The Role of Patents in Scientific Competition: A Closer Look at the Phenomenon of *Royalty Stacking*

by

CHRISTINE GODT

1 Introduction

Recently, patents have become both, a product of scientific research and a measure of performance and excellency. Prior to this, patents were confined to industrial development within the market vicinity – aimed at keeping the idea secret inside the corporation as long as possible until the commercialisation of the end product begins. In contrast, basic science was perceived as a separate counterpart to applied science and defended as a patent-free zone. Scientific performance in basic science was conceived as reputation measured by publications. Today, in the field of natural sciences, patents have supplemented publications and citations as an indicator of reputation not only of individual researchers but also of scientific institutions. This development is highly contested in respect to its impact on basic science. Do patents impede or promote science, and in which ways? Will they accelerate research or slow it down? What kind of incentives do they provide for researchers and their home institutions? When patents found their way into the scientific realm in the 1980s, opponents raised concerns that researchers would hold back their results, publish less or later and refuse the exchange of knowledge and material. In the 1990s, concerns were raised that patents would proliferate, thus stifling research and development.[1] Proponents would claim that patents foster scientific competition,[2] that they set an incentive for individuals to invent and for institutions to invest, thus resulting in more innovation.

In the meantime, the debate has become more sophisticated. There is evidence that scientists in private and in public research do both, patent and publish (Stokes 1997, Agrawal and Henderson 2002, Murray and Stern 2005). The long-perceived tension between patenting and publishing does not seem to exist, at least not sharp and measureable. Empirical evidence suggests that access is more willingly granted to patented knowledge than to material (Walsh, Cho and Cohen 2005). Access problems persist in research on clinical

---

[1] This discussion is known as the "anticommons debate" – an inversed reference to the famous article "Tradegy of the Commons" by Hardin (1968). The parallel was first drawn by Heller (1998). The debate of how to evalute the process is still ongoing: Is patent protection "too strong" (inter alia Eisenberg 1996a, David 2004) or "too weak" (Heller 1999)?

[2] For the US see, e.g., Nelson (1998), Walsh, Arora and Cohen (2003); for Germany, e.g., Hoeren (2005).

C. Godt in: Scientific Competition / M. Albert / D. Schmidtchen / S. Voigt / Mohr Siebeck 2008 / Tübingen diagnostics, suggesting that problems occur when research is closely related to (or being itself) a commercial activity.[3] Overlapping claims, e.g. related to DNA, make it difficult to know one's own rights and those of others (Verbeure, Mattijs and Overwalle 2005). Special attention is paid to the problem of patented research tools.[4] Consent is growing that patents in science do not function in their traditional sense as incentives for the individual researcher to invent. Researchers respond stronger to other incentives (Agrawal and Henderson 2002). Former high-income expectations of research institutions through patenting and licensing have not been fulfilled, at least not for the average university. Instead, it has become evident that patents play different roles for different actors. In industry, beyond the traditional function of competitive exclusion, patent protection for scientific research results serves two different functions. First, patents commodify information and thus secure the transfer of information between internationally decentralised entities. Second, as patents can be purchased, formally intramural research can be outsourced and re-aquired in a contract-based transaction. In other words, patents are essential for the transfer of knowledge between contractors and the firm. For research intensive, small biotech companies, patents serve to attract venture capitel. For universities, other functions prevail: Patents provide benchmarks for ingenuity and high performance, thus enhancing publicity and profile. Increased international cooperation in every form, between scientists and industry[5] and between scientists across borders,[6] has instigated the claiming of intellectual property rights.[7] Patents can help to establish start-up companies, thus providing career opportunities for graduates.[8] For policy makers in industrialised countries, two functions are important: First, a high

[3] Merz, Kriss amd Leonard et al. (2002), Walsh, Cho and Cohen (2005) – then, patent holders are more likely to assert and researchers are more likely to abandon infringing activities.

[4] The public discussion about research tools (see for the US: National Research Council 2005, Gewin 2005; for the UK: Nuffield Council on Bioethics 2002) has given rise to much research (legal, economic and econometric), see Eisenberg (2000), Holman and Munzer (2000) on the one hand highlighting problems, and Walsh, Arora and Cohen (2003) on the other hand aiming at appreasing and structuring the debate.

[5] See the rationale of the 6[th] EU Framework Research Programme (recital 1 of the Decision No. 1513/2002/EG from 27 July 2002, Off. J. l 232/1) and the rationale of the funding policies of the German Research Ministry in: Richtlinien für Zuwendungsanträge (BMBF-Formular 0027/01.03, available at http://www.bmbf.de).

[6] See the contributions in Edler, Kuhlmann and Behrens (2003), see also the descriptions of Knorr-Cetina (1999).

[7] In the case of science-industry collaboration, it is the industrial partner who usually has an interest in proprietarily secured knowledge; empirical evidence for the correlation between industry involvement and patent applications of research institutions is provided by Carayol (July 2005, 5 and 13). In the case of science-science collaboration, it is the scientists themselves who are interested in securing their rights to material and knowledge in order to protect their own future research opportunities.

[8] Or can provide additional pension payments – as suggested by Carayol (2005, 14).

patent standard serves as an instrument in global regulatory competition to attract industry, because innovative, high technology firms tend to prefer countries with a high patent standard. Second, patents are meant to enhance the transfer of knowledge from science to industry, thus securing long-term innovation and growth. Therefore, public policy has fostered the collaboration of science and industry, most prominently by funding schemes, and supported the move of patent protection into basic science.[9]

The following article focuses on the patent function of technology transfer and will only cover the technology transfer from basic science to industry. At its center is the question whether there is a causal link between patents in basic research and technology transfer to industry – as often claimed. Thus, it will neither analyse the much debated impact of patents on scientific research behaviour per se,[10] nor will the incentive for the individual researcher be discussed. The article is less interested in the behavioural incentive of patents to invent than in the institutional effect of patents on technology transfer. Thus, it complements the broad debate about the effects of patents in science by providing an additional perspective. It takes patents on scientific results of public research institutions as a given fact, but asks about the commercial logic underlying the assumption of the causal link. It contributes to a better understanding of the functions and different roles fulfilled by research institutions. The modern university systems, especially in Europe, is characterised by a mixture of competition and cooperation which conventional economic approaches are not easily applied to.[11] The article raises the question if a patent is a decisive *sine qua non* condition or just one enhancing factor among many others that instigate technology transfer. Are they important in some sectors, less important in others? Are they beneficial in some, but detrimental in others?

The article focuses on the counterintuitive phenomenon of "royalty stacking". This expression describes the problem of accumulating royalty promises in the research process which results in an ever decreasing profit margin until the research result is "ready" to be transferred to the process of product

[9] Funding rules require researchers to secure intellectual property rights in their research results. Technology transfer offices are fostered, in Germany as an integral part of the patent reform that abolished the so-called professor's privilege in 2002. This provision had assigned their inventions to them personally. By now, all inventions can be claimed by the university or research institution.

[10] A lot of research has been done in respect of how scientific research has changed under the influence of the hybrid incentive structure of traditional norms and commercial incentives, see only Godt (2007, Chap. 3), v. Overwalle (2006), v. d. Belt (2004), Rai and Eisenberg (2003), Heller and Eisenberg (1998), Blumenthal et al. (1997). Until today, the legal discussion has revolved around the question how science can be shielded and whether the given instruments are sufficient, especially the so-called research exemption in patent law Galama (2000), Holzapfel (2003), Godt (2007, Chap. 6).

[11] Mowery and Sampat (2005, 233) describe this analytical lacuna.

development. Therefore, the phenomenon threatens the very idea of technology transfer from science to industry. It is counterintuitive because it contradicts the very assumption that property rights result into the most efficient distribution of ressources. Therefore, the analysis of the phenomenon of "royalty stacking" may help to understand the conditions required for technology transfer to happen, but may also improve our understanding of the boundaries beyond which the dynamics of the patent system are more detrimental than beneficial to basic science – and in the long run to industrial prosperity and to society as a whole.

The article proceeds as follows. First it describes the phenomenon and its generation (2). It then puts the phenomenon into the broader context of technology transfer in the information society (3). Taking these considerations into account, it portrays some possible policies for the various actors involved (4) before drawing some final conclusions (5).

2 *"Stacking Royalties"*

The expression "Stacking Royalties" describes the "problematique" of accumulated negotiated royalties by researchers in the subsequent research process. If the profit margins for the commercial developer have already been used up before the developer comes into play, technology transfer from science to industry will not happen. The patent attorney Philip Grubb estimated that a royalty accumulation of 20% is the limit for transfering the research result to the industrial process of product development.[12]

There are two causes for the accumulation of royalty claims, one being proprietary, the other being contractual. The proprietary cause is at the heart of the patent system. Problems with this type of accumulation are in built and, until today, dealt with either statutorily or in corporatist ways. However, problems occur in the modern science system because these practical mechanisms are not available to research institutions and because the ever broadening scope of patent protection affects science in particular. The contractual cause is the one that gives rise to yet unresolved challenges for science. Both are mutually reinforcing.

[12] Oral presentation during the workshop on "Genetic Inventions, Intellectual Property and Licensing Practises", organised by the German Federal Government (BMBF) and the OECD, 24/25 January 2002 in Berlin.

2.1 Property

For the sake of analytic precision, "proprietary royalty stacking", first, needs to be distinguished from "stacking patents". The latter, technically called dependency, is *the* central patent mechanism.

2.1.1 Linear dependency distinguished

Dependency describes the "stacking of patents" (not royalties). It is the key to the patent system as it upholds the incentive to invent during the process of continuous progress. It makes the patent the strongest form of intellectual property in comparison with copyright or plant varieties. First of all, the patent provides an incentive to any innovator by granting him/her a time-limited monopoly.[13] However, any further improvement, in principle, has the potential to destroy the economic value of the former innovation before the patent expires. This is what Schumpeter (1942) called "the process of creative destruction". Therefore, in order to uphold the incentive to innovate in the pursuit of progress, the system links initial patents to subsequent patents of follow-on innovators. The idea is that although the subsequent invention is "novel", "non-obvious" and "inventive" and thus patentable on its own, this patent is still covered by the scope of the basic patent.[14] The legal consequence is that neither the base patent holder nor the improver are allowed to use the invention of the other unless authorised by a negotiated license. This mechanism creates mutual blocking rights[15] and enables the pioneer inventor to reap some of the benefits of subsequent improvements. Dependency provides the balance between the incentive for the pioneer and the incentive for improvers.[16] In principle, dependency does not result in royalty stacking. If one patent builds on a previous one (linear dependency), any follower can promise a share of his/her own profits when using a former invention. Privious royalty promises can only be for shares of this promise; thus they do not accumulate over time.

For applied industrial research, linear dependency has not yet caused insurmountable problems (Kowalski and Smolizza 2000). Although history

[13] However, time limits differ considerably. Patents have a maximum livespan of twenty years after first application (although less than half are prolonged after 10 years by their owners). Copyrights usually last seventy years after the death of the creator.

[14] For the dogmatic distinction between "novelty" of the inventive idea and "breadth of a patent scope" which form the basis of dependency in patent law, see Godt (2003, 11), Godt (2007, Chap. 7).

[15] Merges (1994); for an economic description of the equilibrium between sufficiently strong incentives for the pioneer and the improvers, see Scotchmer (2004).

[16] Although, unsurprisingly, the definition of the „right balance“ is highly contested. On the quest for a broad patent scope for the pioneer see, e.g., Kitch (1977), on the quest for sufficiently large incentives for the innovators see, e.g., Nelson (2000), Merges (1996), Scotchmer (1991).

has witnessed situations of blockage in the optics and the aviation industry (Merges 1994, 1996), choosing between the exclusion of competitors and granting a license is a business decision geared by strategic considerations.[17] The hightened concern about rising transaction costs in patent litigation (Fischermann 2005, Kanellos 2005) led economists and lawyers to advise the tightening of patentability requirements (e.g., Merges and Nelson 1990, Barton 2001, 881) by the internal reorganisation of patent offices (Moufang 2003, Straus 2001b, Barton 2000) or by third party review.[18] Besides, ignoring infringements is as widely known[19] as (non-infringing) parallel developments (Scotchmer 2004, 140ff.). Under the threat of compulsory licenses and antitrust motions, industry has usually been willing to find arrangements, preferably via cross-licensing. As a consequence, dependency has until recently attracted little academic attention beyond the field of self-reproductive material.[20]

Problems occur, however, when a patent depends on too many previous independent patents ("property rights complex") (2.1.2) and when too many further developments depend on one basic patent (2.1.3).

2.1.2 Dependency on too many patents: The "property rights complex"

The problem of dependency of one patent on too many parallel patents and the resulting royalty stacking is not a new one for industry and is dealt with under the heading of "property rights complex". The profitable development of an end product is put at risk when too many employees of different firm sections claim a share of the profits from a new (typically assembled) product. In Europe, this problem is explicitly dealt with in remuneration rules for employee inventions in private firms and in public service.[21] As an annex to the law governing employee inventions (German: Arbeitnehmer-

[17] Although the strategic use of patents puts some pressure on the system, see Barton (2000, 2002), European Commission (2003).

[18] Either envisioned as an administrative (Jaffe and Lerner 2004, 22) or a judicial procedure (Lemley 2001).

[19] Schmidtchen (1994, 37), notes two examples: the un-licensed production of light bulbs by Philips and the un-licensed production of plant-oil based butter (margarine) by Jurgens and van den Bergh (later Unilever), both resulting in a market-dominating production.

[20] The classic example is the *sui generis* system of plant varieties, for a concise historic account with an outlook on modern biotechnology see Winter (1992) and Straus (1987).

[21] In Germany: "Richtlinien für die Vergütung von Arbeitnehmererfindungen im privaten Dienst" (RLArbnErfprivD) 20 July 1959 (Bundesanzeiger Nr. 156 v. 18. Aug. 1959), version 1 Sept. 1983 (Bundesanzeiger 1983, 9994). Pertaining to inventions of employees in public service according to "Richtlinien für die Vergütung von Arbeitnehmererfindungen im öffentlichen Dienst" of 1 Dec. 1960 (Bundesanzeiger Nr. 237 from 8 Dec. 1960), enacted as Executive Order of the Minister of Labour after consultation with representatives of employers and employees, based on § 11 ArbnErfG; printed in Bartenbach and Volz (1999, 2002).

erfindergesetz, ArbNErfG), No. 19 of the German remuneration guidelines holds that the value of the whole complex shall be evaluated if a process or a product uses a number of prior inventions.[22] This value (in practice usually 1 to 3% of expected profits) is to be shared by all previous inventors – taking each contribution to the whole into account. Disputes are settled by an arbitral body ("Schiedsstelle") (§ 29 ArbnErfG).

This rule builds on the concepts that each employee is entitled to his/her invention although he/she is paid for making inventions. Technically, only the employer has the right to claim the invention. If the invention is claimed, compensation is due to the employee. This system, installed in Germany in the 1930s, has come under pressure due to the bureaucratic burden for the employer and the risk to miss the four-months deadline (§ 6 sec. 2 ArbnErfG). A national draft reform proposal aims at making the system easier. It proposes the removal of the deadline and of the instrument of the employer to claim the employee's invention ("Inanspruchnahme"). Also the remuneration system is to be simplified. Instead of a share in profits, the employee shall only be entitled to lump sums, with additional royalty promises remaining optional.[23]

In the scientific environment, things differ in three aspects. First, as one single innovative development is usually not confined to one institution, the corporatist mechanism of evaluating "the whole" is not available to a research institution. Typically, dominant patents are owned by a plurality of research institutions. Second, the problem is exacerbated especially in molecular biology by the necessity of using a large array of research tools. Third, according to German law, university scientists are entitled to 30% royalties (§ 42 No. 4 German ArbNErfG).

2.1.3 Too many dependant patents: The inverse "property rights complex"

Problems also occur when too many patents depend on one base patent. This is the problem that has prompted the lively debate about anticommons.[24] Base

[22] "Schutzrechtskomplexe" Nr. 19 RLArbnErfprivD: "Werden bei einem Verfahren oder Erzeugnis mehrere Erfindungen benutzt, so soll, wenn es sich hierbei um einen einheitlich zu wertenden Gesamtkomplex handelt, zunächst der Wert des Gesamtkomplexes, gegebenenfalls einschließlich nicht benutzter Sperrschutzrechte, bestimmt werden. Der so bestimmte Gesamterfindungswert ist auf die einzelnen Erfindungen aufzuteilen. Dabei ist zu berücksichtigen, welchen Einfluss die einzelnen Erfindungen auf die Gesamtgestaltung des mit dem Schutzrechtskomplex belasteten Gegenstandes haben."

[23] For a critical economic analysis see Will and Kirstein (2004). Kirstein and Will (2004), arguing that the profit share is less efficient than a bonus contingent on the project value.

[24] The anticommons debate as a discussion about "the right patent scope" has displaced the formerly more popular questions with economists about the optimal time length of patents (Merges and Nelson 1990, Scotchmer 1999 and the differentiation of patent protection between industries Lemley 1997).

patents which are too broad might block research and competing developments, following (dependent) patents might be too narrow to be economically useful and therefore poison the system by increasing transaction costs and make research more expensive. However, at first glance, the growing number of dependent patents does not instigate the stacking of royalties – the focus of this article. On the contrary, the smaller the scope of patents becomes, the smaller is the chance that other patents will depend on them.

A closer look reveals something else: Not only does the broadening of the patent scope increase the amount of improvements covered by the scope of a prior patent. The growing scope creates the often deplored "patent thicket" (Shapiro 2001) of overlapping claims. This problem is most virulent in molecular science when a nucleotid sequence or a gene sequence is covered by more than one patent (Jensen and Murray 2005, 240), but it also troubles the information industry (David 2000). It was originally dealt with by the outright exclusion of discoveries and theories. With the move of the patent system to cover research results and information, especially in the fields of biotechnology and information technology, this "easy solution" has been blocked.[25] Problems, formerly crowded out by the discovery/invention distinction, seriously threaten the functioning of the patent system.[26] And they also instigate dependencies which result in the accumulation of royalties.[27]

The discussion about the right definition of patentable subject matter (technically the distinction between invention and discovery), in principle, is an old debate about the proper balance between a sufficiently strong incentive for the inventor and the sufficiently broad leeway for improvers. The concepts were transposed to modern science by the economist Suzanne Scotchmer (1991) in her seminal paper.[28] She holds that "sequential innovation" is a specific characteristic of the modern science system. She re-defines modern scientific progress in ways that were formerly enshrined in considerations on the exclusion of discoveries and theories from patentability. Thereby, she inspired the modern debate about the right scope of patents and problems which are due to patents being either too numerous and too narrow or being too broad and thus impeding subsequent developments.[29]

Yet, this discussion is dominated by a discourse about access rights to research results for scientists. The perceived problem is the exercise of

[25] Bearing in mind that the distinction between discovery (theories) and invention has always been conceived as an "entry" qualification to the patent system rather than a semantic definition. See for the historic example of the chemical dye industry v. d. Belt (1992); for modern biotechnology Straus (2001a), Godt (2007, Chap. 2).

[26] For a considered analysis of scientists not known as radical critics of the patent system see Cornish (2004); also the contributions in Dreyfuss, Zimmerman and First (2001).

[27] Seriously considered as a problem also recently by Jensen and Murray (2005, 240).

[28] Scotchmer (1991), later finetuned in Green and Scotchmer (1995).

[29] See the "anticommons debate" (Will and Kirstein 2004, Kirstein and Will 2004).

exclusion and the rising costs of research. Therefore, reflections aim at shielding science from the exercise of patents via a broad research exemption (Eisenberg 1987, Barton 2000, Gold, Joly and Caulfield 2005) or via access-securing compulsory license type mechanisms.[30] These solutions would also ease the problem of stacking royalty promises that follow from licensing. However, with research institutions becoming normal commercial partners and scientific patenting becoming an everyday phenomenon, research exemptions and compulsory schemes will continue to be narrow and rare.[31] Therefore, the problem of royalty stacking will also remain unresolved.

2.2 Contracts

2.2.1 The beast of the knowledge society

The second mechanism for royalty accumulation are contracts. Contractual arrangements can even be more intricate than the property mechanism. The latter only functions when a patent is technically dependent on a plurality of prior patents. Thus, only "using" a patented method in research without making it part of the new patented invention will seldomly result in a veto right or in a claim to royalties. However, contract clauses might "reach through" the use of the patent to future patents to be created (or future contracts) by stipulating that the owner of the patented reseach tool is entitled to royalties from those patents that will only result from using this research tool.[32] This can result in stacking royalties.

There are various reasons for the owner of an intellectual property to negotiate such clauses. Evidently, it helps to keep track of the market. Tracking future dependent patents is difficult. More important is that information goods are licenced instead of sold. In contrast to the industrial era, property of a patented product is not simply or necessarily transferred – like a high-tech microscope. In the information era, only the use of the technology is consented – i.e. licensed. The transfer of property is not at the center of interest. Important is the control of use. For copyright, contractual clauses

[30] Such as the newly discussed clearing-house mechanism for patented diagnostics; see contributions to the Conference "Patents and Public Health", organised by Overwalle under the umbrella of the CIPR, Leuven, Belgium on May 27, 2005, http://www.law.kuleuven.ac.be/cir/conference_27may.htm (visited 7/05).

[31] The Supreme Court of the US upheld a decision of the CAFC in *Duke University v. John Madey* which narrowly interpreted the experimental use exemption as not covering academic non-commercial use per se; for a commentary see Eisenberg (2003).

[32] To be clear: These do not necessarily depend on the previous patent.

allow the restriction of duplication[33] In science, these contracts not only include use restrictions which evidently impede scientific freedom[34], they also promote the stacking of royalties.

2.2.2 Information contracts in science

The public debate about "reach through contracts" as a problem for scientific research was first lauched by an expert advisory committee of the US National Institutes of Health in 1998 (National Institutes of Health (NIH) 1998). It was embedded in the broad discussion about research tool patenting. This committee was the first to frame it as a problem for scientists and labeled it "royalty stacking": When scientists do research, they depend on a variety of research tools (material, methodologies, know-how) which need to be licensed.[35] However, in contrast to industry, additional drivers are in place in science when stipulating the contract fostering the accumulation of royalty promises:

When negotiating a license, the typical remuneration are royalties. In principle, royalties are in the interest of both parties. The uncertain value of the information good is captured by a percentage of profits earned later in the development instead of a fixed price. Payment is postponed until the commercial value materialises. The licensee does not have to procure money immediately. The licensor hopes that the share in profits will be higher than an actual payment.

The effects of these basic principles are reinforced in the scientific environment. For the licensor of a patented research tool, science is the only market and the only source of income. Research tools do not usually give rise to "dependency" of subsequent patents because mostly they *enable* research but do not necessarily form part of the subsequent invention.[36] Therefore, as the chances of future proprietary profit participation are small, the immediate selling prize must be high – but this high price is difficult to realize. In fact, at this early stage the value often seems to be low – a point in favor of royalties. Also, the licensee will normally not be the one to develop the final product ready to be commercialized. Therefore, it is in the interest of the licensor to secure some profit from the value enhancing chain by "reaching through" the contract. The license permits the broadening of the group of people obligated to the original licensor. The contract can not only obligate the licensee to pay

[33] This issue has been intensively discussed as a problem of private legislation undercutting publically secured access rights, see Reichman and Franklin (1999, 964), Samuelson and Opsahl (1999).

[34] This problem was analysed in Godt (2007, Chap. 6).

[35] Type 2 of the three types of cumulativeness of Scotchmer (2004, 144); also coined as "stacking licenses", see Runge (2004, 821).

[36] A big exemption from this rule are gen patents. Both diagnostics and therapeutics will typically be dependent on isolation patents.

a share of his/her profits made when he/she succeeds in improving, patenting and licensing. It can also require him/her to transfer the royalty obligation in favor of the old licensor to the next scientists taking up the research.[37] Assuming that a final research result builds on a broad range of "in-licensed" technologies (apart from previous dominant technologies), such promises accumulate over time.

For scientists as licensees, the royalty promise is of no concern with regard to the problem of the unknown market value of the information good. From their perspective, future royalties will not be debited to their current research budget, but will be borne by the research institution or future aquirers. Therefore, they as well have an incentive to negotiate royalties.[38] In addition, the royalty promise reduces the time investment in negotiations and provides them with quick access to the research tool.[39]

Consequentually, contractual promisses contribute to royalty stacking.

2.3 Discussion

Summing up, with patents being registered in science long before a product becomes reality, two mutually reinforcing factors contribute to the risk of royalty accumulation, a proprietary and a contractual mechanism. The proprietary mechanism touches on the sensitive question of the science/market distinction that was once captured by the invention/discovery distinction. Academically new and challenging, however, is the contractual mechanism. This reason for royalty accumulation deserves more attention. Up to now, patent lawyers and economists have focused on the exclusionary function of property rights and on contracts only as far as the concern the right to exclude. The tectonic shift from sales to lease in information goods has as yet attracted little theoretical analysis.[40]

Under both mechanisms research patents run the risk of accumulating royalty promises before they are finally ready to be commercialised ("royalty stacking"). Thus, the causal link between patents and technology transfer is not as compelling as is often claimed. Patents are one, but not the only condition for technology transfer to happen. Industry will not be interested in aquiring research patents if substantial profit shares have already been assigned to others. Therefore, stacked royalties ultimately threaten the transfer of (patented) knowledge from science to industry.

[37] Type 3 of the three types of cumulativeness of Scotchmer (2004, 145).

[38] Not taking into account institutional long-term interests (like the problem of stacking royalties).

[39] Patience is a decisive factor that influences the "efficient" prize, see Güth, Kröger and Normann (2004).

[40] For a first account see Godt (2007).

3 Technology transfer in the context of the information society

Before addressing policies of how to deal with the stacking of royalties, a brief historical note seems appropriate. The shift of paradigms in research policies came about in the 1980's. In the late 1970s, policy makers had identified a slowing down of innovation in Western economies whereas global technological change was accelerating. Thus, they turned to intellectual property as a classical incentive for innovation and strove for reform, both in the US and in Europe. In the US, the initial idea was to strengthen small and medium sized companies. This was the approach of the celebrious Bayh-Dole Act of 1980. The Act transferred the property of patents resulting from governmentally sponsored reseach to the inventor. Prior to this, those inventions had generally been assigned to the government. However, it came as a surprise that it was the universities and research institutions which primarily profited from the Act. By patenting, they attracted large amounts of investments, gave spin-offs an economic base to start with, and thus not only nurtured, but provided the emerging New Economy with the essential knowledge base. Shortly after its first enactment, the Bayh-Dole Act was adapted to this realization.[41] Even if initial expectations of high revenue only materialised for few universities, the activities of the newly established technology transfer offices strengthened the regional knowledge base of the economy and the reputation of research institutions.

In Europe, the process developed differently. Although driven by the same concern, the legal set-up was fundamentally different. Legally, patents were always assigned to the inventor. In universities, the so-called "Professor's Privilege" safeguarded the inventor's ownership of the invention as part of the academic freedom.[42] Public laws provided for equitable licences granted to everybody when an invention was publicly funded. This mandatory requirement came under pressure, first inside the EU member states,[43] later in EU research policies.[44] Publicly funded research results were diagnosed as not being turned into "useful products", and the mentioned restrictions on the exclusivity of property rights were identified as the reason (Ullrich 1997). By now, public access rights have been either abolished or relegated to administrative regulations.[45] The owner only has the obligation to use the

[41] A short history of the Bayh-Dole Act is provided by Eisenberg (1996b).

[42] Formerly Art. 42 German Employee Inventions Act (Arbeitnehmererfindungsgesetz, ArbNERfG).

[43] See for Germany the advice of the expert group to the Ministry of Science and Technology, Ullrich (1997).

[44] 6th EU Framework Programme, Art. 23 Reg. (EC) No. 2321/2002, Off. J. L 355/23.

[45] E.g. No. 8.1 Internal Regulations of the German Ministry for Education and Research ("Besondere Nebenbestimmungen für Zuwendungen auf Ausgabenbasis") (funding for public research institutions), BNBest-BMBF Juni 2002): Free access has to be provided for other academic research institutions.

results.[46] Patent owners have almost unrestricted power of their intellectual property rights and are even allowed to license them exclusively. Also, the "Professor's Privilege" has been abolished in major EU countries.[47] Like any other employer, the university can claim the intellectual property right with due compensation to the personnel.[48] This reform provided the technology offices with the proper base for professional management of the universities' patent portfolios. Thus, in contrast to the US and in contrast to popular policy perception,[49] the patent was not deployed in its classical way as an initial incentive to invent. The fact that universities come up with innovative ideas is taken for granted.[50] The regulatory core idea was that scientific research patents would instigate technology transfer from research institutions to industry because the knowledge is proprietarily secured. Thereby, the design of scientific research became less geared towards questions valued by the epistemic scientific community but more towards industrial interests. This redefinition of science policies became known as a paradigm shift from science being a "push partner for industry" to industry becoming a "pull partner for science".[51] In other words, it turns the old perspective of science as "producer driven" vis-à-vis the consumers (the colleagues)[52] towards a closer science/industry relation. These motivations of industry and economic policy makers coincided with expectations of policy makers and scientists alike that research institutions could do both, attract additional private funding for research prior to an invention and, after the invention is made, could sell their research results, thus contributing to their funding themselves. Although these expectations have not materialised (not for most US universities, even less in the EU), the effects to improve the knowledge base of the overall economy

[46] For the EC: Art. 23 Reg. (EC) No. 2321/2002, Off. J. L 355/23; for Germany: Nr. 4. 2 BNBest-BMBF June 2002 (ibid); German Research Foundation (DFG): No 13 and 14 "Verwendungsrichtlinie Sachbeihilfe; Vordruck 2.02".

[47] European Commission – Expert Group (2004, 15). In Germany "Gesetz zur Änderung des Gesetzes über Arbeitnehmererfindungen vom 18. Januar 2002", in force since 2 July 2002, BGBl. Part I/2002, p. 414. (Jurisdictions that still adhere to the Professor's Privilege are Finland, Sweden, Norway, and recently installed by Italy).

[48] Although some restrictions apply: e.g. the academic scientist retains the right to publish freely (§ 42 sec. 1 ArbNErfG).

[49] Portraying patents also in the academic sphere as behavioral incentives to invent.

[50] The driving force for academic innovation has been attributed to the scientific norm of esteem in the scientific community, first described in depth by Merton (1938/1973, 1942/1973).

[51] In the EU lauched with the 5th Framework Programme in 1998; in the US through developments instigated by the Bayh-Dole Act 1980, see Godt (2007, Chap. 3); Mowery and Sampat (2005, 224ff).

[52] For an economic behavioral analysis of this relation see Albert (2006).

have been acknowledged. A cooperative system between science and industry has emerged.[53]

From the patent systems' and the behavioural perspective, the key question is whether innovation has become causally stimulated by these reforms fostering technology transfer. As far as preliminary results go, the evidence seems to be mixed. There are other factors that influence the cooperation between science and industry as much as the availablity of patent protection. Beyond institutional and intrafirm organisational arrangements (Owen-Smith and Powell 2001, Bercovitz et al. 2001), there are other legal aspects that foster or impede technology transfer. For instance, in contrast to the US, European provisions on joint ownership do not allow one-sided licensing without the consent of all co-owners, thus slowing down technology transfer (European Commission – Expert Group 2004, 16–17). Property laws in Europe are fragmented. Technology Transfer Offices are still in the process of being built up. Also, the majority of scientists still adhere to classical research norms like instant publishing and cooperative exchange. Both are potentially detrimental to the claim of patents. Where an adaptation to financial incentives in science has occurred, the repercussions of patents on research[54] as well as the repercussions of scientific patenting on the patent system itself (Nelson 2000) have been criticised.

Therefore, it is safe to say that the "problematique" of "royalty stacking" is one facet of the changing environment of the science/industry interface. However, if there is neither technology transfer, nor financial gain for the research institutions, then the suspension of classical research norms cannot be justified. The phenomenon of "royalty stacking" re-traces the profound structural differences of research in academic and industrial settings. It points at problems that were formerly delt with by the exclusion of "discoveries" and "theories" from the patent system. Those problems re-surface and are reinforced by contractual "reach through" arrangements. Stacked royalties undermine both, the policy of why the patents were installed in the realm of science, and the traditional norms of science (as described by Robert Merton). Impeding both patent mechanisms and mechanisms of science will hamper the overall pace of innovation in the long run.

However, it is illusionary to expect that the former invention/discovery distinction can be reinstalled. The convergence is due to the fading distinction between basic science and applied science that is part of the information society. Therefore, other policies must be devised to deal with occurring problems.

[53] Coined by the EU as "innovation system", European Commission – Expert Group (2004, 32).

[54] See only critics like v. d. Belt (2004) and Krimsky (1999).

4 How to catch the beast?

How can the various actors deal with the problem of stacking royalties? In the following, the capacities of industry (1), research institutions (2) and governmental public policy (3) will be considered.

4.1 Industry

As a first reaction, industry could consider the acquisition of research results early in the process. However, this motion contradicts contemporary industrial philosophy to reduce R&D costs by acquiring research results at a fixed price later in the process when commerciability becomes a probable option.

Therefore, strategies must be more effectively geared towards avoiding royalty stacking in scientific institutions. A first step, especially for IP managers in industry and lawyers in private practice negotiating these contracts, is to understand the functional differences of how research results emerge in a public and in a private research setting. Although the difference between basic science and applied science in respect of marketability has largely vanished, the process of how research results are produced is still different. This realization should caution against the transposition of contract clauses that may be common to industry, but may have different effects and be ultimately detrimental in science. Whereas industry has its own ways of dealing with burgeoning patents and licenses (mergers and acquisition, closed or open patent pools) (Scotchmer 2004, 157), science is not in the position to apply these strategies.

A starting point for industry involves two aspects. On the one hand, it can acknowledge that proprietarily secured technology transfer is perceived as socially valuable by both public policy and research institutions. On the other hand, it should understand that the dichotomy of the private and public research realm is ultimately favorable to economic evolution. Taking both into consideration, industry has at least two options to prevent the accumulation of royalties in research institutions. First, it can refrain from negotiating royalties. This seems to be a cooperative (information) problem inside industry that needs to be resolved. Any licensor of a research tool has an interest in negotiating as high a percentage as possible irrespective of the danger that the profit margin is used up before any end product has reached the market. The bottom line is, however, that everybody loses out because no product at all will be developed. This consideration might induce industrial associations to draw up a code of conduct aimed at reducing use restrictions and favoring one-time payments instead of royalties when licensing research tools to public research institutions. Second, industry can finance research tools, promote their pooling and open access, either by putting them into the public domain or by pooling them via "one-stop" (clearinghouse) arrangements.

4.2 Research institutions

The most eminent goal for research institutions is to formulate a patent strategy that articulates the profile of the research institution and adopts corresponding rules. These policies will position the institution somewhere on the line between a merely publicly funded institution driven by research interests formerly labeled as basic science (with no obvious commerciability) and an applied science institution aiming at revenue generated by the sale of research results to industry. Such policies will include the duties and freedoms of scientists, principles of their remuneration and publication rules[55] (especially rules on publication if research is funded directly by private companies).

These policies translate into patent policies: If a research institution aims at being a basic science institution, not interested in technology transfer, then it should be easy to convince a licensor of patent tools to sell a tool instead of licensing it. This strategy can be complemented by the recommendations of the Dutch Advisory Council for Science and Technology Policy (AWT) which advises research institutions not to patent very basic and broad inventions (Dutch Advisory Council for Science and Technology Policy (AWT) 2001). From the perspective of the licensor, the revenue in these institutions is uncertain anyway. This might help institutions such as Max Planck Institutes to avoid royalty promises altogether. On the other hand, for institutions working very closely with industry, royalty promises will be unproblematic. Industry is used to the royalty quarrels. The challenge lies with the "middle range" institutions, i.e. most universities. They have to devise procedural strategies to avoid royalties as far as possible. One policy principle might be to oblige their researchers to avoid royalties by first trying to buy the tool. If this is economically unreasonable, they must negotiate the smallest possible royalty. Also, a form of recordkeeping needs to be installed, in order to stay below the 20% margin that impedes later commercialisation.[56]

4.3. Government public policy

Stacking Royalties has to do with the newly emerging commodification of information, with the patenting of research tools and "reach through" contracts. Governments should approach the emerging problems more courageously. Mechanisms need to be devised for the financing of research tools. Administrations can pool them, provide public access, or help industry to find

[55] In respect to clauses relating to publication freedoms, a variety of model contracts are already available, an overview is provided by Peter and Runge (2004).

[56] The record is also important for use restrictions.

"one-stop" solutions, devise policies promoting free access of non-commercial research institutions to research tools.

One important instrument is the regulation of public funding. The licensing of research tools can be limited by obliging recipients of public funding to provide free access to emanating research results. Here, more economic research needs to be done.[57]

5 Conclusion

The phenomenon of "royalty stacking" threatens the very goal of technology transfer from science to industry. In this respect, it is a challenge to research policy. It is a result of two distinct mechanisms, one proprietary, the other contractual. The proprietary mechanism is rooted in the expansion of patents into areas traditionally defined as "discovery" or "theory" and formerly excluded from the patent system. The contractual mechanism is primarily due to the transition from sale contracts to lease contracts in the user market. In combination, these two mechanisms can have detrimental effects on the transfer of technology from science to industry when the royalty share becomes "too large". Two lessons can be learnt: First, the claim of patents does not *per se* secure the transfer of knowledge. A patent is only a *conditio sine qua non*, but other conditions have to be met as well. Second, the phenomenon of "stacking royalties" sheds light on the diverse nature of the scientific process. There are areas which are suited to commercialization, there are others which are not. The latter seem insusceptible to market mechanisms. Patenting in the field of basic science which was formerly classified as a market failure (justifying public funding) gives rise to problems that were once delt with by its exclusion from the patent system. With the fading distinction between basic and applied science, new mechanisms have to be devised in order to conserve scientific norms if science is to continue to serve as an incubator for "fresh knowledge".

Thus, the phenomenon of "stacking royalties" helps to understand changes and continuities in science. Even if the concept of science and the market as opposites seems outmoded, differences persist. Science as a system has become diverse, integrating areas which can be modeled on market mechanisms. Other areas continue to function differently. These differences must be taken into account if research policies want to exploit the potential of both realms, the realm of "intentionless" science with long lasting processes and the realm of science with high susceptibility for economic innovation.

[57] See Scotchmer's (2004, 152) idea of research exemptions counterintuitively favouring the pioneer.

References

Agrawal, A., and R. Henderson (2002), "Putting Patents in Context: Exploring Knowledge Transfer from MIT", *Management Science*, 48, 44–60.
Albert, M. (2006), "Product Quality in Scientific Competition", *Papers on Strategic Interaction* 6-2006, Jena: Max Planck Institute of Economics.
Bartenbach, K., and F. E. Volz (1999), *Arbeitnehmererfindervergütung – Kommentar*, 2. Ed., Köln: Heymanns.
Bartenbach, K., and F. E. Volz (2002), *Arbeitnehmererfindungsgesetz – Kommentar*, C., Köln: Heymanns.
Barton, J. H. (2002), *United States Law of Genomic and Post-Genomic-Patents*, München: VCH Verlagsgesellschaft.
Barton, J. H. (2000), "Policy Forum: Intellectual Property Rights. Reforming the Patent System", *Science*, 287, 1933–1934.
Barton, J. H. (2001), "Antitrust Treatment of Oligopolies with Mutually Blocking Patent Portfolios", *Antitrust Law Journal*, 69, 851–882.
Belt, H. v. d. (1992), "Why Monopoly Failed: The Rise and Fall of Société La Fuchsine", *British Journal of the History of Science*, 25, 45–63.
Belt, H. v. d. (2004), "A New Constellation of Knowledge and Power: Gene Patents in the Information Society – Mag ik uw genen even patenteren?" *Philosophy Journal of the Netherlands, ndl.: Krisis*, 5, 22–37.
Bercovitz, J., M. Feldman, I. Feller, and R. Burton (2001), "Organizational Structure as a Determinant of Academic Patent and Licensing Behavior: An Explanatory Study of Duke, John Hopkins, and Pennsylvania State Universities", *Journal of Technology Transfer*, 26, 21–35.
Blumenthal, D., E. G. Campbell, M. S. Anderson, N. Causino, and K. S. Louis (1997), "Withholding Research Results in Academic Life Sciences: Evidence From a National Survey of Faculty", *Journal of the American Medical Association*, 277, 1224.
Carayol, N. (July 2005), "Academic Incentives, Research Organization and Patenting at a Large French University", http://cournot2.u-strasbg.fr/EEAAS/carayol/research.htm.
Cornish, W. (2004), *Intellectual Property: Omnipotent, Distracting, Irrelevant*, Oxford: Oxford University Press.
David, P. A. (2000), "A Tragedy of the "Public Knowledge" Commons: Global Science, Intellectual Property and Digital Technology Boomerang", http://www.oiprc.ox.ac.uk/EJWP0400.pdf.
David, P. A. (2004), "Can 'Open Science' be Protected from the Evolving Regime of IPR Protection?" *Journal of Institutional and Theoretical Economics*, 160; 1, 9–34.
Dreyfuss, R., D. L. Zimmerman, and H. First (eds) (2001), *Expanding the Boundaries of Intellectual Property: Innovation Policy for the Knowledge Society*, Oxford and New York: Oxford University Press.
Dutch Advisory Council for Science and Technology Policy (AWT) (2001), "Trading in Knowledge. University Patenting Policy for the Benefit of Utilising Knowledge", Advisory Council for Science and Technology Policy, Den Haag.
Edler, J., S. Kuhlmann, and M. Behrens (eds) (2003), Changing Governance of Research and Technology Policy: The European Research Area, Cheltenham, UK; Northampton, MA: Edward Elgar.
Eisenberg, R. (1987), "Proprietary Rights and the Norms of Science in Biotechnology Research", *Yale Law Journal*, 97, 177–231.
Eisenberg, R. (1996a), "Patents: Help or Hindrance to Technology Transfer", 161–171 in: F. B. Rudolph and L. V. McIntire (eds), *Biotechnology: Science, Engineering, and Ethical Challenges for the Twenty-First Century*, Washington: Joseph Henry Press.

Eisenberg, R. (1996b), "Public Research and Private Development: Patents and Technology Transfer in Government-sponsored Research", *Virginia Law Review*, 82, 1663–1752.
Eisenberg, R. (2000), "Re-Examining the Role of Patents in Appropriating the Value of DNA Sequences", *Emory Law Journal*, 49, 783–800.
Eisenberg, R. (2003), "Patent Swords and Shields", *Science*, 299, 1018–1019.
European Commission (2003), "Strategic Use and Adaptation of Intellectual Property Rights Systems in Information and Communications Technologies-based Research", *Working Paper EUR 20734 EN*, http://europa.eu.int/comm/research/rtdinfo/index_en.html.
European Commission – Expert Group (2004), "Management of Intellectual Property in Publicly-Funded Research Organisations: Towards European Guidelines", *Working Paper EUR 20915 EN*, http://europa.eu.int.
Fischermann, T. (2005), „In der Grauzone: Trickreiche Patentjäger pressen amerikanischen Unternehmen Millionensummen ab. Jetzt kommen sie nach Europa", DIE ZEIT (24.02.2005), 31.
Galama, J. E. M. (2000), "Expert Opinion on the Case For and Against the Introduction of a Grace Period in European Patent Law", http://www.european-patent-office.org/news/pressrel/2000_07_25_e.htm.
Gewin, V. (2005), "Locked in the Lab: Intellectual Property Disputes Make it Hard for Research to Escape", *Nature*, 437, 948–949.
Godt, C. (2003), *Streit um den Biopatentschutz: Stoffschutz, Patente auf Leben und Ordre Public – nationaler Gestaltungsspielraum bei der Umsetzung der Europäischen Biopatentrichtlinie, ZERP-Diskussionspapier 1/2003*, ZERP: Bremen.
Godt, C. (2007), *Eigentum an Information: Der Funktionswandel des Patentschutzes in der Wissensgesellschaft: Die genetische Information als Beispiel*, Tübingen: Mohr Siebeck.
Gold, E. R., Y. Joly, and T. Caulfield (2005), "Genetic Research Tools, the Research Exeption and Open Science", *GenEdit*, 3, 1–11.
Green, J., and S. Scotchmer (1995), "On the Devision of Profit in Sequential Innovation", *RAND Journal of Economics*, 26, 20–33.
Güth, W., S. Kröger, and H.-T. Normann (2004), "Durable-Goods Monopoly with Privately Known Impatience: A Theoretical and Empirical Study", *Economic Inquiry*, 42, 413–424.
Hardin, G. (1968), "The Tragedy of the Commons", *Science*, 162, 1243–1248.
Heller, M. (1998), "The Tragedy of the Anticommons: Property in the Transition from Marx to Markets", *Harvard Law Review*, 111, 621–688.
Heller, M. (1999), "Boundaries to Private Property", *Yale Law Journal*, 108, 1163–1223.
Heller, M., and R. Eisenberg (1998), "Can Patents Deter Innovation? The Anticommons in Biomedical Research", *Science*, 280, 698–701.
Hoeren, T. (2005), "Zur Patentkultur an Hochschulen: auf neuen Wegen zum Ziel", *Wissenschaftsrecht*, 38, 131–156.
Holman, M. A., and S. R. Munzer (2000), "Intellectual Property Rights in Genes and Gene Fragments: A Registration Solution for Expressed Sequence Tags", *Iowa Law Review*, 85, 735–748.
Holzapfel, H. (2003), *Das Versuchsprivileg im Patentrecht und der Schutz biotechnologischer Forschungsinstrumente*, Baden-Baden: Nomos.
Jaffe, A. B., and J. Lerner (2004), *Innovation and Its Discontents: How Our Broken Patent System is Endangering Innovation and Progress, and What to Do about it.* Princeton: Princeton University Press.
Jensen, K., and F. Murray (2005), "Intellectual Property Landscape of the Human Genome", *Science*, 310, 239–240.

Kanellos, M. (2005), "Stacking Patent Claims – for Gold Mines", *ZDNet News:* http://news.zdnet.com/2100-9589_22-5796531-2.html.
Kitch, E. W. (1977), "The Nature and Function of the Patent System", *Journal of Law and Economics*, 20, 265–290.
Kirstein, R., and B. Will (2004), "Efficient Compensation for Employees' Inventions", *Manuscript, 30. Sept. 2004.*
Knorr-Cetina, K. (1999), *Epistemic Cultures*, Cambridge, MA: Harvard Univ. Press.
Kowalski, T. J., and C. M. Smolizza (2000), "Reach-through Licensing: A US Perspective", www.Pharmalicensing.com /features/disp/963567614_398edffe132c5.
Krimsky, S. (1999), "The Profit of Scientific Discovery and its Normative Implications", *Chicago-Kent Law Review*, 75, 15–39.
Lemley, M. (1997), "The Economics of Improvement in Intellectual Property Law", *Texas Law Review*, 75, 989.
Lemley, M. (2001), "Rational Ignorance at the Patent Office", *Northwestern University Law Review*, 95, 1495–1532.
Merges, R. P. (1994), "Intellectual Property Rights and Bargaining Breakdown: The Case of Blocking Patents", *Tennessee Law Review*, 62, 75–106.
Merges, R. P. (1996), "Contracting into Liability Rules: Intellectual Property and Collective Rights Organizations", *California Law Review*, 84, 1293–1393.
Merges, R. P., and R. R. Nelson (1990), "On the Complex Economics of Patent Scope", *Columbia Law Review*, 90, 839–916.
Merton, R. K. (1938/1973), "Science and the Social Order", 254–266 in: N. W. Storer (ed.), *The Sociology of Science*, Chicago: University of Chicago Press.
Merton, R. K. (1942/1973), "The Normative Structure of Science", 267–285 in: N. W. Storer (ed.), *The Sociology of Science*, Chicago: University of Chicago Press.
Merz, J. F., A. G. Kriss, and D. G. B. Leonard et al. (2002), "Diagnostic Testing Fails the Test", *Nature*, 415, 577–579.
Moufang, R. (2003), Vortrag vor dem Deutschen Nationalen Ethikrat am 23. April 2003, http://www.nationalerethikrat.de/texte/pdf/Forum_Patent_03-04-23_Protokoll.pdf (11/03).
Mowery, D. C., and B. N. Sampat (2005), "Universities in National Innovation Systems", 209–239 in: J. Fagerberg, D. C. Mowery and R. R. Nelson (eds), *The Oxford Handbook of Innovation*, Oxford: Oxford University Press.
Murray, F., and S. Stern (2005), "Do Formal Intellectual Property Rights Hinder the Free Flow of Scientific Knowledge? A Test of the Ant-Commons Hypothesis", *Paper prepared for NBER Academic Science and Entrepreneurship Conference, June 2005.*
National Institutes of Health (NIH) (1998), "Report of the National Institutes of Health (NIH) Working Group on Research Tools" (June 4), www.nih.gov/news/researchtools/index.htm.
National Research Council (2005), *A Patent System for the 21th Century*, www.nap.edu.
Nelson, L. (1998), "The Rise of Intellectual Property Protection in the American University", *Science*, 279, 1460–1461.
Nelson, R. R. (2000), "Observations on the Post-Bayh-Dole Rise of Patenting at American Universities", *Manuscript*.
Nuffield Council on Bioethics (2002), "The Ethics of Patenting DNA", Nuffield Council on Bioethics, http:www. nuffieldbioethics.org, London.
Owen-Smith, J., and W. W. Powell (2001), "To Patent or Not: Faculty Decisions and Institutional Success at Technology Transfer", *Journal of Technology Transfer*, 26, 99–114.
Peter, M., and P. Runge (2004), "Leitfaden zur Gestaltung von Drittmittelverträgen zwischen Hochschulen und der Industrie", http://www.gewrs.de/files/leitfaden_duesseldorfer_vertragswerkstatt.pdf.

Rai, A. K., and R. Eisenberg (2003), "Bayh-Dole Reform and the Progress of Biomedicine", *Law and Contemporary Problems*, 66, 289–314.
Reichman, J. H., and J. A. Franklin (1999), "Privately Legislated Intellectual Property Rights: Reconciling Freedom of Contracts with Public Good Uses of Information", *Univ Penn L R*, 875–950, 875–970.
Runge, C. F. (2004), "Enclosure, Intellectual Property and Life-Science Research", *Journal of World Intellectual Property*, 7, 807–827.
Samuelson, P., and K. Opsahl (1999), "Licensing Information in the Global Information Market: Freedom of Contract Meets Public Policy", *European Intellectual Property Review*, 386–393.
Schmidtchen, D. (1994), "Kommentar zu Erich Kaufer: Innovationspolitik als Ordnungspolitik", 33–39 in: C. Ott and H.-B. Schäfer (eds), *Ökonomische Analyse der rechtlichen Organisation von Innovationen*, Tübingen: Mohr-Siebeck.
Schumpeter, J. (1942), *Capitalism, Socialism and Democracy*, New York: Harper & Row.
Scotchmer, S. (1991), "Standing on the Shoulders of Giants: Cumulative Research and the Patent Law", *Journal of Economic Perspectives*, 5, 29–41.
Scotchmer, S. (1999), "On the Optimality of the Patent Renewal System", *RAND Journal of Economics*, 30, 181–196.
Scotchmer, S. (2004), "Standing on the Shoulders of Giants: Protecting Cumulative Research", in: S. Scotchmer (ed.), *Innovation and Incentives*, Cambridge, Mass: MIT Press.
Shapiro, C. (2001), "Navigating the Patent Thicket: Cross Licenses, Patent Pools, and Standard-Setting", http://faculty.haas.berkeley.edu/shapiro/thicket.pdf.
Stokes, D. (1997), *Pasteur's Quadrant: Basic Science and Technological Innovation*, Washington D. C.: Brookings Institution.
Straus, J. (1987), "The Principle of "Dependence" under Patents and Plant Breeders' Rights", *Industrial Property*, 26, 433–443.
Straus, J. (2001a), "Produktpatente auf DNA-Sequenzen: Eine aktuelle Herausforderung des Patentrechts", *Gewerblicher Rechtsschutz und Urheberrecht*, 1016–1021.
Straus, J. (2001b), "Elemente eines Änderungsprozesses zur ggf. erforderlichen Verbesserung und Präzisierung der Richtlinie 98/44 des Europäischen Parlaments und des Rates vom 6. Juli 1998 über den rechtlichen Schutz biotechnologischer Erfindungen in Folge der technischen und gesellschaftlichen Entwicklung der letzten Zeit unter Berücksichtigung der Aspekte des internationalen Rechtsrahmens: Stellungnahme erstellt im Auftrage des Bundesministeriums der Justiz", München: Bundesministerium der Justiz.
Ullrich, H. (1997), "Mehr Initiative, mehr Innovation", *Mitteilungen der deutschen Patentanwälte*, 80–86.
v. Overwalle, G. (2006), "Reconciling Patent Policies with the University Mission", Ethical Perspectives: *Journal of the European Ethics Network 13 (No. 2)*, 231–247.
Verbeure, B., G. Mattijs, and G. v. Overwalle (2005), "Analysing DNA Patents in Relation with Diagnostic Genetic Testing", *European Journal of Human Genetics*, 1–8.
Walsh, J. P., A. Arora, and W. M. Cohen (2003), "Research Tool Patenting and Licensing and Biomedical Innovation", www.merit.unimaas.nl/epip/papers/walsh_paper.pdf.
Walsh, J. P., C. Cho, and W. M. Cohen (2005), "View from the Bench: Patents and Material Transfer", *Science*, 309, 2002–2003.
Will, B., and R. Kirstein (2004), "Effiziente Vergütung von Arbeitnehmererfindungen", *Zeitschrift für Betriebswirtschaft*, 25–49.
Winter, G. (1992), "Patent Law Policy in Biotechnology", *Journal for Environmental Law*, 4, 167–187 (republished in P. Drahos, Intellectual Property, Ashgate, Dartmouth, 181–201).

Contents