinction between discovery and invention as commonly used in actual patent examination is not relevant here, however, since we look at a hypothetical patent system.

¹⁹ Classifying knowledge fields and technologies in particular as cumulative and non-cumulative technologies do exist, which they do not, not even in case of far-reaching.

8. Interactivity

Knowledge or rather learning also has the property of being interactive or recombinant, giving rise to connectivity and complexity.²⁰ Particular types of interaction are cumulation (reaping complementarities) and substitution which may work in parallel during a learning process or in an embodiment process.²¹ As cumulation dominates over substitution net growth of knowledge will result. This creates a need to pool or source knowledge from many sources, e.g. many individuals in many fields. Continued learning and knowledge trade of knowledge assets then increasingly involves collaboration. Interactivity then will increase transaction costs and more so when codification is poor as in early stage learning with many new discoveries, creative learning with many new ideas or learning with many inputs from various sources in different fields with different codes with interdisciplinary and multi-technology development as special cases. These are all circumstances that disfavour a property rights approach unless transaction costs can be mitigated through clearance contracting of some sort e.g. an open source model or open innovation or science model or patent pooling or cross-licensing schemes or joining all players in an collaborative organization such as a consortium or integrated firm in which the functionality of IPRs in open co/innovation is largely an open question. This calls for experimentation and empirical studies, both of which currently grow. History has provided many examples of the occurrence of temporary open pockets with weak IP regimes, giving rise to successful current technology collaborations and more current models of open innovation and IP pooling are promising. Maybe future will find hybrid private/semi-public property approaches in learning proper. At least learning about proper property properties of knowledge has not (yet) become propertized.

²⁰ This has been widely recognized and phrased in various terms. E.g. David (1993) assigns interactivity and cumulateness to knowledge besides its public goods properties.

²¹ E.g. the shift in the technology base from an old to a new product generation typically involves both substitution (i.e. scrapping of old knowledge) and cumulation (i.e. scrapping of old knowledge) and cumulation (i.e. adding new knowledge to the remainder of the technology base). Typically also cumulation dominates over substitution with some measure of knowledge amounts (Granstrand 1994). Thereby Schumpeter's notion of creative destruction is challenged.

Appendices

Appendix A

Patents on scientific research methods – a thought-provoking example

What has been the private and social returns on investment in scientific endeavours like the discovery or invention of Pythagoras theorem or the works of Francis Bacon or Charles Darwin or Kenneth Arrow? Is there any way to answer such questions that could provide a basis for deciding a) if there is a risk of underinvestment in such endeavours and b) if so, whether a property approach is the best remedial approach by itself or in conjunction with other approaches?

To pursue this line of questioning one step further we could ask ourselves whether a temporary private property right like a patent right should be applied not only to scientific results (products) but also to scientific research methods (processes). Figure 1 provides a concrete example of the latter. As seen, the example is a “Humboldt invention” i.e. an invention for both teaching and research. A US patent has been granted to a method to tutor research students, and Figure 1 gives a drawing of the process.²²

²² The full patent document is about a dozen pages with a number of claims.

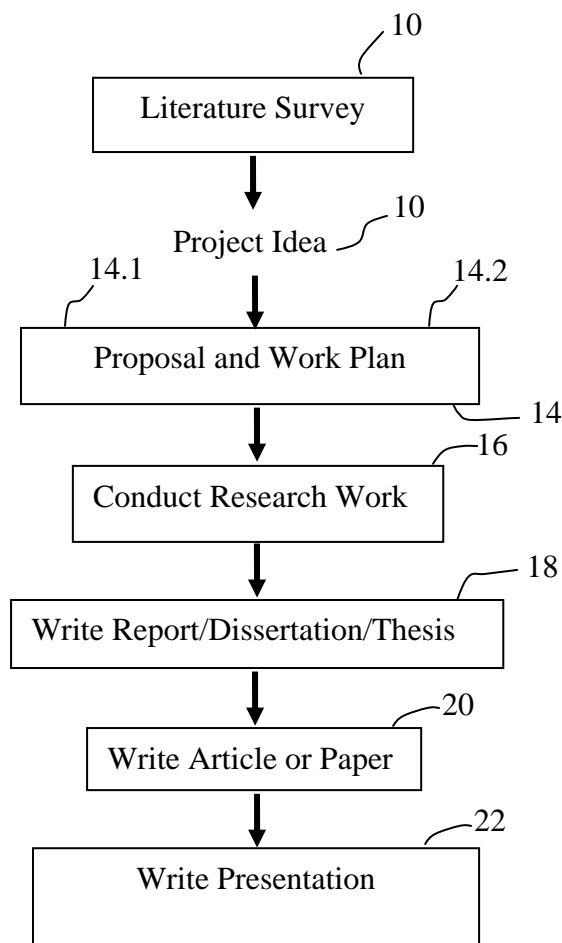


Figure 1

As seen, the process is quite generic and the patent has a wide scope. One can arguably claim that the patent hardly fulfills novelty and non-obviousness criteria and that it would not hold up in court.²³ However, the point here is to ask about the consequences upon S&T and economic progress of making scientific research methods patentable subject matter. Do other researchers on balance feel deterred to tutor or incentivized to invent around or develop better tutoring methods or inclined to get a license? What are the response strategies if any? And what are the exploitation strategies of the patent holder? Start a new university? Sell the patent to a patent troll?

And further down the road, what will happen if the teaching and research method space will be filled up of interdependent patents? And more generally if new emerging fields of S&T are being filled up long before the results are implemented in products? The field of nano-technology is already full of patents if not filled up and thereby will provide perhaps the first natural experiment how propertizing an emerging S&T field will turn out. Property rights are

²³ En passant one can note that it is currently hard to challenge the validity of an already granted patent in the US unless one is actually sued for infringement. Suing may in turn not be in the best interest for the holder of a weak patent compared to having third parties live in the shadow of litigation.

necessary but not sufficient for markets to function but an exchange economy may still be more efficient for certain types of knowledge and information, e.g. generic but poorly codified.

As markets increasingly proliferate in S&T own research and the use of research results of others will increasingly be considered commercial as there is an ever-present business opportunity in form of licensing. Thus universities will be considered commercial and lose their non-profit status. This in turn puts into question whether the traditional use of disclosed patent information can be considered a non-infringing non-commercial activity. If not the patent system in extending its scope and fostering S&T markets has become not only counterproductive but autodestructive.

All these and many more questions are in need of serious concern and research with results that hopefully will not be covered by property rights limiting institutional innovations and their diffusion.

Issues in the Swedish Government patent investigation

**Title: Review of the economic aspects
of patenting for growth of companies**

Main issues:

- **How to create understanding and insight especially in small knowledge-intensive companies about the economic benefits – and costs – associated with patenting (i.e. the economics of patenting)?**
- **How can knowledge-intensive companies be stimulated to patent their innovations to a larger extent?**
- **What is the connection between patenting and economic growth?
(- and how could it be improved?)**
- **How and why does the patenting frequency in Sweden decline?**

Overall method design of the Swedish patent/growth-investigation

Levels and units of analysis

International (Europe, Japan, US, Nordic countries)

National (Sweden) Patent statistics

Supply and demand of IP education.

Interviews with significant actors

Case studies

Industry/sector

- Services (financial, medical, telecom, energy, university, military)

- Industries (esp. BHT and ICT based)

Company

- Large (ca 50)

- SME (5 sub-samples)

- Patent agents

- Entrepreneurial region

Innovation Sweden's economically largest, 1945–2005

Technology system Biomaterials

Patent

- Vintages of patents kept full term
- Chemical patents

Sample of Recommendations from the Swedish Gov't Patent/Growth-investigation

- 1) Strengthen**
 - **State entrepreneurship and IP capabilities, especially in technology based public services**
 - **SMF entrepreneurship and IP capabilities and collaboration SMFs/LFs**
 - **LF entrepreneurship for diversification**
 - **The economic and IP competence in Sweden's entrepreneur system**
 - **Swedish growth appropriation from innovations**
- 2) Promote English as a business and IP language**
- 3) Support international patent system reform (harmonization, rationalization of PTO-system, PCT, unified European patent and court system, patentability criteria (raise inventive step, reformulate 'technical character') etc.)**
- 4) Transform the Swedish PTO offensively**
- 5) Create an interministerial Strategy Council for IP and Innovation policies at the highest political level**
- 6) Make substantial efforts to raise IP awareness, understanding and capabilities in teaching and practice (national competence centres, chairs in IP economics, teaching programs, new certification schemes, special advisors in IP and business development, development of guidelines for boards and IP audits, etc.**
- 7) Introduce a package of financial incentives (e.g. a state patent-fund, subsidies to employment of IP specialists, complementary reward systems, early stage patenting subsidies for SMF)**
- 8) Earmark 4% ± 1% of state financed R&D for patent and IPR efforts**