THESIS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

# Innovation and Intellectual Property

Strategic IP Management and Economics of Technology

MARCUS HOLGERSSON

Department of Technology Management and Economics

CHALMERS UNIVERSITY OF TECHNOLOGY

Gothenburg, Sweden 2012

Innovation and Intellectual Property
Strategic IP Management and Economics of Technology
MARCUS HOLGERSSON



ISBN 978-91-7385-761-1
Doktorsavhandlingar vid Chalmers tekniska högskola, Ny serie nr 3442
ISSN 0346-718X

Industrial Management and Economics
Department of Technology Management and Economics
Chalmers University of Technology
SE-412 96 Gothenburg
Sweden
Telephone + 46 (0)31-772 1000

Printed by Chalmers Reproservice
Gothenburg, Sweden 2012

To Erika and Rune

## Abstract

Innovations and technological developments have been recognized for their central importance for economic success and growth at least since the 1930s. Intellectual property (IP) and intellectual property rights (IPRs), such as patents, trade secret rights, and copyrights, have during more recent decades caught increasing attention, and, mainly due to various developments at macro level, IP has become an important source of competitive advantage at micro level in many industries. This has led to an increased importance of strategic IP management, and the related research field has been growing since the late 1990s. This thesis aims to contribute to this growing field, and the first purpose of this thesis is *to explore and explain strategic and innovation related IP management practices, and the managerial and economic consequences of such practices*. Apart from the growing importance of IP management in general, an increased focus on open and collaborative approaches for creating innovations has led to a need for new and adapted IP management skills. The second purpose of this thesis is therefore *to develop managerial and economic frameworks, models, and tools to be used in the intersection between IP management and open innovation practices*. These purposes are addressed in a cover paper and six appended research papers of theoretical/conceptual as well as of empirical nature, being based on interviews, questionnaires, patent statistics, and document studies.

In connection to the first purpose the results show that, while many small firms have problems with properly benefitting from the patent system, large firms have increasingly developed their IP strategies, especially their patent strategies. The purpose is then not only to appropriate monopolistic returns from innovations but also to govern various forms of open innovation. Large firms were found to in a first step increase their patenting (in terms of quantity), and in a second step focus more on selective, quality-oriented, and internationalized patenting. Additional results show that the internationalization leads to a convergence in managerial choices of output markets for patenting worldwide, in parallel with market and technology diversification. Further, a case from mobile telecommunications illustrates the role of IP management in the governance of open innovation systems. Finally, two cases from the automotive industry illustrate the IP-related problems that arise in connection to divestments and other types of disintegrations (‘IP disassembly problems’), and how IP management can mitigate them.

This leads to the second purpose, related to the development of models, tools, and frameworks for IP management in relation to open innovation. First, the thesis provides a conceptual framework of innovation openness, especially pinpointing the role of IPRs. This framework emphasizes three key dimensions of innovation openness: resource distribution, technology governance, and technology accessibility. Second, a framework for managing the IP disassembly problem is presented, enabling increased exit opportunities and decreased transaction costs. Third, a method for determining fair, reasonable, and non-discriminatory royalties in licensing collaborations is developed, applicable to multilateral licensing deals.

It stands clear that contemporary IP management is not (and has never been) only about maximizing excludability. Strategic IP management must therefore be developed and integrated with technology and corporate management in order to foster success at the micro level of firms, and thereby also at macro level. Developments in IP management skills (e.g., sourcing, control, commercialization, licensing, valuation, pricing) and IP contracts will then most likely lead to increased efficiency of interorganizational technological relationships and quasi-integrated organizational forms, and thereby also to increased innovativeness and economic development.



**Keywords:** *Intellectual property right; open innovation; research and development; innovation economics; technology management; strategy; value appropriation; licensing; governance; theory of the firm*

## Acknowledgements

The pursuit of a PhD is a large and difficult task. However, when pursuing it with the support of supervisors, colleagues, friends, and family it is also an enjoyable and highly rewarding undertaking. I have been fortunate to have such support, and I am deeply thankful for that.

Ove Granstrand, who talked me into pursuing a PhD and continued to supervise me along the road, has been of major importance for this thesis. I will always remain grateful for Ove's generosity in terms of ideas, knowledge, personal network, and friendship. Clas Wahlbin, who tragically passed away a little more than a year before the finish of this thesis, made a lasting impact not only on the content of this thesis, but also on me as a person. Clas was genuinely helpful, generous, and kind, with solid methodological insights and experience. Mats Magnusson provided the so necessary push towards finishing the thesis, and contributed both as supervisor and as director of Institute for Management of Innovation and Technology (IMIT).

Feedback has been given by numerous people, and for that I am indebted not only to my supervisors, but also to other colleagues, journal reviewers, and conference discussants. I am especially thankful to Fredrik Tell who gave constructive feedback on a draft of this thesis at the final seminar, leading to a substantial improvement before the final submission. Similarly, the feedback given by Björn Remneland-Wikhamn and Frank Tietze at my licentiate seminar improved an earlier version of this thesis. Thank you!

I am sincerely grateful to the Industrial Management and Economics research group, including MELT project colleagues and external collaborators. This group has provided an inspiring environment with highly knowledgeable scholars. Bengt Domeij and Thomas Ewing have enlightened me about the details and peculiarities of law, and eventually even I came to realize that law is actually quite fun. Multiple discussions with Marcel Bogers and Nicole Ziegler have also been highly rewarding. Similarly, So Young Sohn and her research team at Yonsei University have enabled a stimulating exchange of ideas and contacts.

I also thank all my current and previous colleagues at Chalmers who have supported and inspired me, including everyone in the "innovation corridor". More specifically, I am grateful to all fellow PhD students at Chalmers for exciting discussions about research and other things, and my gratitude goes especially to Anders Billström, Fredrik Wernersson Brodin, Klas Eriksson, and Marcus Linder.

The administrative support at both IMIT and Chalmers has always been careful, efficient, and friendly. I am especially thankful to Birgitta Andersson, Carina Blomkvist, Lucas Hörte, and Bengt Karlsson at IMIT and Eva Burford, Angelica Linnehav, and Yvonne Olausson at Chalmers.

One of the probably most important inputs to the PhD process stems from all the contributing firms, respondents, and interviewees. I am truly grateful for the time you have taken to answer my questions. An equally important input stems from the financial sponsors enabling the research. The financial support from Chalmerska forskningsfonden, E.ON, IMIT, STINT, Vinnova, and Zacco is thus gratefully acknowledged.

Most importantly, I want to express my gratitude to my family. Erika, you are my biggest inspiration. And Rune, who would have thought that a newborn little boy could offer his father so much support? I love you both.

Marcus Holgersson

Gothenburg, October 2012

## List of appended papers

### Paper I

The anatomy of rise and fall of patenting and propensity to patent: The case of Sweden. Co-authored with Ove Granstrand. Published in *International Journal of Intellectual Property Management*, 2012, Vol. 5, No. 2, pp. 169-198.

### Paper II

Patent management in entrepreneurial SMEs: A literature review and an empirical study of innovation appropriation, patent propensity, and motives. Forthcoming in *R&D Management*.

### Paper III

Multinational technology and intellectual property management - Is there global convergence and/or specialization? Co-authored with Ove Granstrand. Forthcoming in *International Journal of Technology Management*.

### Paper IV

Conceptualizing innovation openness: A framework and illustrative case. Co-authored with Marcel Bogers and Ove Granstrand. Submitted to an international journal. An earlier version was presented at the R&D Management Conference, 23-25 May, 2012, Grenoble.

### Paper V

The 25% rule revisited and a new investment-based method for determining FRAND licensing royalties. Co-authored with Ove Granstrand. Published in *les Nouvelles*, 2012, Vol. 47, No. 3, pp. 188-195.

### Paper VI

Managing the intellectual property disassembly problem. Co-authored with Ove Granstrand. Submitted to an international journal. An earlier version was presented at the European Patent Academy workshop at the European Patent Office, 4-5 June, 2012, Munich.

# List of contents

## List of figures



## List of tables

## List of abbreviations

| | |
|---|---|
| AIPPI | International Association for the Protection of Intellectual Property |
| CAFC | Court of Appeals for Federal Circuit |
| CAPM | Capital asset pricing model |
| CCC | Change of control clause |
| CEO | Chief executive officer |
| China | People's Republic of China |
| CIPO | Chief intellectual property officer |
| CTO | Chief technology officer |
| EPO | European Patent Office |
| ETSI | European Telecommunications Standards Institute |
| FDI | Foreign direct investment |
| FRAND | Fair, reasonable, and non-discriminatory |
| GDP | Gross domestic product |
| GM | General Motors |
| GPL | General Public License |
| IC | Intellectual capital |
| ICT | Information and communication technology |
| IP | Intellectual property |
| IPR | Intellectual property right |
| ISA | International Searching Authority |
| JV | Joint venture |
| Korea | Republic of Korea ('South Korea') |
| M&A | Merger and acquisition |
| MAD | Merger, acquisition, and divestment |
| MC | Marginal cost |
| MELT | Management, economics, law, and technology |
| MNC | Multinational corporation |
| NPE | Non-producing entity |
| PCT | Patent Cooperation Treaty |
| PLC | Product life cycle |
| PRT | Property rights theory |
| PTO | Patent and trademark office |
| RBT | Resource-based theory |
| ROI | Return on investment |
| R&D | Research and development |
| SME | Small or medium-sized enterprise |
| TCT | Transaction cost theory |
| TRIPS | Agreement on Trade-Related Aspects of Intellectual Property Rights |
| USPTO | United States Patent and Trademark Office |
| VC | Venture capital |
| VCC | Volvo Car Corporation |
| WIPO | World Intellectual Property Organization |
| WTO | World Trade Organization |

# 1 Introduction

On August 24, 2012, a federal jury in San Jose, California, awarded Apple a one billion US dollar damage from Samsung, its main competitor in the smartphone industry, due to patent infringement. While Apple's market value rose with roughly 15 billion US dollar after the verdict, the Samsung stock price dropped by 7.5%, leading to a decrease in market value of twelve billion US dollar, probably partly due to the risk of an injunction in connection with the final ruling that was yet to come. The stock of another competitor, Nokia, rose by 6% after the decision, probably because Nokia's smartphones used the Microsoft Windows mobile operating system. The Nokia/Windows ecosystem was expected to be less vulnerable to infringement accusations than Google's Android operating system that was used by Samsung and many others. Expectations were therefore that Nokia would be able to catch some of the market shares that would be lost by Samsung in case of an injunction. Expectations were also that the Nokia/Windows ecosystem would grow in popularity among smartphone manufacturers, which in turn would attract application developers and thereby increase the popularity and utility of the ecosystem as a whole.

The case above is only one out of several recent high level court cases illustrating the role of intellectual property rights (IPRs) for firms and their success. These cases have been frequently reported in various news media during the early 2010s, and the importance of IPRs and intellectual property (IP) for technology-based businesses has thus been increasingly highlighted in recent years. However, these issues are not new. In the late 19th century Alexander Graham Bell's patents were central to the success of his business in relation to competitors, although the Swedish telecommunications firm LM Ericsson's initial success was actually enabled much due to the absence of a Swedish patent in Bell's portfolio. In the emerging aircraft industry in the early 20th century the Wright brothers sued a number of competitors for infringing Wright's patents for aircraft control, arguably curbing the US aircraft industry development to the extent that the US government eventually forced the industry to reach cross-licensing agreements in order not to fall too far behind European competitors.[1] In the 1980s "patent wars" were frequently fought, for instance between Japanese and US firms in the electronics industry and between Procter & Gamble and Kimberly Clark in the diaper industry.

Court cases and patent wars like the ones described above are useful examples of the importance of IP, as they provide instances where IP has major implications

[1] See the Manufacturer's Aircraft Association.

for the success of firms. Only a small part of all IPRs are ever subject to court cases, however. This thesis studies strategic IP management more generally, with a focus on IP related to technological innovations. Strategic management of technological IP refers to formulating and executing strategies related to technological IP, including issues such as how to acquire and create IP, how to govern IP, and how to exploit and extract value from (commercialize) IP.

A prerequisite for innovation related IP is the development of new innovations. Much research has highlighted the importance of innovations and technological developments for economic growth and welfare (e.g., Baumol, 2002; Rosenberg, 1982; Rosenberg & Birdzell, 1986; Scherer, 1999; Schumpeter, 1934, 1942; Solow, 1956, 1957). Much research has also covered the area of technology and innovation management (e.g., Burns & Stalker, 1961; Chesbrough, 2003; Pavitt, 1990; Teece, 2009; Trott, 2008; Utterback, 1994). The research area of IPRs has traditionally been treated within the disciplines of law and/or economics (e.g., Arrow, 1962; Domeij, 2003; Romer, 2002), while the research on innovation related IP management has traditionally been scarce (Granstrand, 1999; Hanel, 2006). However, IP management research has been growing since the late 1990s (e.g., Granstrand, 1999; Pisano, 2006; Pisano & Teece, 2007; Reitzig, 2004; Somaya, 2012), much due to the macro level policy driven emergence of 'pro-patent eras' with increasing patenting around the world (e.g., Granstrand, 1999; Hall, 2005; Hall & Ziedonis, 2001; Hu, 2010; Hu & Jefferson, 2009; Kortum & Lerner, 1998). This thesis contributes to the growing literature on IP management by its first purpose: *to explore and explain strategic and innovation related intellectual property management practices, and the managerial and economic consequences of such practices*.

An important development during the 2000s, with implications for IP management, has been the growing practice and research of open innovation (e.g., Chesbrough, 2003; Dahlander & Gann, 2010; Laursen & Salter, 2006), referring to innovation activities and processes that cross organizational boundaries. Such activities can include technology trade, licensing, collaborative research and development (R&D), crowdsourcing, acquisitions, divestments, etc. The practice of open innovation sets new requirements for strategic IP management. A common traditional assumption has been that IPRs should be used to maximize excludability (protection) of innovations in order to enable high returns from in-house production and commercialization. Although that view is still valid under many conditions, it must be complemented with a more multifaceted portfolio of strategies and strategy combinations in order to align IP management with the general technology and innovation strategy, be it open or closed, in order to foster firm success. This thesis contributes to this area by its second purpose: *to develop managerial and economic frameworks, models, and tools to be used in the* *intersection between intellectual property management and open innovation practices*.

The thesis focuses on technical inventions and innovation related intellectual property, albeit in a non-exclusive way. This focus puts patents at the core, since patent systems are specifically designed to promote (technological) innovations by giving the owner of a patent the right to exclude others from commercially exploiting the patented invention. Further, the primary focus is on firm-level IP management, rather than national IPR policies and IPR systems. However, interdependencies between micro and macro levels must be taken into account when studying IP management, since national and international institutions (such as patent laws) govern the available set of strategic options for management. Therefore, implications are derived for both management and policy.

This thesis consists of these cover chapters and six appended papers. The cover part is outlined as follows. The introductory chapter is followed by a frame of reference in chapter 2. The methodology and paper-specific purposes and research questions are motivated and described in chapter 3. This is followed by summaries of the appended papers in chapter 4. Some of the main results from the study are described in chapter 5. Chapter 6 contains a discussion of the results, and finally the main conclusions are summarized in chapter 7.

# 2 Frame of reference

This frame of reference starts with a section in which a number of basic concepts needed throughout the thesis are defined, and continues with a section explaining the rationale of patent and IPR systems. Two important trends underlying this thesis are described in the subsequent section. These trends include the emergence of a pro-patent era, in which the importance of IP for management has grown, and the increased focus on open innovation, setting new requirements on IP management. After the description of these trends, three different theories of the firm are described. A section on appropriation strategies is then followed by a related section on strategic IP management. Finally, key research papers within the field are presented, as identified by a structured literature review.

## 2.1 Basic concepts

Innovations in general, including developments of useful technical knowledge (technology), i.e., technological innovations, are major factors behind economic developments (Baumol, 2002; Rosenberg, 1982; Rosenberg & Birdzell, 1986; Scherer, 1999; Schumpeter, 1934, 1942; Solow, 1956, 1957). An innovation is then commonly defined as something new that has come to some sort of use, a definition that makes a separation between invention and commercialization activities or processes (Freeman, 1982; Garcia & Calantone, 2002; Granstrand, 1999; Layton, 1977; March, 1991; Schumpeter, 1934). Granstrand (1999, p. 58) defines an *innovation* as a “change in ideas, practices or objects involving some degree of (i) novelty or creation based on human ingenuity and (ii) success in application”. An *invention*, in comparison, can be defined as a “first idea, sketch or contrivance of a new-to-the-world product, process or system, which may or may not be patented” (Freeman, 1982, p. 201). An invention is thus turned into an innovation when the invention comes to its first use (it is commercialized), for instance by being sold the first time (in the case of a product invention) or by being usefully applied in production (in the case of a process invention). Inventions and innovations should not be confused with the concept of *discoveries*, i.e., findings of pre-existing features of nature (Granstrand, 1999). This may, for example, be a law of nature. An invention differs from a discovery in that it is invented by man – hence not existent before being invented. An *imitation* is defined as a close reproduction, copy, or duplication of something once perceived as an invention (*ibid.*). Finally, the European Patent Office (EPO) defines (as of 2012) a *patent* as “a legal title granting its holder the right to prevent third parties from commercially exploiting an invention without authorization”.

The main difference between discoveries on one hand and inventions and innovations on the other hand is that the latter two require an active agent that "creates" the invention (innovation). These agents are here denoted *inventors* and *innovators*, and the latter concept is then a broader concept that can include commercializing agents besides inventing agents (inventors), as well as hybrids of inventors and commercializing agents (such as application developers). Inventors and innovators, respectively, can refer to individuals, firms, or other types of inventive and innovative agents, and are in this thesis used for denoting inventive and innovative agents in general, if not further specified.

## 2.2 Patent and IPR systems for incentivizing innovation

The fact that there are active agents involved in the innovation process implies that the stream of inventions and innovations that are created is dependent upon incentives for such agents to invent and innovate, typically in terms of returns from their efforts. Knowledge has characteristics of a(n) (impure) public good (Stiglitz, 1999), meaning that consumption by one actor does not restrict consumption by others (non-rival) and that it is difficult to exclude actors from using the good (non-excludable). The non-excludability leads to investors in R&D, technology, and innovation having problems with reaching positive returns on investments (ROIs):

> As we have seen, information is a commodity with peculiar attributes, particularly embarrassing for the achievement of optimal allocation. In the first place, any information obtained, say a new method of production, should, from the welfare point of view, be available free of charge (apart from the cost of transmitting information). This insures optimal utilization of the information but of course provides no incentive for investment in research. (Arrow, 1962, pp. 616-617)

Profits from innovations are likely to end up with holders of complementary assets when imitation is easy, rather than with the inventing agent (Teece, 1986). Underinvestment in R&D and innovation then occurs due to this market failure (Arrow, 1962; Demsetz, 1967; Levin et al., 1987; Mansfield et al., 1977). Considering the importance that technological developments have for economic developments and growth, states try to incentivize technology and innovation investments by various means. Patent systems are therefore constructed to make technical knowledge temporarily excludable, enabling innovators to appropriate returns from their investments and thereby incentivizing generation (and diffusion) of inventions. This is then a consequentialist, and more specifically utilitarian, justification of the patent system. By contrast, deontological justifications (based on moral rights/rules) of IPR systems include that one should have the right to reap benefits from one's own labor and that one should have the rights related to one's own personality or identity (Granstrand, 1999).

Neoclassical economic theory in the footsteps of Marshall (1890) and others is commonly used to explain the utilitarian rationale of patent systems (e.g., Granstrand, 1999, 2010; Greenhalgh & Rogers, 2010; Scotchmer, 2004). The following is an explanation based on a product innovation: When a firm receives a patent on a product technology, the society as a whole makes a temporary welfare "loss" (deadweight loss) due to monopolistic pricing above the marginal cost (MC), while the firm can make a profit (enabling a positive ROI). This is a sacrifice made from society's point of view in order to create incentives for potential inventors not only to invest in R&D in the first place, but also to disclose their inventions through patent publications. When the patent term ends or when substitute technologies are provided[2] the price will fall closer to the MC, leading to increased welfare for society at large.[3] To summarize, patent systems have two main purposes:

1. To stimulate R&D and innovation investments.
2. To stimulate knowledge disclosure.[4]

A patent system is one, but not the only, way of incentivizing generation of technological innovations. Alternatives to a patent system, also tailored to incentivizing R&D investments (but not necessarily knowledge diffusion) and commonly used as complementary systems, include sales tax reductions and subsidies, innovation procurement contracts, R&D tax credits/deductions, innovation prizes, and R&D grants/subsidies (David, 1993; Granstrand, 2003; Greenhalgh & Rogers, 2010; Scotchmer, 2004; Wright, 1983). The patent system has actually received a lot of critique for creating too high transaction costs and monopolistic over-pricing leading to welfare losses (Bessen & Meurer, 2008; Granstrand, 2011; Jaffe & Lerner, 2004; Machlup & Penrose, 1950), and some have even suggested to abolish the system. The consequences of abandoning the patent system are however very difficult to overlook, and the following quote from the 1950s to some extent pervades also contemporary views of the patent system:

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

---

[2] For instance after 'inventing around' activities by competitors being attracted by excess profits, as argued by Schumpeter (1942).

[3] Since products are typically based on more than one patented invention, and since there might be substitute products and inventions, reality is of course seldom as simple as this economic model.

[4] A national patent application is typically published 18 months after the filing (priority) date or when the patent is granted, whichever comes first.

> we have had a patent system for a long time, it would be irresponsible, on the basis of our present knowledge, to recommend abolishing it. (Machlup, 1958, p. 80)

A number of more or less adjustable parameters are related to an IPR system at national level, and when managing the system the purpose is ultimately to spur dynamic competition while sacrificing as little static competition as possible. In addition, states commonly try to promote domestic interests (which does not necessarily comply with the promotion of competition). Parameters related to the design of an IPR system include: What should be protectable[5]; how long should it be protected; how strong should it be protected; where should it be protected; what should be the cost; etc. (e.g., Gilbert & Shapiro, 1990; Klemperer, 1990; Merges & Nelson, 1990). A general problem is then that various IPR systems are typically designed in a ‘one size fits all’ type of way (Thurow, 1997). This is problematic since various actors, intangibles, and technologies are impacted differently from the same IPR system. Technologies with short product life cycles (PLCs) and low investment levels have the same maximal protection time by patents as technologies with long PLCs and high investment levels. The latter typically needs longer market exclusivity to reach positive ROIs, whereby also a longer protection time would ideally be given, and vice versa.[6] Further, small and medium sized enterprises (SMEs) have been shown to benefit differently from patent systems than large firms (Blind et al., 2006; de Rassenfosse, 2012; Leiponen & Byma, 2009).

A national IPR system consists of a range of various IPRs, some of the most common being patent rights, trade secret rights, design rights, copyrights, and trademark rights (Koktvedgaard & Levin, 2004; Rockman, 2004; Spence, 2007). The availability and design of different types of rights vary across jurisdictions, however. This thesis focuses primarily on patents and to some extent trade secret rights and trademark rights. Three typical requirements for patentability of an invention are that it should (1) be novel, (2) be useful / be industrially applicable / have technical character (depending on jurisdiction), and (3) be non-obvious. Worth noting is that a patent in itself does not give the owner any freedom to use the invention commercially (*freedom to operate*).[7] The patent does only give the

---

[5] ‘Patentable subject matter’ in the case of the patent system.

[6] Some flexibility in terms of patent protection time is available in cases of pharmaceutical inventions subject to many years of trials before marketing due to government regulations.

[7] Consider a case in which a basic invention is patented by company A. Company B then improves the basic invention and patents this improvement. Then company B needs a license from company A on the basic invention patent before having the right to produce its product (based on both inventions). Securing such licenses and ensuring that there are no blocking patents is sometimes called ‘patent clearance’.

owner a right to prevent others from using the patented invention commercially, not a right for the owner to commercialize it him-/herself. *Trade secret rights* protect from misappropriation of valuable secrets that are not generally known. However, a trade secret does not protect from others inventing the same thing independently or from reverse engineering (in general). Hence, trade secrets are most suitable for secrets that are difficult to discover or reverse engineer (see section 2.5). Note also that patents and copyrights expire after a certain time[8] while there is no legally codified end to trade secret rights. Most IPRs only offer a national protection. If an invention is patented in Germany it offers only legal protection in Germany. This does not give the owner right to prevent others from commercializing the invention in, for example, France. Copyrights make an exception in that they commonly protect the owner internationally, at least in practice (Koktvedgaard & Levin, 2004).

## 2.3 Two important trends for IP management

This section will describe two important trends that have important implications for IP management. First, the emergence of a pro-patent era is described, including a brief description of the history of patent systems. During the pro-patent era, the importance of IP for management has grown. Second, the phenomenon of open innovation is described, and the increased focus of open innovation leads to new requirements on IP management.

### *2.3.1 Brief history and the emergence of a pro-patent era*

The history of patent-like rights goes back to at least the 14th century (Granstrand, 1999) although what is often referred to as the first formal patent statute was adopted in Venice in 1474 (Guellec & Potterie, 2007). However, China's first patent law came as late as in 1984 (Keupp et al., 2010) which can be compared to 1623 in England, 1790 in the US, and 1819 in Sweden.

In the early 1980s, legal changes in the US, including the establishment of the US Court of Appeals for Federal Circuit (CAFC) and the strengthening of enforcement of patent rights, led to what is sometimes referred to an explosion in patenting in the US (e.g., Hall, 2005) and the *pro-patent era* (Granstrand, 1999). Since then, US patenting has grown rapidly and large firms have increased their

[8] The length of a copyright varies in different jurisdictions. In the US and in Sweden, for example, a copyright lasts for 70 years after the death of the creator of the copyrighted work. A patent typically lasts for 20 years after the filing of the application as long as the renewal fees are being paid. See also Greenhalgh and Rogers (2010) for a description of the length, breadth and coverage of various intellectual property rights.

patenting a lot, exemplified by the top ten patentees[9] in Table 2.1. The pro-patent era has subsequently spread to large parts of the world, especially to Europe and Asia, and Asian firms (especially Japanese and Korean ones) in fact hold a large share of granted US patents. The worldwide patenting has also increased during the same period, albeit with a slightly slower pace, see Figure 2.1.

In parallel with increased patenting, IPR systems around the world have evolved, and also converged. This development has been spurred by the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) in 1994, and its enforcement through the World Trade Organization (WTO) (Maskus, 2000).[10]

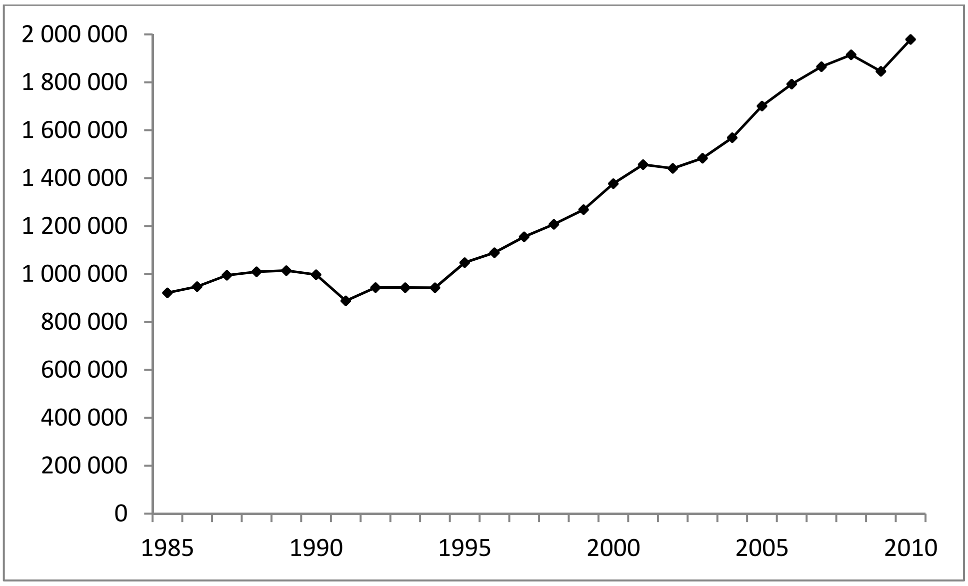
**Table 2.1 Top ten patentees in terms of granted US utility patents in 1987, 2000, and 2011**

| | 1987 | No. | | 2000 | No. | | 2011 | No. |
|---|---|---|---|---|---|---|---|---|
| 1 | Canon | 847 | 1 | IBM | 2886 | 1 | IBM | 6148 |
| 2 | Hitachi | 845 | 2 | NEC | 2021 | 2 | Samsung | 4868 |
| 3 | Toshiba | 823 | 3 | Canon | 1890 | 3 | Canon | 2818 |
| 4 | General Electric | 779 | 4 | Samsung | 1441 | 4 | Panasonic | 2533 |
| 5 | US Philips | 687 | 5 | Lucent | 1411 | 5 | Toshiba | 2451 |
| 6 | Westinghouse | 652 | 6 | Sony | 1385 | 6 | Microsoft | 2309 |
| 7 | IBM | 591 | 7 | Micron Technology | 1304 | 7 | Sony | 2265 |
| 8 | Siemens | 539 | 8 | Toshiba | 1232 | 8 | Seiko Epson | 1525 |
| 9 | Mitsubishi Electric | 518 | 9 | Motorola | 1196 | 9 | Hitachi | 1455 |
| 10 | RCA | 504 | 10 | Fujitsu | 1147 | 10 | GE | 1444 |
| | Total: | 6785 | | Total: | 15913 | | Total: | 27816 |

*Source:* Statistics from USPTO for year 2000 and 2011, and Granstrand (1999) for year 1987

[9] The concept 'patentee' denotes the patent applicant, while 'patentor' is the person or actor granting the patent. Similarly 'licensee' denotes a license buyer, while the 'licensor' is the license seller.

[10] See also Wallerstein et al. (1993) for a discussion on harmonization and differentiation of IPR systems.




*Source:* Statistics from WIPO

**Figure 2.1 Total number of patent applications worldwide per year, 1985-2010**

The growth in patenting indicates an increasing importance of IP. Granstrand (1999, 2000) elaborates upon the notion of *intellectual capitalism*, a form of capitalism where the traditional dependence upon fixed assets is increasingly replaced with dependence upon intellectual capital (IC) and intangible[11] assets, such as knowledge, competence, patents, trademarks, etc. *Intellectual capital* then "comprises all immaterial resources that could be considered as assets with some kind of assignable capitalized value" (Granstrand, 1999, p. 18).[12] Intellectual capital is typically divided into three different types (e.g., Bontis, 2002; Edvinsson, 1997; Lev, 2001; Marr & Adams, 2004; McConnachie, 1997; Roos et al., 1997; Sveiby, 1997); human capital (knowledge, skills, experience, etc., related to specific employees), structural capital (organization, management, attitudes, R&D, software, etc.), and relational capital (relationships with all different stakeholders, including customers and suppliers). It is difficult to account for the values of intellectual property, assets, capital, etc., however, since there are no exchange values related to them (Hall, 1989). Nevertheless, attempts to value

[11] Note that the word intellectual is commonly exchanged with intangible or immaterial. The concept 'intangibles' is for instance often used with the same meaning as intellectual or immaterial assets.

[12] Note however that the concepts intellectual property, intellectual capital, intellectual assets, and intellectual property rights have not yet been fully established and homogenously defined in academia and practice (Marr & Adams, 2004).

IPRs are frequently made, as illustrated by Interbrand's valuation of top trademarks (see Table 2.2). IPR value distributions are extremely skewed (Harhoff et al., 2003; Lanjouw et al., 1996; Scherer, 1999). In fact, patent value distributions are so skewed that an infinite variance cannot be ruled out. This means firstly that the capital asset pricing model (CAPM) cannot be unreservedly used when valuing patent assets (Granstrand, 2003), and secondly that portfolio strategies do not guarantee that average values will reach a stable mean (Scherer, 1999). In general, patents and other IPRs are very difficult to value, even *ex post*, due to the difficulty in assessing the related cash flows.[13]

**Table 2.2 The world's most highly valued trademarks**

| 2009 Rank | Trademark | 2009 Value (BUSD) | 2007 Rank | 2007 Value (BUSD) | 2001 Rank | 2001 Value (BUSD) |
|---|---|---|---|---|---|---|
| 1 | Coca-Cola | 68.7 | 1 | 65.3 | 1 | 68.9 |
| 2 | IBM | 60.2 | 3 | 57.1 | 3 | 52.8 |
| 3 | Microsoft | 56.6 | 2 | 58.7 | 2 | 65.1 |
| 4 | GE | 47.8 | 4 | 51.6 | 4 | 42.4 |
| 5 | Nokia | 34.9 | 5 | 33.7 | 5 | 35.0 |
| 6 | McDonald's | 32.3 | 8 | 29.4 | 9 | 25.3 |
| 7 | Google | 32.0 | 20 | 17.8 | >100 | - |
| 8 | Toyota | 31.3 | 6 | 32.1 | 14 | 18.6 |

*Source:* Interbrand (2009)

A number of measures have been used by various scholars to point at the increasing relative value of intellectual capital, although few of them actually provide any clear evidence if scrutinized.[14] The fact that the share of people's

[13] See Copeland et al. (2005) and Damodaran (2002) for general valuation principles and Mun (2006) for a real options approach in valuing patents and other assets.

[14] Many of the measures of increasing importance of IP and intellectual capitalism that have been used can be questioned. *First*, looking at increased patenting, the worldwide increase to a large extent stems from increases in patenting in the United States and various countries in Asia, such as Japan, Korea, India and China (see Figure 2.2). Since the rise in Asia might be due to general catching-up effects (e.g., Abramovitz, 1986) this does not provide proof of increasing intellectual capitalism. Additionally, the industrialization of the world has increased during the same period, which affects the statistics of patent applications. Industrialization in itself is of course related to intellectual capitalism, however.

*Second*, the value of trademarks is sometimes used as a measure. The sum of the values of the eight most highly valued trademarks in 1992 was 132.6 BUSD (Granstrand, 1999), while the sum of the values of the eight most highly valued trademarks in 2009 (which is another set of lives spent on education and learning increases and that the intensity of knowledge and information in products and services rises (Granstrand, 1999) still indicate that society is becoming increasingly knowledge-based, however.

Looking at the development of national patent frequency in various countries it is clear that the developments since the rise of the pro-patent era vary across countries (see Figure 2.2). While national patenting has been increasing in the US and in Asia, it has been decreasing in a number of small industrialized European countries, exemplified by Sweden and some other similar small countries in Figure 2.2. In this connection it is important to note that there are a number of different routes to take when applying for a patent, and statistics must therefore be treated with care.

Swedish *patentees* (patent applicants) can file patent applications not only to the Swedish patent and trademark office (PTO), but also to any other national PTO, to the European Patent Office (EPO), or in the international Patent Cooperation Treaty (PCT) system.[15] Therefore, the decline in Swedish national patenting does not imply a decreased inventive output in Sweden, but could just as well indicate

---

trademarks) was 363.8 BUSD (Interbrand, 2009). This corresponds to an increase in trademark values of 174% from 1992 to 2009 in nominal terms. Since the most highly valued trademarks are mainly owned by US companies, the value growth can be compared to the increase in GDP for the US from 1992 to 2007 which was 229% in nominal terms (based on OECD Statistics, 2009). Hence, the growth in trademark values has been lower than the growth of GDP in the US. At the same time, comparing growth in trademark values with GDP growth as an indication of intellectual capitalism is misleading, since much of the GDP growth might be driven by intellectual capital and knowledge and this measure might therefore underestimate intellectual capitalism. Nevertheless, the fact that the GDP of the US grows faster than the top values of trademarks could, if anything, be seen as an indicator of decreased intellectual capitalism, or more specifically decreased relative importance of trademarks.

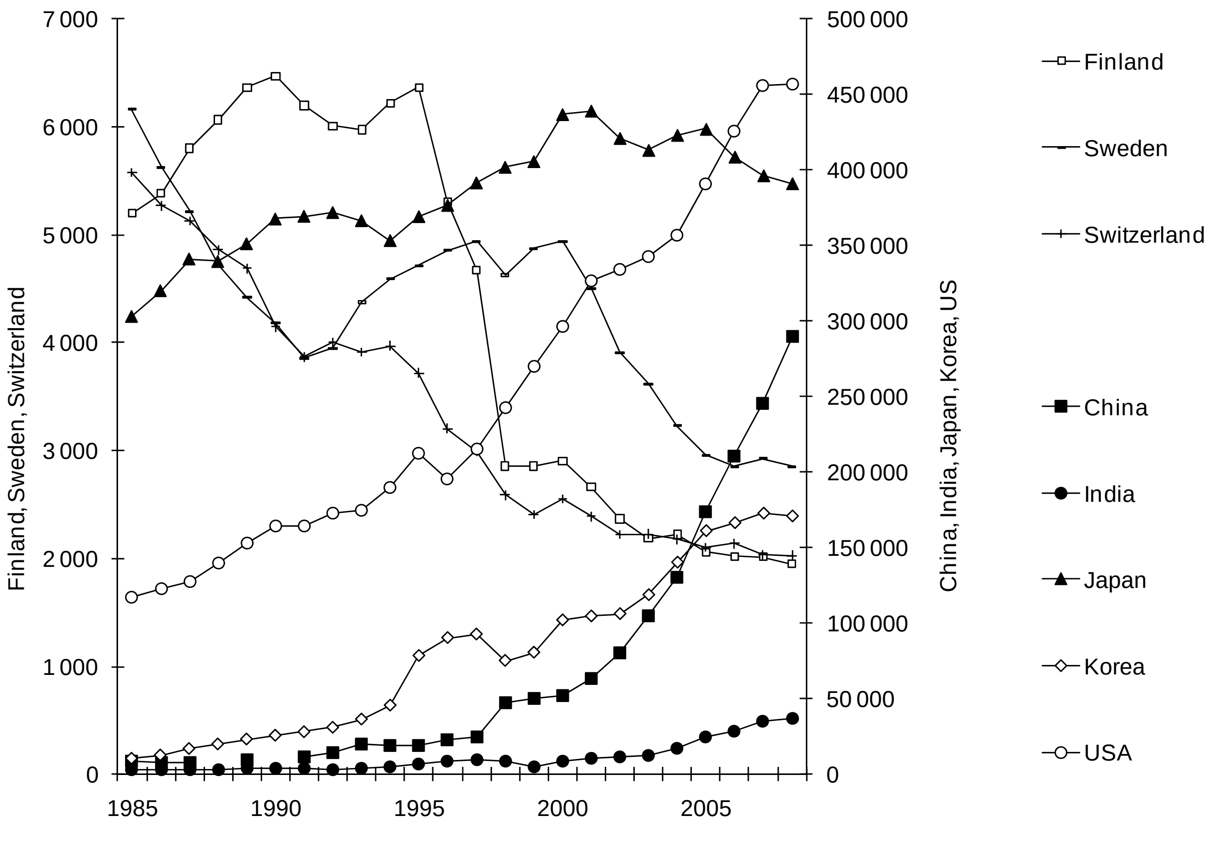
*Third*, some scholars compare market values of companies with low numbers of employees (e.g., Google) with market values of companies with high numbers of employees (e.g., Ford) to show that the relative value of intellectual capital in the world has risen since companies with only few employees nowadays can outcompete very large organizations in terms of market values. However, such a comparison is also misleading since human capital is an important part of intellectual capital.

*Fourth*, the market to book-ratio, i.e., Tobin's q, can be used, which indicate the relation between a company's market value and the booked value of its assets. Still, the development of Tobin's q over time shows no clear evidence for increased levels of intellectual capital (despite the all-time high around year 2000). Part of the reason for this might be more liberal accounting with companies beginning to book more and more intangible assets, leading to a decreased Tobin's q.

[15] The PCT system allows an applicant to file a single application in one language and get an international priority date. That priority date is then valid in all PCT contracting states, meaning that one single patent application is enough to file for patent protection in all contracting states (more than 140). However, for the application to proceed to a valid patent, a number of actions need to be taken, typically including translation work and national patent applications.

a strategic change among its inventing actors, impacting the propensity to patent patentable inventions/innovations.

Apart from cross-country variations, patent propensities vary across industries (Arundel & Kabla, 1998; Brouwer & Kleinknecht, 1999; Mansfield, 1986; Scherer, 1983). Further, small and medium sized enterprises (SMEs) have lower propensities to patent than large firms (Arundel & Kabla, 1998; Brouwer & Kleinknecht, 1999; Chabchoub & Niosi, 2005; Mansfield, 1986), while they have (had) higher patent per R&D ratios than large firms (Bound et al., 1984).[16] In addition, firms with R&D collaboration agreements have been found to be more likely to patent than others (Brouwer & Kleinknecht, 1999). A conclusion is that patents help formalizing R&D collaborations and that they have an important role in the governance of open innovation.




*Source:* Statistics from WIPO and national PTOs

**Figure 2.2 National patent applications in selected countries per year, 1985-2008**

[16] An important fact here is however that innovation activities in SMEs are underestimated when measured by R&D statistics while innovation activities in large firms are underestimated when measured by patent statistics (Pavitt, 1982).

### *2.3.2 Open innovation*

The concept of *open innovation* was introduced in 2003 by Chesbrough, defining it as “a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as firms look to advance their technology” (Chesbrough, 2003, p. XXIV). However, open innovation-like practices had been identified by both practitioners and researchers much earlier (Dahlander & Gann, 2010; Gemünden et al., 1992; Granstrand, 1982; Granstrand & Sjölander, 1990; Trott & Hartmann, 2009; von Hippel, 1988, 2005) using other terms, such as technology acquisition (sourcing) and exploitation (commercialization). Since the establishment of the concept in 2003, an increasing amount of academic research has stressed the possibilities for firms to increase innovativeness and competitiveness through the use of *inbound open innovation* by relying upon external sources of knowledge and *outbound open innovation* by relying upon external paths to markets (Chesbrough & Crowther, 2006; Dahlander & Gann, 2010; Enkel et al., 2009; Laursen & Salter, 2006; van de Vrande et al., 2009). In addition, a *coupled mode* of open innovation has been recognized (Enkel et al., 2009), in which knowledge is developed and commercialized jointly with external partners, for instance through innovation alliances and networks (Adner & Kapoor, 2010; Dittrich & Duysters, 2007; Mowery et al., 1996). A related stream of literature has instead focused on openness in terms of the public good nature (non-rivalry and non-excludability) of innovations and knowledge (Baldwin & von Hippel, 2011; O'Mahony, 2003; von Hippel, 1988, 2005; von Hippel & von Krogh, 2003).

There are different potential benefits of employing some form of openness in innovation. One main advantage for a firm employing an open innovation strategy is that the firm can access outside resources, including skilled researchers and engineers (Chesbrough, 2003). Additionally, by adopting various forms of openness firms can avoid duplicate R&D work by allowing technology trade, enabling both lowered R&D costs (for the acquirer) and increased revenues from technology sales (for the seller). This could potentially also enable benefits from economies of scale in in-house R&D, while at the same time enabling economies of scope across firm boundaries by cross-fertilization of technologies developed by different firms. Empirical research has confirmed that there are benefits with employing some level of openness in innovation (Gemünden et al., 1992; Laursen & Salter, 2006).

Technology-sharing across firm boundaries comes with requirements, however, both in terms of internal technological capabilities and *absorptive capacity*, i.e., the ability to recognize, assimilate and apply external knowledge commercially (Cohen & Levinthal, 1990), and in terms of *network competence*, i.e., the “ability to handle, use, and exploit interorganizational relationships” (Ritter & Gemünden, 2003, p. 745), and it is clear that more open is not always better (Laursen & Salter, 2006). Empirical studies have rather shown that there are complementarities between open and closed forms of innovation (e.g., Cassiman & Veugelers, 2006; Faems et al., 2010; West & Gallagher, 2006).

There are different possible explanations for why various forms of open innovation have possibly increased, and a few of them will be mentioned here. *First*, due to increased R&D costs and decreased profits from product sales (typically due to shorter PLCs) it is increasingly difficult to obtain an acceptable ROI from innovation investments (Chesbrough, 2007). Increased R&D costs are partly results of companies (and products) becoming increasingly technologically diversified (Granstrand & Oskarsson, 1994; Granstrand et al., 1997; Kodama, 1986; Pavitt et al., 1989). As the diversification increases, the costs of R&D increase (Granstrand & Oskarsson, 1994). Granstrand (1998) suggests that this partly has to do with the coordination and integration work necessary when incorporating multiple technologies in the firm, and Granstrand and Oskarsson (1994) specifically argue for the importance of utilizing external technology acquisition in increasingly technologically diversified firms. By partially relying upon external technology sourcing firms can lower costs for acquiring necessary technologies (Chesbrough, 2007). *Second*, technological developments, for example in information and communication technologies (ICTs), have decreased market transaction costs (but probably also management costs), possibly improving the relative efficiency of market-like transactions (Coase, 1988; Shapiro & Varian, 1999; Williamson, 1975) and thereby enabling the use of various forms of open innovation. *Third*, the increased use of patents in the pro-patent era combined with demands for diversified technologies increase the likelihood that firms encounter problems to ensure freedom to operate. Before commercially using a technology, firms must collect all necessary IPRs to ensure freedom to operate (Granstrand, 1999; Granstrand & Oskarsson, 1994; Somaya et al., 2011). The problem of collecting all necessary rights is sometimes called the *IP assembly problem* (Granstrand, 1999, 2010). This problem can then be mitigated by various forms of open innovation, including licensing deals, mergers and acquisitions (M&As), integration through joint ventures (JVs), etc. Hence, patents and other IPRs not only create the IP assembly problem, they are also part of the solution by enabling technology and knowledge trade (Arora, 1997; Arora et al., 2001; Bogers et al., 2012; Davis, 2008; Granstrand, 2004; Lichtenthaler, 2010). Without IPRs knowledge trade would likely be hampered due to the nature of information, which needs to be revealed for the buyer before traded, and after having been revealed a potential buyer has no longer any need to pay for the information (Arrow, 1962). This is often referred to as the *information paradox*.

## 2.4 Theories of the firm

The most basic and fundamental question to be explained by theories of the firm is: Why do firms exist? This question is also related to the boundaries of firms, or more generally the level of integration among economic agents, as well as to strategic management, since it typically deals with efficiencies of alternative ways of organizing economic activity. Different theoretical streams of literature have been developed in order to provide explanations, and three streams are especially useful for the purpose of this thesis; *transaction cost theory* (TCT), *property rights theory* (PRT), and *resource-based theory* (RBT). These provide different perspectives, and multiple authors have emphasized complementarities rather than rivalry among alternative theories of the firm (e.g., Granstrand, 1998; Jacobides & Winter, 2005; Williamson, 1985).

### *2.4.1 Transaction cost theory*

TCT, as pioneered by Coase (1937) and Williamson (1975, 1985, 1996), uses transactions as the unit of analysis, and emphasizes the importance of transaction costs for economic organization. TCT argues that the main reason for organizing economic activity within a firm is that there are costs associated with organizing economic activity on a market (Coase, 1988). Such costs can be divided into *ex ante* transaction costs, including costs for drafting, negotiating, and safeguarding agreements, and *ex post* transaction costs, including costs for maladaptation, haggling, dispute governance, and bonding (Williamson, 1985). Coase (1937) summarizes the basics of TCT:

> We may sum up this section of the argument by saying that the operation of a market costs something and by forming an organization and allowing some authority (an “entrepreneur”) to direct the resources, certain marketing costs are saved. (Coase, 1937, p. 392)

Williamson (1975) also distinguishes between transactions on the market and within the hierarchy (within the integrated firm). Like Coase, Williamson thereby sees markets and firms as “alternative instruments for completing a related set of transactions” and further that “whether a set of transactions ought to be executed across markets or within a firm depends on the relative efficiency of each mode” (Williamson, 1975, p. 8). Six important concepts related to TCT are bounded rationality, opportunism, small-numbers, information impactedness, asset specificity, and atmosphere (a seventh one, incomplete contracting, is described below in connection to PRT). First, TCT assumes *bounded rationality*, i.e., that behavior is intendedly rational, but only limitedly so (Simon, 1947), and *opportunism*, i.e., self-interest seeking with guile (Williamson, 1975). Opportunism is enabled by incomplete contracting (see below), and includes “ex ante adverse selection (hidden information), ex post moral hazard (hidden action), and hold-up problems” (Mahoney, 2005, p. 75). Opportunism creates larger problems with *small-numbers* conditions than with large-numbers conditions, since multiple competitive exchange relations mitigate opportunistic behavior. However, large-numbers conditions may evolve into small-numbers conditions, for instance due to first-mover advantages or asset specificities (see below). *Information impactedness* exists when “true underlying circumstances relevant to the transaction, or related set of transactions, are known to one or more parties but cannot be costlessly discerned by or displayed for others” (Williamson, 1975, p. 31). Both information impactedness and opportunism can be mediated by internal management, incentivizing organizational integration rather than market transactions. *Asset specificity* is a concept which refers to investments in assets (sites, physical assets, human assets, and dedicated assets) to support a specific transaction (Williamson, 1983, 1985). Asset specificity leads to parties being tied to a specific transaction and each other, further spurring small-numbers conditions and opportunism, possibly incentivizing organizational integration. The concept of *atmosphere*, finally, refers to preferences related to different modes of transaction. For example, many people find giving something away for free is rewarding, and some people also receive greater satisfaction from being self-employed than doing the same work as an employee in a large corporation. Such preferences thus impact the choice of transaction mode (Williamson, 1975).

### *2.4.2 Property rights theory*

PRT, being closely related to TCT, emphasizes the importance of (private) property rights in economic organization, especially when dealing with externalities (e.g., Alchian & Demsetz, 1973; Coase, 1960; Demsetz, 1967; Hart, 1995; North, 1990). Three types of rights related to properties are usually distinguished; the right to use and transform a resource, the right to earn income from a resource, and the right to transfer ownership of the resource (Eggertsson, 1990). This distinction of different types of rights is important in IP management, since a licensing deal might, for example, give the licensee (license buyer) the right to use and profit from a technology, while the right to transfer ownership is left with the licensor (license seller). Early advocators of PRT were optimistic in their views of how private property rights could enable efficient economic organization. The work by Coase (1960) showed that without transaction costs and with freely transferable property rights, negotiation between economic agents leads to efficient outcomes regardless of how property rights are allocated initially, as long as private property rights are defined. However, three problems with property rights hamper such economic efficiency. First, it is costly to enforce the rights (North, 1990). Second, it is costly to transfer the rights (*ibid*.). Third, due to bounded rationality (Simon, 1947) contingent claim contracting is costly and incomplete/imperfect (Coase, 1988; Hart, 1995; Williamson, 1985, 1996), leaving unknown residual rights. Thus, contracting parties risk to face costly renegotiations *ex post*, a risk that most likely lowers the willingness to make *ex ante* relationship specific investments that could otherwise have improved economic efficiency (Hart, 1995). The state holds an important function here in mitigating such problems and limiting exchange costs by enforcing contracts in a predictable manner (Eggertsson, 1990). The problems can also be mitigated by organizational integration, which implies that the boundaries of the firm are interdependent with economic efficiency (Hart, 1995). If the problems are relatively costly, boundaries are likely to expand, while if internal management is relatively costly, boundaries are likely to contract.

Two additional problems for economic organization related to PRT should be mentioned here. The first problem is the *tragedy of the commons*. Hardin (1968) showed that scarce common goods, having characteristics or rivalry and non-excludability, can be subject to overuse if multiple individuals act opportunistic and individually. By defining private property rights, common goods can be transformed into private goods, mitigating the tragedy of the commons problem. Figure 2.3 illustrates a common typology over different types of goods, including common and private goods, based on the characteristics of rivalry in consumption and excludability.[17] The second problem is the *tragedy of the anticommons*. Heller (1998) showed that a resource can be subject to underuse if there are multiple exclusion rights related to the resource distributed across multiple agents (it is an “anticommons good”) (see also Heller & Eisenberg, 1998). Such underuse can, for example, arise due to hold-up problems in cases where multiple patents related to a single product or process are owned by different agents (Lemley & Shapiro, 2007). To summarize, economic problems can arise due to both excludability and non-excludability characteristics, and IP management deals with both types of problems.

Returning to the typology of different types of goods in Figure 2.3, the concept of public goods, being non-rivalrous and non-excludable, traces back to Samuelson (1954). Besides these characteristics, public goods (and knowledge) are typically subject to “low marginal cost of reproduction and distribution (which makes it difficult to exclude others from access), and substantial fixed costs of original production” (David, 1993, p. 27). Further, knowledge can be viewed as an *impure public good* (Stiglitz, 1999). While the “consumption” and use of knowledge is non-rivalrous and can be undertaken at zero marginal cost, knowledge is far from completely non-excludable. One part of the impurity is a result from an inherent

[17] Another important distinction of different types of goods is based on the cross-elasticity of demand between two goods. If the cross-elasticity of demand is positive, the goods are complementary, while if it is negative, the goods are substitutes.

characteristic of knowledge and human behavior – to keep some knowledge secret for various reasons. This can also include technological means of secrecy, such as encryption technologies. Controllability by such means is however lost when knowledge is disclosed. Another part of the impurity is created by states, by enabling excludability by patent systems and other IPR systems. Hence, property rights, and more specifically IPRs, are part of what differentiates knowledge as an impure public good from more general public goods. This is important, since while consumption of knowledge can be undertaken at zero marginal cost, the production (creation/invention) of knowledge is often costly, and possibilities to appropriate value from knowledge investments are necessary to incentivize such investments. This will be further described in section 2.5.

| | | | |
|---|---|---|---|
| | | Excludability of a good means that it is possible to exclude individuals from consuming the good. | |
| | | **Excludable** | **Non-excludable** |
| Rivalrous consumption means that the consumption of one individual detracts consumption of another individual. | **Rivalrous** | Private goods | Common goods |
| | **Non-rivalrous** | Club goods | Public goods |

**Figure 2.3 A typology of different types of goods**

Now, a definition of properties in relation to resources should be made before moving from PRT to RBT. In this thesis, *properties* are defined as resources with some form of assigned ownership. Since there might be multiple rights related to a property, as described above, and these rights can be contracted to different parties, a general definition of ownership is that the owner of a resource is the holder of the residual rights (Grossman & Hart, 1986). Thus, the owner of a property is defined as the holder of the residual rights related to the property, while a property is a resource with *de jure* or *de facto* assigned ownership. An *intellectual property* (IP) is then a property of immaterial character (although it can have material representations in form of, for example, blueprints, prototypes, or products). Following this reasoning, the concept of intellectual property incorporates not only intellectual resources controlled by legal ownership, but also intellectual resources controlled by other means, for instance control of complementary resources. To be precise, intellectual properties are in fact often not controlled by legal ownership of the resources themselves (e.g., a technology), but rather by ownership of legal rights related to the properties (e.g., a patent). Thus, the concept of IPRs will be distinguished from the concept of IP (see also

Granstrand, 1999). IP will be used as a broad concept for intangible resources with ownership assigned to them, while IPRs are the legal rights related to such resources (while at the same time constituting specific IP). To exemplify, a portfolio of IP can consist of a technology and the patent right related to that technology. Both the technology and the patent right constitute the IP, but only the patent right is an IPR.

### *2.4.3 Resource-based theory*

RBT uses resources as the central unit of analysis. Penrose (1959) argues that a firm consists of productive resources being administered in order to render services useful to the firm. The combination and synergies of material resources and human resources enable unique services, leading to competitiveness of firms (Chandler, 1990; Penrose, 1959). Being more concerned with growth than size of firms, Penrose (1959) argues that unused resources (at least partly) direct the expansion of firms, while available managerial resources limit the growth.

Itami and Roehl (1987) emphasize the role of “invisible assets” (resources), such as experience, information, technologies, brands, reputation, and culture, for firm competitiveness. Such invisible resources require time, money, and conscious efforts to build, and are often impossible to acquire “off the shelf” [although mergers and acquisitions can provide opportunities for such trade, as argued by Wernerfelt (1984)]. Due to the difficulties in building and trading them, invisible (or intellectual) resources are an important source of differentiation and sustainable competitive advantage, and controlling environmental, corporate, and internal information flows is central for successfully building invisible resources (Itami & Roehl, 1987).

Barney defines [after critique from Priem and Butler (2001)] resources as “the tangible and intangible assets a firm uses to choose and implement its strategies” (Barney, 2001, p. 54). A competitive advantage exists when a value creating strategy is implemented by a firm without “simultaneously being implemented by any current or potential competitors” (Barney, 1991, p. 102). A sustained competitive advantage is then a competitive advantage that the current or potential competitors are unable to duplicate (Barney, 1991). The competitive implications of a resource can be assessed by the VRIO framework, analyzing the resource’s **v**alue, **r**areness, cost to **i**mitate, and exploitability by the **o**rganization (Barney, 1991; Barney & Hesterly, 2005). Strategic IP management clearly has an important role to play for firm competitiveness, since IP impacts all four parts (V, R, I, and O) of this framework.

Prahalad and Hamel (1990) emphasize the role of *core competences* in firm competitiveness, while Granstrand et al. (1997) emphasize the importance of having *distributed technological competences*. Much like Itami and Roehl (1987) the long-term efforts needed to build core competences are emphasized by Prahalad and Hamel (1990). Core competences should then be difficult to imitate, and the strategic use of IPRs has a role to play, although the “comprehensive pattern of internal coordination and learning” is what the original authors emphasize as the main source of inimitability (Prahalad & Hamel, 1990, p. 84). Prahalad and Hamel (1990, p. 81) further argue that the “real sources of advantage are to be found in management’s ability to consolidate corporatewide technologies and production skills into competencies that empower individual businesses to adapt quickly to changing opportunities”.

This statement relates to the concept of dynamic capabilities, being defined as “the firm’s ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments” (Teece et al., 1997, p. 516). Teece et al. (1997) make a distinction between replication and imitation. Replication “involves transferring or redeploying competences from one concrete economic setting to another” (Teece et al., 1997, p. 525) while imitation is “replication performed by a competitor” (p. 526). Teece et al. (1997) argue that although replication is often difficult due to the complexity of the resources and capabilities (see also Lippman & Rumelt, 1992; Prahalad & Hamel, 1990), not the least due to the tacit nature of many organizational routines (Nelson & Winter, 1982), IPRs provide an additional barrier for imitators. Competitive advantage is only generated by competences difficult to imitate, and IPRs are of increasing importance for limiting imitation (Teece et al., 1997) and therefore central for competitive advantage.

The latter points relate to ability of firms to *capture* (appropriate) value (see also section 2.5), which is typically also of most interest for IP management. However, the ability to *create* value is equally important for firms. Wernerfelt (1984, p. 172) argues that “strategy for a bigger firm involves striking a balance between the exploitation of existing resources and the development of new ones”. Value can then be created by developing new resources, by using old resources in new ways, or by combining resources in new ways (Moran & Ghoshal, 1999; Penrose, 1959; Porter, 1985; Schumpeter, 1934). Although value creation is typically not of central focus for IP management, the latter does actually impact the former. This will be further discussed in section 2.6.

### *2.4.4 Firms, hybrids, and markets*

The second purpose of this thesis relates to IP management in open innovation. As described above, open innovation refers to innovation activities and processes that cross organizational boundaries, and the separation between hierarchies (firms) and markets it thus central.

The three above described theories of the firm, especially PRT and TCT, provide different but complementary explanations of firm existence. PRT define the firm as being composed of the resources it owns (Grossman & Hart, 1986), and emphasize that ownership of economically relevant nonhuman resources are what gives the employer authority in an employer-employee relationship in comparison with an independent contracting relationship. Authority is then a central difference between economic activity within a firm and on a market (Simon, 1947). Early advocators of PRT argued that nonseparabilities of working tasks (i.e., that multiple individuals are needed to perform a joint task) are an important reason for the creation of firms (Alchian & Demsetz, 1972). Complex diversified firms as described by Chandler (1962) cannot be explained by nonseparabilities, however (Williamson, 1975). Instead, TCT argues that firms are used to achieve collective action when the use of market prices fails (Arrow, 1974), for instance due to information impactedness, asset specificity, uncertain contracting, and job-specific learning and skills (Williamson, 1975). Modern PRT argues that firm size depends on optimal allocation of property rights, considering incompleteness in contracting and transaction costs (Hart, 1995), although diminishing returns to management need to be taken into account (Coase, 1988). RBT distinguishes between the firm and the market in that the "essential difference between economic activity inside the firm and economic activity in the 'market' is that the former is carried on within an administrative organization, while the latter is not" (Penrose, 1959, p. 13), and identifies the ambiguity of the concept of a firm:

> A 'firm' is by no means an unambiguous clear-cut entity; it is not an observable object physically separable from other objects, and it is difficult to define except with reference to what it does or what is done within it. (Penrose, 1959, p. 9)

> The concept of the firm developed above does not depend on the ramification of stock ownership or the mere existence of the power to control […] On the other hand, long-term contracts, leases, and patent license agreements may give an equally effective control […] If a corporation is controlled by […] a larger corporation, it is part of the larger firm only if there is evidence of an administrative co-ordination of the two corporations […] Thus, although many industrial firms are more or less loosely bound together by a common source of finance or a strong element of common ownership, the mere existence of such connections is not of itself sufficient evidence that administrative co-ordination is effective and adequate enough to justify calling such a grouping a firm. (Penrose, 1959, pp. 18-19)

The distinction between a firm and a market is thus not clear-cut, and there are various degrees of hierarchy (Williamson, 1985). There are also different forms of internal organizations, such as matrix or multidivisional structures (Williamson, 1975), with varying applicability to different situations. In addition, markets are institutions that can be designed in different ways to mitigate transaction costs to variable extent (Coase, 1988). Thus, the choice between markets and hierarchies is not a binary one; there are multiple types of hierarchies and multiple types of markets, and in addition multiple types of hybrids in between (Williamson, 1991). One example of a hybrid is long-term continuous relationships between buyers and sellers (e.g., Ford et al., 1998; Gadde & Håkansson, 2001). Granstrand (1982) then argues that quasi-integrated forms of organizations (hybrids) are most conducive to technological innovation and that they will therefore become more common as a result of market and organization failures and managerial and technological innovations. This argument then anticipates the concept of open innovation, as described above.

## 2.5 Innovation appropriation strategies

Innovation activities aim to create something new and useful. However, most innovators are not only concerned with value creation, but also with capturing a share of that value. The ability to capture returns from R&D investments is commonly called *appropriability* (Levin et al., 1987; Teece, 1986). The appropriability regime is related not only to legal impediments (patents, copyrights, etc.) but also to the nature of the technology (product/process, tacit/codified) (Teece, 1986, 2006). In case of a "tight" appropriability regime (meaning that imitation is difficult or impossible, for instance due to a perfect patent), the innovator will likely collect a large share of profits from innovation. By contrast, when imitation is easy, access to complementary assets is central to capture returns from innovation (Teece, 1986). Teece (1986) early argued that tight appropriability regimes are rare, and that controlling complementary assets is therefore at core for innovators to appropriate returns from innovation. However, Teece as well as others have subsequently identified that appropriability is not exogenously given in an industry, but can be endogenously shaped by firms, governments, and technological change (Granstrand, 1999; Pisano, 2006; Pisano & Teece, 2007; Somaya, 2012; Teece, 2006). However, subsequent works have emphasized that tight appropriability regimes are not necessarily always most conducive for firm profitability (Dahlander & Wallin, 2006; Pisano, 2006), especially in industries where innovation is cumulative and complementary (David, 1993; Teece, 2009).

The fact that the appropriability can be endogenously shaped means that appropriation strategies are important for enabling firms to capture returns from their innovation investments. A number of empirical studies have studied the relative effectiveness and importance of various means and strategies of protecting the competitiveness of new products and processes. Similarly as for patent propensity (see section 2.3.1), the effectiveness of different means varies widely across industries. Patents are typically more effective for product innovations than for process innovations (Granstrand, 1999; Levin et al., 1987).

However, patents have been shown to be one of the least effective means for appropriation in numerous studies (Brouwer & Kleinknecht, 1999; Cohen et al., 2000; Granstrand, 1999; Harabi, 1995; Kitching & Blackburn, 1998; Leiponen & Byma, 2009; Levin et al., 1987). Instead, firms typically rate informal means of appropriation more effective, such as sales or service efforts, market lead times, learning and cost reductions, secrecy, and switching costs. The only exception is found among Japanese firms, where patents have been rated the most effective means (Granstrand, 1999). In this connection it is important to note that various appropriation means are not mutually exclusive, as is, at least implicitly, assumed in some of the abovementioned studies. Market lead time, which is one appropriation strategy commonly studied, can for example be prolonged by both patent and trade secrecy protection. In addition, various means are complements rather than substitutes. A product innovation can typically be protected by both process secrecies and product patents, as well as by learning effects in production, marketing, superior after sales services, etc.

The relatively low effectiveness of patents for appropriation can be related to some of the drawbacks with patenting. The main perceived drawbacks are the possibilities for competitors to legally invent around patents (illustrating the rareness of tight appropriability regimes, despite patent protection) and the information disclosure related to patenting (Harabi, 1995; Levin et al., 1987), as well as the high economic and non-economic costs of patenting (Cohen et al., 2000; Kitching & Blackburn, 1998). Despite these drawbacks and the perceived relative low effectiveness of patents, firms seem to make use of them frequently. In some industries where patents were rated unimportant, roughly 60% of patentable inventions were nevertheless patented (Mansfield, 1986).[18] This is sometimes referred to as the *patenting paradox*, leading to the question: Why do firms patent?

This question has rendered a number of studies. Despite the fact that patents have been shown to have little effectiveness in appropriation, the main motive for patenting among firms in general is to protect innovations and thereby prevent imitation (Arundel et al., 1995; Blind et al., 2006; Cohen et al., 2000; Duguet & Kabla, 1998; Giuri et al., 2007; Granstrand, 1999; Thumm, 2004; Veer & Jell, 2012). Other important motives are to avoid trials and to reach a strong position in negotiations (Arundel et al., 1995; Duguet & Kabla, 1998; Granstrand, 1999) and to block other firms' R&D and patenting efforts (Cohen et al., 2000). Additionally, in industries where standards are of importance, for instance in

[18] The patent propensity is however higher among firms where patents are rated more important for appropriation (Arora & Ceccagnoli, 2004; Arundel & Kabla, 1998).

telecommunications, the possibility to reach a strong position in the standard by patenting essential inventions is an important motive to patent (Bekkers et al., 2002; Granstrand, 1999).

## 2.6 Strategic management of intellectual property

Appropriation strategies as discussed above are closely related to the field of strategic management. Firms not only need to handle various forces on their current market (Porter, 1980), they need to dynamically explore new opportunities and at the same time exploit opportunities previously identified (March, 1991; Teece, 2006, 2009; Teece et al., 1997). As described in the introduction, strategic management of technological IP here refers to formulating and executing strategies related to technological IP, including issues such as how to acquire and create IP, how to govern IP, and how to exploit and extract value from (commercialize) IP. Thus, strategic IP management is central to both the exploration and exploitation of opportunities.

The term *strategic* IP management is here used to mark a distinction to more operational IP management and to emphasize the relation to general strategic management. Mintzberg defines a strategy as "a pattern in a stream of decisions" (Mintzberg, 1978, p. 934), and (Mintzberg & Waters, 1985) emphasize that strategies typically lie on a continuum between deliberate and emergent strategies. Deliberate strategies are patterns of decisions realized as intended, while emergent strategies are patterns of decisions realized despite or without intentions. Hence, Mintzberg and Waters recognize that on one hand are strategies not always deliberate, and on the other hand does a deliberate plan not always lead to a pattern of decisions according to the plan. Porter (1980, p. 34) describes competitive strategy as "taking offensive or defensive actions to create a defendable position in an industry […] and thereby yield a superior return on investment for the firm". Relating IP management to this, two different aims of patenting can be identified. The first one, being an offensive aim, is to "block competitors from using a technology and in so doing increase their costs and time for imitation and/or for inventing around the patent, in order to increase their willingness to pay for a license or to stay away from a market (thereby ensuring 'market freedom')". The second one, being a defensive aim, is to "block the competitors from blocking oneself, and thereby ensure 'design freedom'" (Granstrand, 1999, p. 214). The offensive aim then relates to both proprietary strategies, in which the patent holder tries to obtain an exclusive position in a technology, and leveraging strategies, in which the patent holder tries to get other direct or indirect benefits from a patent, for instance through licensing to generate revenues or through cross-licensing to access other resources (Somaya, 2012). In addition, benefits of patenting include: The creation of an identifiable asset that can be used in licensing, financing, cooperation, divestment, etc.; the creation of an asset that can be activated on the balance sheet; the enablement of intra-firm licensing for cross-country transfer of profits; etc. (Granstrand, 1999, 2010). Costs of patenting relate to the direct costs of writing (including translating), filing and renewing patents, the costs of monitoring and enforcing patents, and the drawbacks with the related information disclosure.

In a resource-based view of the firm a strategy can be described as the resource allocation that facilitates a maintained or improved performance (Barney, 1997). A similar emphasis on resources could be traced to the military-related[19] definition of strategy as "the science or art of employing all the military, economic, political, and other resources of a country to achieve the objects of war" (Encyclopedia Britannica, 2010).[20] Taking the increasingly dynamic business landscape into account, strategic management literature commonly focus on (1) how to best utilize existing resources of the firm and (2) how to develop, renew and adapt resources and competences by dynamic capabilities (Teece, 2009; Teece et al., 1997; Wernerfelt, 1984). IP management, and more specifically patent management, is central to both these concerns as exemplified by the following quote:

> 1. Patent rights are important as competitive means for the protection and commercial exploitation of new technologies.
>
> 2. Patent information is important as a means for technology and competitor intelligence. (Granstrand, 1999, p. 71)

*First*, strategic IP management impacts opportunity exploitation and the utilization of existing resources, and a few examples are given here. IP strategies are used to enable value appropriation from innovation investments (Arundel, 2001; Granstrand, 1999; Levin et al., 1987; Teece, 1986, 2006). Technology exclusivity can primarily be protected by patents or trade secrets, enabling larger market shares and higher margins. In addition, in order to support opportunity exploitation activities, IP management must ensure freedom to operate within a certain domain. As described above, a patent does not provide the patent holder freedom to operate; exclusive rights (e.g., patents) related to necessary complementary resources can be held by other agents restricting and blocking the freedom to operate, possibly leading to hold-up problems and tragedies of the anticommons (Heller, 1998; Heller & Eisenberg, 1998). Available reactive solutions for IP management include integration, acquisition of blocking rights,

[19] The concept of strategy was first established in relation to military activities.

[20] Information resources are commonly heterogeneously distributed and "sticky", i.e., costly to acquire, transfer, and use in a new setting (von Hippel, 1994), and therefore a source of competitive advantage.

contractual agreements (license agreements), invalidation of blocking rights, and infringement. Strategic IP management also involves proactive solutions. Patentability requires novelty of the invention and firms can therefore act strategically in order to limit other actors' possibilities to patent by *defensive publishing* (or in other terms *strategic disclosure*), meaning that the novelty of an invention is "exhausted" with some sort of publication. Trade secrets are not published; a well-kept trade secret does therefore not enable freedom to use the protected secret if someone else would patent it. This is an inherent risk with relying upon trade secrecy protection.[21] Finally, IP management enables many different ways of commercializing technologies. Besides leveraging internal exploitation by product and service "production", the use of IP enables open innovation and external technology exploitation, for instance by patent sales and various types of licensing schemes (Alexy et al., 2009; Bogers et al., 2012; Chesbrough, 2003).

*Second*, and maybe less obvious, strategic IP management impacts opportunity exploration and dynamic capabilities, and again a few examples are given. As described above, IPRs and patents enable knowledge and technology trade, which would otherwise be hampered by the information paradox (Arrow, 1962). This, in turn, enables new combinations leading to innovations (Schumpeter, 1934). Technologies in a specific industry, such as the ICT industry, can, for example, find new uses in other industries (Björkdahl, 2009), leading to technological convergence (Rosenberg, 1963). Alternatively, inventors can transfer their technologies to other firms within the same industry that are better suited to make the application, production, and marketing investments that are necessary to turn inventions into commercially successful innovations, again by enabling combinations of resources of different types. Further, patent information can give rich data, as illustrated by the quote above, for instance as input to the internal R&D process. Such data can direct a firm's R&D activities towards, for example, in-licensing, inventing around activities, complementary innovation activities, or blocking activities. Patents, being a measurable output of R&D, can also be used to stimulate internal inventiveness (Granstrand, 1999). In cumulative (systems) technologies, where multiple agents are involved, patents can be used to govern and enable the interorganizational exploration processes. IPRs and related contracts can reduce information impactedness, uncertainty, and opportunism[22] and thereby, by decreasing risks, enable investments in complementary innovation

---

[21] This is true also in the US after its America Invents Act (2011), where the first-to-invent criterion of patentability was changed to the first-to-file (a patent application) criterion.

[22] See section 2.4.1 or Williamson (1975) for descriptions of these concepts.

and transaction-specific assets. An example is the use of FRAND requirements in some standards, meaning that participants must agree to license out their essential patents to fair, reasonable, and non-discriminatory (FRAND) licensing terms. A “tight” appropriability regime is then not necessarily most conducive for dynamic competitiveness, especially not if widening the scope from the firm perspective to the perspective of innovation networks and technological ecosystems (Baldwin & von Hippel, 2011; Dahlander & Wallin, 2006; Pisano, 2006).

As described above, knowledge is an impure public good, and the use of IPRs and patents is commonly assumed to aim to increase excludability of an intellectual resource. However, IP management can also work to limit excludability and enable (controlled) accessibility, as in the case of open source licensing schemes (O'Mahony, 2003). Strategic IP management can thus be used to proactively ensure accessibility to innovations, in order to promote cumulative innovation under certain conditions. It is then clear that IP strategies have to be aligned with corporate strategies and environmental factors in order to reap their full potential (Alexy et al., 2009; Granstrand, 1999; Phelps & Kline, 2009; Reitzig, 2007).

A number of important factors for IP management can be identified (see Table 2.3 for examples). First, the innovation type impacts the effectiveness of various IP strategies. Typically, product innovations are relatively more suited for patent protection than, for example, process innovations. Second, as for most types of strategies, there are differences between large and small firms in terms of how effective various IP strategies are. Third, different industries are to various extent suitable for different types of management, due to the characteristics of the technologies, the legal situation (patent protection is for instance not applicable to all types of technologies), or something else. Fourth, the technological complexity, i.e., whether products and services are based on single inventions or more or less complex combinations of inventions, impacts the requirements on IP management. Businesses based on complex technologies may for instance require the use of various types of licensing strategies to enable freedom to operate. Fifth, the IP regime and the IPR laws and institutions available in either an industry or a nation impact the available managerial strategies. Patent protection on a market requires not only patent laws, but also that such laws are enforced (while monitoring is typically left to patent holders). Sixth, the market structure impacts the effectiveness of various types of IP management. If a market is guarded by other means, for instance by state monopolies, it might be inefficient to protect it also by IPR protection, since that is typically costly.

Naturally, this thesis cannot investigate strategic IP management in all available combinations of these “dimensions” of factors. Nevertheless, variations in most dimensions have been covered by the thesis. Paper II, for example, includes firms with both product and process innovations and focuses on SMEs while Paper IV and VI focus on large firms. Paper IV uses a case from the electronics industry with complex technologies while Paper VI uses cases from the automotive industry with less complex technologies. Paper III takes into consideration both weak and strong IP regimes, and Paper IV uses a case in which the market structure varies over time.

**Table 2.3 Examples of factors related to IP management**

| Factor | Examples | References (examples) |
|---|---|---|
| Innovation type | Process<br>Product<br>Service | Arundel and Kabla (1998), Brouwer and Kleinknecht (1999), Granstrand (1999) |
| Firm size | Large<br>Small | Arundel and Kabla (1998), Brouwer and Kleinknecht (1999), Davis (2006), Hanel (2006), Kitching and Blackburn (1998), Mansfield (1986) |
| Industry | Chemical<br>Electronics<br>Mechanical<br>Pharmaceutical<br>Software | Chabchoub and Niosi (2005), Granstrand (1999), Hall and Ziedonis (2001), Mansfield (1986), O'Mahony (2003), Scherer (1983) |
| Technological complexity | Complex (‘Mul-tech’)<br>Cumulative<br>Discrete | Bessen (2004), Bessen and Maskin (2009), Cohen et al. (2000), Granstrand et al. (1997), Hall and Ziedonis (2001), Somaya et al. (2011), Teece (2009) |
| IP regime | Strong<br>Weak | Granstrand (2006b), Hu and Jefferson (2009), Keupp et al. (2010), Teece (1986, 2006) |
| Market structure | Competition<br>Monopoly<br>Oligopoly | Bekkers et al. (2002), Blind and Thumm (2004), Granstrand (1999) |

## 2.7 Key research papers within the field

This final section of the frame of reference presents results from a structured literature review, aimed to identify the most important works and scholars, in addition to what has been described above. This literature review is based on a topic search in the Web of Science database on 2 May, 2012. The topic search identifies words or phrases in titles, keywords, or abstracts, but only in papers published by journals included in the Web of Science database (typically those listed by different Science Citation Indexes). Thus, the search is limited to journal papers, meaning that some important works in form of books, reports, and papers in other journals are lacking. Additionally, ranking important works based on their citations, as is done here, is subject to large limitations as well, since a high number of citations does not necessarily mean many reads or large impact. Despite its limitations, a citation-based review is useful for identifying at least some of the most important works in a field, and it is therefore used here as a complement to the literature discussed above.

The literature review used the search string ("intellectual propert*" OR patent*) AND (economic* OR manag* OR strateg*), within the research area ‘business economics’. The result of the search listed 2 483 papers, and this list was exported and analyzed with the HistCite software provided by ThomsonReuters.

The most cited papers are presented in Table 2.4. Clearly, this list is dominated by papers that are not explicitly studying IP management. With a few exceptions (Hall, 1992; von Hippel & von Krogh, 2003), the papers in Table 2.4 are only implicitly related to IP management, and mainly by the use of patent documents in the measurement of innovative output (number of patents) or innovation relatedness (patent citations, inventors).

However, the most productive authors as identified by the literature review are those that actually do work on IP management, despite the fairly late interest for the subject among management scholars. The list of the most productive scholars in terms of paper output, as presented in Table 2.5, is topped by Ulrich Lichtenthaler and Holger Ernst. A number of their co-authored papers were retracted[23] during the summer of 2012, however, and the ranking would probably have been different if taking that into account. Other scholars on the list include, for example, Josh Lerner, Oliver Gassmann, John Cantwell, Christine Greenhalgh, Markus Reitzig, and Deepak Somaya. Table 2.5 also lists the most common research outlets for the papers identified in the structured review. The list is unquestionably topped by Research Policy, followed by a number of journals ranging from technology and innovation-oriented ones (e.g., International Journal of Technology Management and R&D Management) to more general ones (e.g., Strategic Management Journal and Organization Science). The journals focusing specifically on various aspects of IP have not (yet) reached the top list.

The most rewarding result of this structured literature review is probably the identification of the most cited references by the identified literature. The top twenty list is presented in Table 2.6, and includes some of the most important works underlying the field of strategic IP management. Griliches (1990) is again ranked first, cited by more than 10% of the identified papers, and followed by Levin et al. (1987), being probably the first empirical study on different

[23] Ulrich Lichtenthaler has claimed responsibility for most of the errors leading to retractions.

appropriation strategies. The works by Arrow (1962) and Teece (1986) are early and important cornerstones in the field on the theoretical and conceptual level, and the list also includes some important empirical works, such as Hall and Ziedonis (2001), Mansfield (1986), and Trajtenberg (1990). The connection to innovation management and strategic management is finally illustrated by, for example, Barney (1991), Cohen and Levinthal (1990), March (1991), and Teece et al. (1997).

**Table 2.4 The most cited papers as identified by the structured literature review**

| | **Author and year** | **Journal** | **Title** | **GCS** |
|---|---|---|---|---|
| 1 | Griliches (1990) | Journal of Economic Literature | Patent statistics as economic indicators - A survey | 1018 |
| 2 | Mowery et al. (1996) | Strategic Management Journal | Strategic alliances and interfirm knowledge transfer | 643 |
| 3 | Ahuja (2000a) | Administrative Science Quarterly | Collaboration networks, structural holes, and innovation: A longitudinal study | 608 |
| 4 | Davenport et al. (1998) | Sloan Management Review | Successful knowledge management projects | 483 |
| 5 | Almeida and Kogut (1999) | Management Science | Localization of knowledge and the mobility of engineers in regional networks | 434 |
| 6 | Hall (1992) | Strategic Management Journal | The strategic analysis of intangible resources | 357 |
| 7 | Stuart (2000) | Strategic Management Journal | Interorganizational alliances and the performance of firms: A study of growth and innovation rates in a high-technology industry | 302 |
| 8 | Ahuja (2000b) | Strategic Management Journal | The duality of collaboration: inducements and opportunities in the formation of interfirm linkages | 274 |
| 9 | Owen-Smith and Powell (2004) | Organization Science | Knowledge networks as channels and conduits: The effects of spillovers in the Boston biotechnology community | 263 |
| 10 | von Hippel and von Krogh (2003) | Organization Science | Open source software and the "private-collective" innovation model: Issues for organization science | 242 |

Notes: GCS = Global Citation Score (total number of citations from papers included in the entire Web of Science database)

**Table 2.5 The most productive scholars and the most common research outlets (journals)**

| Most productive scholars | # | Most common outlets | # |
|---|---|---|---|
| **1.** Lichtenthaler U | 15 | **1.** Research Policy | 189 |
| **2.** Ernst H | 14 | **2.** International Journal of Technology Management | 81 |
| **3.** Lerner J | 12 | **3.** Technovation | 75 |
| **4.** Gassmann O | 10 | **4.** Technological Forecasting and Social Change | 52 |
| **5.** Grupp H | 10 | **5.** Technology Analysis & Strategic Management | 45 |
| **6.** Wright M | 10 | **6.** Strategic Management Journal | 38 |
| **7.** Blind K | 9 | **7.** R&D Management | 36 |
| **8.** Nelson RR | 9 | **8.** Research-Technology Management | 34 |
| **9.** Cantwell J | 8 | **9.** Industrial and Corporate Change | 32 |
| **10.** Greenhalgh C | 8 | **10.** Management Science | 30 |
| **11.** Li MX | 8 | **11.** International Journal of Industrial Organization | 25 |
| **12.** Rogers M | 8 | **12.** IEEE Transactions on Engineering Management | 24 |
| **13.** Stern S | 8 | **13.** PICMET 2010: Technology Management for Global Economic Growth | 24 |
| **14.** Chu AC | 7 | **14.** Journal of Technology Transfer | 22 |
| **15.** de la Potterie BV | 7 | **15.** Journal of Product Innovation Management | 20 |
| **16.** Mowery DC | 7 | **16.** Journal of Business Ethics | 19 |
| **17.** Park Y | 7 | **17.** PICMET '07, Vols 1-6, Proceedings: Management of Converging Technologies | 19 |
| **18.** Popp D | 7 | **18.** Journal of International Business Studies | 18 |
| **19.** Reitzig M | 7 | **19.** Journal of Business Venturing | 17 |
| **20.** Somaya D | 7 | **20.** Organization Science | 17 |

Notes: # = Number of papers

**Table 2.6 The most frequently cited references by the research field**

| | Author and year | Journal | Title | # |
|---|---|---|---|---|
| 1 | Griliches (1990) | Journal of Economic Literature | Patent statistics as economic indicators - A survey | 258 |
| 2 | Levin et al. (1987) | Brookings Papers on Economic Activity | Appropriating the returns from industrial research and development | 209 |
| 3 | Cohen and Levinthal (1990) | Administrative Science Quarterly | Absorptive capacity: A new perspective on learning and innovation | 205 |
| 4 | Teece (1986) | Research Policy | Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy | 178 |
| 5 | Jaffe et al. (1993) | Quarterly Journal of Economics | Geographic localization of knowledge spillovers as evidenced by patent citations | 177 |
| 6 | Nelson and Winter (1982) | - (book) | An Evolutionary Theory of Economic Change | 168 |
| 7 | Hall and Ziedonis (2001) | The RAND Journal of Economics | The patent paradox revisited: An empirical study of patenting in the U.S. semiconductor industry | 126 |
| 8 | Hausman et al. (1984) | Econometrica | Econometric models for count data with an application to the patents-R&D relationship | 116 |
| 9 | Barney (1991) | Journal of Management | Firm resources and sustained competitive advantage | 109 |
| 10 | Teece et al. (1997) | Strategic Management Journal | Dynamic capabilities and strategic management | 106 |
| 11 | Jaffe (1986) | American Economic Review | Technological opportunity and spillovers of R&D: Evidence from firms' patents, profits and market value | 101 |
| 12 | Cohen and Levinthal (1989) | The Economic Journal | Innovation and learning: The two faces of R&D | 97 |
| 13 | Mansfield (1986) | Management Science | Patents and innovation: An empirical study | 96 |
| 14 | Trajtenberg (1990) | The RAND Journal of Economics | A penny for your quotes: Patent citations and the value of innovations | 94 |
| 15 | Heller and Eisenberg (1998) | Science | Can patents deter innovation? The anticommons in biomedical research | 88 |
| 16 | Kogut and Zander (1992) | Organization Science | Knowledge of the firm, combinative capabilities, and the replication of technology | 88 |
| 17 | March (1991) | Organization Science | Exploration and exploitation in organizational learning | 87 |
| 18 | Arrow (1962) | NBER | Economic welfare and the allocation of resources for invention | 84 |
| 19 | Mansfield et al. (1981) | The Economic Journal | Imitation costs and patents: An empirical study | 83 |
| 20 | Merges and Nelson (1990) | Columbia Law Review | On the complex economics of patent scope | 83 |

Notes: # = Number of citing papers among the 2 483 papers identified

# 3 Research design and methodology

The methods applied are described in detail in the appended papers. A short overview of the overall methodology and the basic assumptions employed is however given here, as well as a description of the relation between the overall purpose of the thesis and the various appended papers. The chapter also includes some contextual background to the conducted research.

## 3.1 Research projects

The research underlying this thesis has been performed in two projects; *Patents and Innovations for Growth and Welfare*[24] and *Management, Economics and IP Law of Open Distributed Innovation Processes*. Both projects have been conducted within the Industrial Management and Economics research group at Department of Technology Management and Economics at Chalmers University of Technology.

While the first research project is more policy and macro level oriented, the second is more management and micro level oriented. However, large interdependencies and interactions between the micro and macro levels have been found, and the two projects have therefore turned out to have major synergies, especially regarding the relation between micro and macro levels.

The nature of IP issues requires an international and interdisciplinary approach when studying them (e.g., Granstrand, 2003), which has been addressed in both of the abovementioned research projects. More specifically, the need for taking managerial, economical, legal, and technological (MELT) factors into account have been identified in the projects, and the research teams have thus been designed to include such skills.[25] Management, economics, and engineering have however been the main focus in this thesis, and these disciplines are also the author's main disciplines.

## 3.2 Research purposes and sub-studies

Rather than being guided by an *ex ante* stated and overarching purpose or research question, the research process underlying this thesis has been guided by a general interest in exploring and developing the field of management and economics of IP. As the research process has evolved, the overall research has been directed by various aspects of opportunism, including financing and publication opportunities,

[24] See also SOU (2006) and Granstrand (forthcoming).

[25] Other disciplines, such as sociology, behavioral science, political science, and history (technological, economical, and general) are also of importance.

access to empirical data, and questions arisen in relation to new findings. As such, the research process has been continuously adjusted, although always with a focus on management and economics of (technological) IP. However, each single paper, or sub-study, has been directed by a clear purpose and/or research question(s) (see Table 3.1).

Nevertheless, the research results contribute to two overall purposes. The first purpose is *to explore and explain strategic and innovation related intellectual property management practices, and the managerial and economic consequences of such practices*. This purpose, mainly being descriptive and explanatory, is related to *describing* IP management. It is also related to *explaining* the causes of such IP management, and to *predicting* consequences.

The thesis also contributes to a more normative purpose. The use of various types of open innovation practices (e.g., Baldwin & von Hippel, 2011; Chesbrough, 2003) requires new and/or adapted strategic IP management skills. The second purpose is therefore *to develop managerial and economic frameworks, models, and tools to be used in the intersection between intellectual property management and open innovation practices*. This purpose is related to *prescribing* new frameworks, models, and tools for IP management, and again to *predicting* consequences in order to prescribe the most effective and efficient solutions.

The six appended papers contribute to these two thesis purposes to various extents, see Figure 3.1. The first purpose mainly relates to Paper I-IV and VI, while the second purpose mainly relates to Paper IV-VI. Each single paper is then related to a paper-specific purpose and one or more research questions, as further described below and in Table 3.1.

Patent statistics (see, e.g., Figure 2.2) show that patenting in small countries, including Sweden, decreases, a trend that has not yet been explained. The purpose of Paper I is therefore to describe and explain fluctuations in patenting frequency and patenting propensity, especially concerning national applications filed at the Swedish PTO.

Previous research indicates that there are differences in how large firms and SMEs utilize and benefit from patent systems. A main finding from previous research is that SMEs are less likely to use patents than larger firms (e.g., Arundel & Kabla, 1998; Brouwer & Kleinknecht, 1999; Chabchoub & Niosi, 2005; Mansfield, 1986). The purpose of paper II is therefore to review empirical literature on patent propensity, appropriation strategies, and motives for patenting and also to empirically study how patenting is used by R&D management in entrepreneurial SMEs.

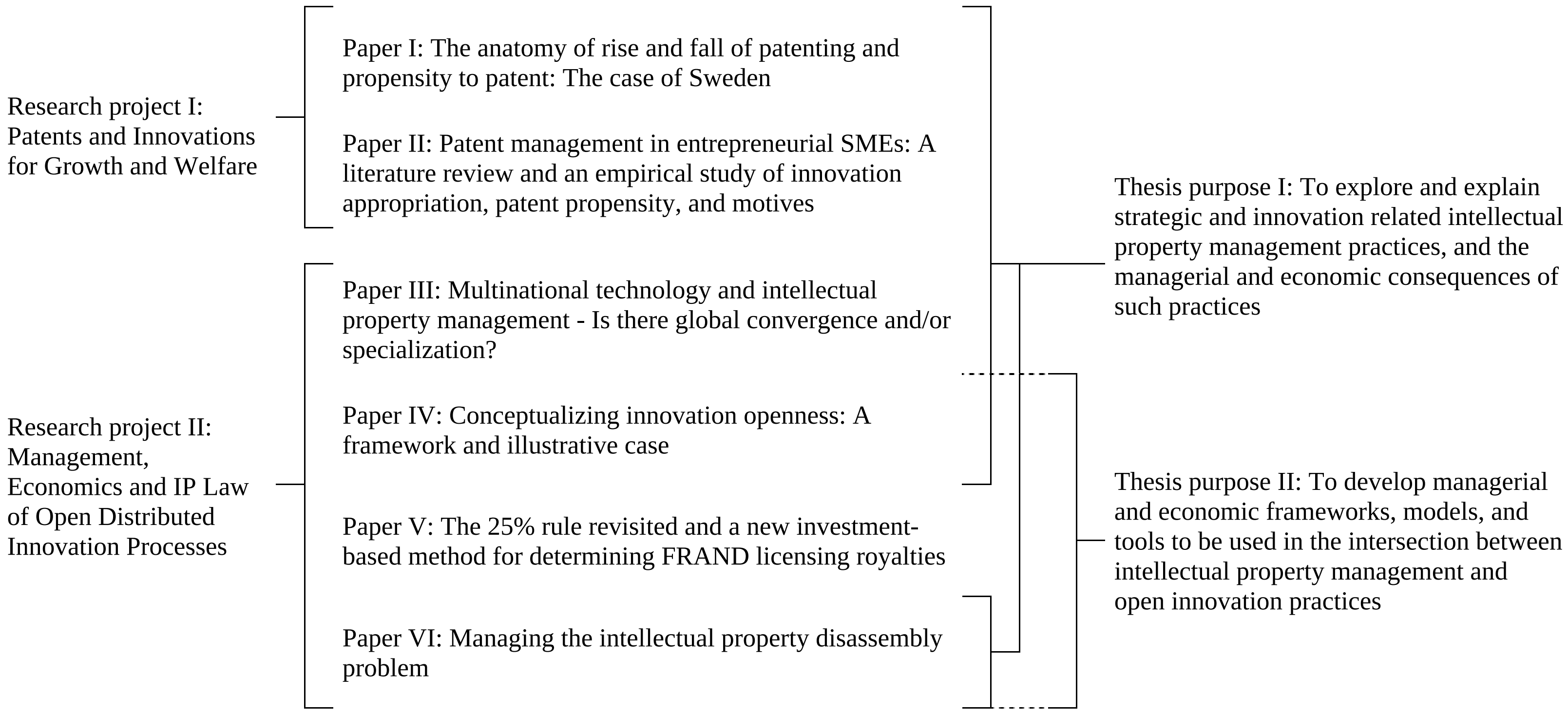



**Figure 3.1 Relation between thesis purposes and appended papers**

Globalization and internationalization of businesses in general, and patenting in particular, lead to the question whether firms in different countries around the world increasingly develop similar strategies and behaviors. If so, and if similar markets are chosen for patent applications, there should be signs of global convergence in terms of preferred markets for patenting from firms and inventors in various countries (market convergence). If there is a convergence of preferred markets, a related question is whether there is also a convergence of the set of prioritized technologies in various countries (technology convergence[26]), or whether technological specialization dominates.[27] The purpose of Paper III is thus to explore developments along a number of dimensions of convergence and their interrelations in a global context, and the ensuing implications of any signs of convergence for technology management.

A related question, to some extent addressed in Paper III, is whether there is a convergence of international management practices. An example of an increasingly important phenomenon worldwide is the management of innovation in an open and collaborative way over firm boundaries. Despite an increasing amount of research on open innovation, little consensus is yet to be found about what openness in innovation actually means. The purpose of paper IV is therefore to develop a general conceptual framework for innovation openness. The paper especially looks into the role of IP management in governing innovation openness.

In collaborative R&D where multiple actors are involved in inventing and commercializing a technology, the value that is created and captured jointly by these actors must be distributed in some way, most desirably by fair and reasonable principles. This is a central issue for IP management in firms employing such innovation strategies. The purpose of Paper V is to develop and present a generalized method for calculating reasonable royalties, which works not only in one-to-one but also in many-to-many (as well as in one-to-many and many-to-one) licensing deals.

[26] Note that technology convergence is distinguished from technological convergence, as studied by Rosenberg (1963) and others. Technological convergence then means that two or more technologies are increasingly jointly developed, combined, or merged.

[27] For studies of technological specialization, see Archibugi and Pianta (1992, 1994), Cantwell (1989, 1991), Cantwell and Vertova (2004), Dosi et al. (1990), Gambardella and Torrisi (1998), Patel and Pavitt (1987, 1991), and Soete (1981, 1987).

**Table 3.1 Paper-specific purposes and research questions**

| | | |
|---|---|---|
| Paper I | Title | *The anatomy of rise and fall of patenting and propensity to patent: The case of Sweden* |
| | Purpose | To describe and explain fluctuations in patenting frequency and patenting propensity, especially concerning national applications filed at the Swedish PTO |
| | Research question | 1. What are the causes of fluctuations in patent applications filed at the Swedish PTO? |
| Paper II | Title | *Patent management in entrepreneurial SMEs: A literature review and an empirical study of innovation appropriation, patent propensity, and motives* |
| | Purpose | To review empirical literature on patent propensity, appropriation strategies, and motives for patenting and also to empirically study how patenting is used by R&D management in entrepreneurial SMEs |
| | Research question | 1. What is the current state of empirical research of patent propensity, appropriation strategies, and motives for patenting?<br>2. What is the importance and role of patenting in entrepreneurial SMEs?<br>3. What are the motives for and against using patenting among entrepreneurial SMEs? |
| Paper III | Title | *Multinational technology and intellectual property management - Is there global convergence and/or specialization?* |
| | Purpose | To explore developments along a number of dimensions of convergence and their interrelations in a global context, and the ensuing implications of any signs of convergence for technology management |
| | Research question | 1. Do the sets of country markets selected by inventive firms/individuals for patenting become increasingly similar, i.e., is there a market convergence globally?<br>2. Do the sets of technological areas developed and patented by inventive firms/individuals become increasingly similar, i.e., is there a technology convergence globally? |
| Paper IV | Title | *Conceptualizing innovation openness: A framework and illustrative case* |
| | Purpose | To develop a general conceptual framework for innovation openness |
| | Research question | 1. What are the main dimensions of innovation openness?<br>2. What is the role of intellectual property in open innovation systems? |
| Paper V | Title | *The 25% rule revisited and a new investment-based method for determining FRAND licensing royalties* |
| | Purpose | To develop and present a generalized method to calculate reasonable royalties, which works not only in one-to-one but also in many-to-many (as well as in one-to-many and many-to-one) licensing deals |
| | Research question | 1. How should values be distributed in cases of multiple intellectual property rights holders? |
| Paper VI | Title | *Managing the intellectual property disassembly problem* |
| | Purpose | To describe and provide solutions to the intellectual property disassembly problem |
| | Research question | 1. How do intellectual property rights impact separation of previously integrated and technology-based firms, units, portfolios, etc.?<br>2. How can the intellectual property disassembly problem be mitigated? |

Finally, in various types of open innovation activities or terminations of collaborative R&D projects, as well as in various types of M&As and divestments (MADs), a specific IP-related problem can occur, namely the problem to find a contractual arrangement for allocation of IPRs that allows for separating out (disentangling) an entity or unit of resources in order to enable a transaction or transfer of it. In Paper VI, this is defined as the *intellectual property disassembly problem*, and the purpose of Paper VI is to describe and provide solutions to the intellectual property disassembly problem.

### 3.3 Basic assumptions and research strategy

Before describing the research methods used, it is of importance to describe the point of departure of the study in terms of epistemological and ontological assumptions, since these naturally impact and guide the choice of methods as well as the analysis of the collected data. The basic assumptions of this thesis can probably most closely be described as critical realism (Bhaskar, 1989). In critical realism, social phenomena are assumed to be "produced by mechanisms that are real, but that are not directly accessible to observation and are discernible only through their effects" (Bryman & Bell, 2007, p. 628).[28] Hence, in terms of ontology (the nature of existence), the critical realist approach accepts neither pure objectivism nor pure constructionism. Regarding epistemology (the nature of knowledge), critical realism implies two things:

> First, it implies that, whereas positivists take the view that the scientist's conceptualization of reality actually directly reflects that reality, realists argue that the scientist's conceptualization is simply a way of knowing that reality […] Secondly, by implication, critical realists unlike positivists are perfectly content to admit into their explanations theoretical terms that are not directly amenable to observation. As a result, hypothetical entities to account for regularities in the natural or social orders (the 'generative mechanisms' to which Bhaskar refers) are perfectly admissible for realists, but not for positivists. (Bryman & Bell, 2007, p. 18)

Critical realism has been argued to constitute more accurate assumptions than the prevailing positivist approach when studying the interplay between micro and macro levels in economics (Lawson, 1997, 2003). This has come as a reaction to the mathematical modeling and pure deductive approach otherwise commonly used in mainstream economics:

[28] For a description of social structures and social mechanisms, see Bhaskar (1989) or Smith (1998).

> It seems to be the case, however, that the ontological presuppositions of the methods of mathematical modeling used by economists are rarely questioned or even acknowledged, at least not in any systematic or sustained way. As a result, the possibility of a lack of ontological fit […] is not considered […] And my assessment, simply stated […] is that these preconditions of mathematical-deductivist methods appear not to arise very often in the social realm. (Lawson, 2003, p. 12)

The critique of mainstream economics above does not mean that mathematical methods and models, and the related clarity, rigor and consistency, should be abandoned, but they should be complemented with other methods. As Lawson (2003, p. 21) puts it: "I do though insist that these attributes are not enough, that ability to illuminate the social realm counts as well."

Drawing upon the arguments above, both inductive and deductive research strategies are used in the research underlying this thesis. These are seldom pure forms of methodologies, since deductive studies typically include an element of induction and vice versa. The combination of induction and deduction means that this study can be categorized as an iterative study in which data and theory are simultaneously (or iteratively) developed and analyzed (Bryman & Bell, 2007). Also drawing upon the arguments above, both qualitative and quantitative research methods are iteratively used. This is further discussed below.

### 3.4 Research methods and data sources

The IPR field is an area where a lot of quantitative data sources are available. These are very useful, but sole reliance upon these data sources would probably not give as valuable and interesting results as if complementing with other types of data. In fact, numerous authors have advocated the use of multiple methods, commonly denoted triangulation[29], in order to increase validity (Bryman & Bell, 2007; Creswell, 2008; Flick, 2009; Jick, 1979). Multiple methods can however do more than only increase validity, especially when combining quantitative and qualitative methods:

> That is, beyond the analysis of overlapping variance, the use of multiple measures may also uncover some unique variance which otherwise may have been neglected by single methods. It is here that qualitative methods, in particular, can play an especially prominent role by eliciting data and suggesting conclusions to which other methods would be blind. Elements of the context are illuminated. In this sense, triangulation may be used not only to examine the same phenomenon from

---

[29] Note that the exact definition of triangulation varies slightly in various literatures on research methods.

> multiple perspectives but also to enrich our understanding by allowing for new or deeper dimensions to emerge. (Jick, 1979, pp. 603-604)

This study has therefore employed various data collection methods, including interviews, questionnaires surveys, patent statistics, and document studies, in a complementary way. These methods are described below and more in depth in the various papers, and they are summarized in Table 3.2. Besides the data sources specifically described in the papers, a number of interviews framing the research in an industrial and international context have been undertaken. The reason for this has essentially been to further increase the number of perspectives and to enrich the understanding of the subject, as argued by Jick (1979), especially due to its interdisciplinary and international character. The most important of these 'contextualizing' interviews are presented in Table 3.3. In addition, meetings with practitioners and scholars at various conferences have also provided important input to the study.

**Table 3.2 Empirical data collection methods in the different papers**

| | **Patent statistics** | **Questionnaires** | **Interviews** | **Document studies[1)]** |
|---|---|---|---|---|
| Paper I | X | X[2)] | X[3)] | - |
| Paper II | - | - | X | - |
| Paper III | X | - | X | X |
| Paper IV | X | - | X | X |
| Paper V | - | - | - | - |
| Paper VI | - | - | X | X |

Notes: 1) This category emphasizes the use of document studies for empirical data collection. Note that all studies contain some form of document study when designing and framing the study based on previous research.
2) The author of this thesis did not take part in the main questionnaire and sample design, but did take part in data collection and data analysis.
3) The author of this thesis did not take part in the interviews.

**Table 3.3 List of the most important contextualizing interviews**

| Company/organization | Country | Interviewee(s) position at time of interview |
|---|---|---|
| AstraZeneca India | India | Managing Director |
| Biocon | India | Founder and CEO |
| Delhi High Court | India | High Court Judges |
| E.ON | Sweden | Head of Innovation and Environment<br>R&D Coordinator |
| Ericsson | Sweden | Vice President of Patent Strategies and Portfolio Management |
| EU-China IPR2 | China | Team Leader |
| Evalueserve | India | Chairman<br>Global Head of IP Operations |
| Huawei | China | IP Deputy Director<br>Vice Director of Industry Standard |
| IBM | UK | IP Law Counsel |
| IBM | Japan | Senior Counsel IP Law |
| Infosys | India | Associate Vice President & Head of IP Cell |
| Japan Intellectual Property Association | Japan | Executive Managing Director |
| Japan Management of Technology Association | Japan | Senior Executive Director<br>Secretary General |
| Korean Institute for Intellectual Property | Korea | Researchers |
| Korean Intellectual Property Office (KIPO) | Korea | Director International Cooperation Division |
| Macau government | Macau | Legal advisor to government |
| Ministry of Science and Technology | China | Director |
| NanoCarrier | Japan | Senior Advisor |
| Nokia | Finland | Vice President Legal and IP |
| Nokia | UK | Director IPR Regulatory Affairs |
| Samsung | Korea | Head of IP Litigations |
| SKF | Sweden | Director SKF Business Consulting |
| State Intellectual Property Office | China | Hearing<br>Researchers |
| Tata Consultancy Services | India | Head of Components Engineering Group<br>Consultants |
| The Office of the Controller General of Patents, Designs & Trade Marks (CGPDTM) | India | Controller General<br>Head of Delhi Patent Office |
| Tokyo Small and Medium Business Investment & Consultation | Japan | President and CEO (Former director of IP Strategy Headquarters in Japan) |
| Volvo Group | Sweden | President and CEO<br>CEO of Volvo Technology Transfer |

The purpose of Paper I is to describe and explain fluctuations in patenting frequency and patenting propensity, especially concerning national applications filed at the Swedish PTO, and it is based primarily on patent statistics and questionnaire surveys, but to some extent also on interviews. The sources for patent statistics were primarily the Swedish PTO, the US PTO (USPTO), and the World Intellectual Property Organization (WIPO), and they are mainly used to describe the fluctuations in patenting. A questionnaire survey was performed among three samples of firms; large patentees, small patentees, and patent consultancy firms. The data from the questionnaire mainly explains the fluctuations. Tail sampling was found most suitable when sampling. On one hand, the use of tail sampling could limit the generalizability of the results, but on the other hand there is a large benefit in the fact that the results then do actually explain a major part of the fluctuations on national level. Thus, in this case tail sampling is expected to increase the validity of the results. The large patentees were essentially sampled among the largest Swedish firms with the highest patenting frequency, in order to explain as much of patenting fluctuations on national level as possible. 38 out of 73 firms responded (52%). The sample of SMEs focused on smaller patentees with a decrease in patent frequency. 20 out of 51 firms responded (39%). The third sample consisted of the largest patent consultancy firms in Sweden. The 12 out of 14 responding firms (86%) jointly corresponded to about 83% of the total sales of the patent consultancy industry in Sweden.[30] All in all, questionnaires from 70 respondents were collected.

Paper II presents a literature review and empirical material collected in interviews in three samples of entrepreneurial SMEs. The concept of entrepreneurial firms is in this case used to denote on one hand firms based on new technologies and on the other hand firms with new or improved commercialization.[31] The primary data source in Paper II is 26 semi-structured interviews. Non-probability sampling was used when selecting the firms, focusing on the tail of firms in various variables. The first interview sample consisted of eight firms with high sales growth, the second sample consisted of twelve hi-tech firms, and the third sample consisted of six firms in a Swedish region, ‘Gnosjöregionen’, recognized for its entrepreneurial spirit (Wigren, 2003). See Paper II for more details.

[30] Note that the author of this thesis did not take part in the questionnaire and sample design for the samples of large and small patentees in Paper I. The author did however take part in the questionnaire design and sampling for the sample of patent consultancy firms, as well as in the data collection and data analysis for all samples.

[31] See Gartner (1990) for a discussion on the concept of entrepreneurship.

Paper III explores developments along a number of dimensions of convergence and their interrelations in a global context, and the ensuing implications of any signs of convergence for technology management. It is mainly based on patent statistics, but also to some degree on interviews with large firms, PTOs, and policy representatives worldwide (about 50, including many of the ones in Table 3.3) and on documents (e.g., patent laws). The patent data was collected from WIPO and USPTO. The paper focuses on global convergence, and convergence is then defined as a decrease in difference. To mitigate problems with measurement validity, three different difference indexes, based on patent statistics, were constructed for market convergence and technology convergence, respectively, i.e., six difference indexes in total.[32] All pairs of countries were compared in terms of patent market shares and technology shares, and related measures, resulting in $(N^2 - N)/2$ unique difference indexes for each type of index, with $N$ number of countries (although missing data for some countries led to fewer unique indexes in practice). Convergence was then measured as a decrease in difference indexes. See Paper III for a more elaborate description of index constructions and statistical tests.

The purpose of paper IV is to develop a general conceptual framework for innovation openness. The framework is built upon previous research to large extent, but also upon a longitudinal case study of technology development in mobile telecommunications. The case study is based primarily on document studies and secondarily on interviews (among which only a few have been conducted within this PhD project). In addition, the case partly includes quantitative data on essential patents in the different telecommunication standards (1G, 2G, 3G, and 4G), reported to the European Telecommunications Standards Institute (ETSI). The patent data is partly used to measure how concentrated among actors the technological development is in various generations of standards. However, since the essential patents are self-reported to ETSI, and since extensive over-reporting is likely due to the importance of holding a strong patent position in standard setting and licensing agreements, the reported essential patents need to be evaluated before treating them as essential patents to ensure measurement validity. Such evaluations have been made in various studies, among only a few are publicly available. Here, the results from the studies conducted by Fairfield Resources International (2005, 2007, 2009a, b) are used.

[32] Some of these indexes are partly based on the work of Balassa (1965) on revealed comparative advantage. Technology convergence further relates to the works on technological specialization by Soete (1981, 1987), Patel and Pavitt (1987, 1991), and others.

The purpose of Paper V is to develop and present a generalized method to calculate reasonable royalties, which works not only in one-to-one but also in many-to-many (as well as in one-to-many and many-to-one) licensing deals. Paper V does not include any empirical data, but relies upon tool development based on fairness principles and basic algebra.

Finally, Paper VI aims to define, describe, and provide solutions to the intellectual property disassembly problem. The empirical data set consists of two cases from the automotive industry, namely Saab Automobile and Volvo Car Corporation (VCC), based on interviews and document studies. In order to explore the problem, which has not previously been researched, open and unstructured interviews were deemed most appropriate (Bryman & Bell, 2007). 15 interviews were carried out face to face within the two case companies, typically lasting in between one and three hours (with a few exceptions of shorter telephone interviews). The interviewees included the chief executive officers (CEOs), chief technology officers (CTOs), and other important executive/management/R&D positions in the case companies. In addition, five interviews were carried out with seven interviewees among large law firms as well as independent observers and personnel from other automotive companies. The interviews within each case were complemented with documents (from newspapers, annual reports, company statements, etc.) and used to compile a case story. Thus, the empirical data in Paper VI is based on 20 interviews with 22 interviewees as well as on document studies.

# 4 Summaries of and contributions to the appended papers

This chapter presents the summaries of the appended papers. These summaries leave little room for methodological, theoretical, and empirical details. Therefore, readers are referred to chapter 5 and the appended papers for more information. The chapter also includes descriptions of the author's contributions to co-authored papers.

## 4.1 Paper I

**The anatomy of rise and fall of patenting and propensity to patent: The case of Sweden**

Fluctuations in patenting frequency and propensity to patent have caught increasing interest, not the least since the emergence of a worldwide pro-patent era. In this paper fluctuations in Swedish patent frequency are described and analyzed, based on statistics and questionnaire survey studies among large and small patentees as well as among IP consultancy firms, complemented with interviews. The results confirm the importance of size of R&D and size of patenting resources for both large and small firms and for both positive and negative growth of patenting. In addition, some new determinants were found, of which some also discriminated between large and small firms. A shift to more quality-oriented patenting strategies with more selective patenting led to decreased patenting propensity and frequency, especially among large firms. As to propensity to patent using different routes, national first filings are declining in the longer run on average for small countries like Sweden and Finland, as especially large companies internationalize their IP operations and increasingly use the PCT route.

*Author's contribution:* The author of this thesis did not take part in the initial study design, including the sampling of large and small patentees. The author did however take part in designing the sub-study among patent consultancy firms. Data collection and data analysis was handled jointly by the paper's two co-authors in collaboration with a number of other project members, and the final paper was written jointly by the two co-authors.

## 4.2 Paper II

**Patent management in entrepreneurial SMEs: A literature review and an empirical study of innovation appropriation, patent propensity, and motives**

Managers make a number of strategic choices when trying to capture returns from innovation investments, including what appropriation strategy to use and whether or not to patent, strategic choices that depend among other things on firm size. Previous literature, being reviewed in this paper, shows that the patent propensity is lower in (SMEs) than in large firms and that patenting as means for appropriation is of less importance among SMEs. CEOs and/or R&D managers of 26 entrepreneurial SMEs have been interviewed to explain these differences and to provide insight on how patenting is used in SMEs. The patent competence was low among the studied SMEs, and internal patent resources were found to be important for effective and efficient use of the patent system; for application as well as monitoring and enforcement. While of limited perceived importance for protecting inventions in entrepreneurial SMEs, patents were used to attract customers and venture capital, which is of utmost importance for the survival and growth of these firms. Thus, patenting has an important role to play even in firms where the protective function of patents is secondary.

*Author's contribution:* Single-authored paper.

## 4.3 Paper III

**Multinational technology and intellectual property management - Is there global convergence and/or specialization?**

The paper gives various indications of market and technology diversification as well as of global market and technology convergence (rather than specialization) in the context of managerial, legal and economic convergence. The results show that different countries focus on a wider but increasingly similar set of markets for R&D outputs in form of patents, which implies increasing intra-national market diversification and inter-national market convergence. The results also show that different countries focus on a wider but increasingly similar set of technologies that are patented, which implies increasing intra-national technology diversification and inter-national technology convergence. In addition, intellectual property (IP) legal convergence takes place as newly industrialized countries (NICs) have strengthened their IP regimes in compliance with TRIPS and subsequently do so in the context of their indigenous innovation policies. Asian NICs have significantly increased their international patenting and supply of patented inventions. Altogether, this puts new demands across countries on multinational technology and innovation management skills, and in particular multinational IP management skills.

*Author's contribution:* The idea of the convergence theme employed in the paper was originated by the co-author. The author of this thesis then had the main responsibility for the quantitative study design, index development, quantitative data collection, and quantitative analysis. Data from interviews aiming to complement the quantitative data was collected jointly by the two co-authors. Interpretations and analysis on a more general level was performed jointly by the co-authors, as was the authoring of the final paper.

## 4.4 Paper IV

### Conceptualizing innovation openness: A framework and illustrative case

Open innovation has become an increasingly recognized source of innovativeness and competitive advantage. However, various perspectives on innovation openness co-exist and a complete comprehension of the underlying mechanisms and dimensions is still lacking. This paper therefore develops a conceptual framework that helps to better describe and analyze innovation openness. We draw on resource-/capability-based, transaction-/contract-based and (intellectual) property rights-based perspectives to conceptualize innovation openness as consisting of three main dimensions, namely resource distribution, technology governance and technology accessibility. We also present an illustrative case of four generations of mobile communication systems to exemplify the value of the framework and to further illustrate the multi-layered and dynamic nature of innovation openness, as well as the important role of intellectual property rights. As such, we conclude that any notion of a stable optimum and one-dimensional view on innovation openness is overly simplistic and likely to mislead managerial and policy decisions.

*Author's contribution:* The author of this thesis had the main responsibility for the illustrative example, including collection and analysis of new data (mostly secondary), complementing already available historical data from one of the other co-authors. The conceptual development was performed jointly by the three co-authors, as was the writing of the final paper. The author of this thesis is the corresponding author of the paper.

## 4.5 Paper V

### The 25% rule revisited and a new investment-based method for determining FRAND licensing royalties

This paper starts with briefly discussing the 25% rule and the argumentation for and against it. The paper continues with developing a new investment-based method for determining FRAND licensing royalties, a method not only applicable to one-to-one bilateral licensing deals but also to multilateral deals with multiple license sellers and multiple license buyers. The paper ends with discussing limitations and generalizations, opening up for further research.

*Author's contribution:* The idea to base licensing royalties on equal rates of ROI had been presented for the case of bilateral licensing in an earlier paper by one of the co-authors (Granstrand, 2006a), resulting in what is stated as Case A in the paper. That co-author had the idea to generalize this result to multilateral licensing deals (Case B and Case C), and developed the formal specifications for generalizing the model. The author of this thesis then used the idea that licensees could be treated both collectively and individually (see the second paragraph of the Appendix in the paper), and could thus add further developments to the model, resulting in what is now reported as Case B and Case C in the paper. The author of this thesis also created the accompanying calculation tool, available for download. The final paper was written jointly by the two co-authors.

### 4.6 Paper VI

**Managing the intellectual property disassembly problem**

This paper deals with the *intellectual property (IP) disassembly problem*. The IP disassembly problem refers to the problem of separating and disintegrating intellectual property rights (IPRs) for enabling a sale of a part of a company / business / project. Managing this problem becomes increasingly important, as it is amplified by a number of current trends, such as technological convergence, technological diversification, open innovation, and an increasing number of mergers, acquisitions, and divestments. Based on a comparative case study of Saab Automobile and Volvo Car Corporation, this paper describes the problem and suggests a framework for managing it.

*Author’s contribution:* The study was designed jointly by the two co-authors, partly based on previous conceptual work on the reverse problem of IP assembly by Granstrand (1999, 2003). The data collection was mainly undertaken through interviews in which both authors took part, although some of the interviews were performed separately. The case descriptions were also summarized and written by the author of this thesis, while the general conceptual development, analysis, and writing of the rest of the paper was performed jointly by the two co-authors. The author of this thesis is the corresponding author of the paper.

# 5 Main results

This chapter summarizes some of the main results in the appended papers as well as the frameworks, models, and tools that have been developed. The first section relates mainly to the first thesis purpose; to explore and explain strategic and innovation related intellectual property management practices and the managerial and economic consequences of such practices. The second section relates to the second thesis purpose; to develop managerial and economic frameworks, models, and tools to be used in the intersection between intellectual property management and open innovation practices. This chapter can only give a short summary of some of the most important results, and additional results and interpretations are available in the appended papers.

## 5.1 Descriptive and explanatory results

This section describes chosen parts of the wide range of descriptive and explanatory results on strategic IP management that is available in the appended papers. It is structured to transition from macro level quantitative data to micro level data in various forms, in order to give the reader a general overview of macro trends before moving over to firm level results. Firm-level explanations behind macro level trends are provided, and a number of cases are also described, including cases on IP governance, IP assembly, and IP disassembly, as well as a brief description of patent management in entrepreneurial SMEs.

### *5.1.1 Background*

The pro-patent era emerged in the US in the 1980s following legal changes that strengthened the IP regime and the rights for patent holders. The creation of the CAFC in 1982 intended to stabilize and unify the US patent system, which was previously subject to unpredictability in rulings (especially in terms of enforceability) and forum shopping among the patentees and potential infringers (Merz & Pace, 1994). US patents became less likely to be invalidated after the establishment of the CAFC (Henry & Turner, 2006), leading to an increased number of patent litigations (Merz & Pace, 1994) and a surge in patenting in general (Granstrand, 1999; Hall, 2005; Hall & Ziedonis, 2001). In addition, the Bayh-Dole Act in 1980 enabled universities, small businesses, and non-profit organizations to pursue ownership of patented inventions resulting from government-funded research, and this is an additional explanation for the increase in US patenting since the early 1980s (Mowery et al., 2001). More recently, a similar shift to (relatively more) pro-patent legislations has spurred patenting in China (Hu & Jefferson, 2009) and many other countries. However, national patenting in Sweden and other small European countries has not followed a similar path (as illustrated by Figure 2.2).

### *5.1.2 Internationalization of Swedish patenting*

Table 5.1 shows a number of different time series of patent applications related to Sweden. Figure 5.1 presents normalized graphs for the same time series, relating numbers to their equivalent for year 2000 in order to give an overview of the growth and/or decline in various types of application streams from 2000 to 2010.[33]

When studying and interpreting the patent statistics in Table 5.1 and Figure 5.1 it is important to consider three different perspectives. *First*, there is patent data relating to a demand for protection on a specific market. In the case of Sweden indications of this include not only the number of national Swedish applications[34] but also the number of EPO applications being validated in Sweden. While the number of Swedish national applications decreased in between 2000 and 2010, the number of EPO applications being validated in Sweden was roughly the same in 2010 as in 2000, albeit with fluctuations in between. *Second*, there is patent data relating to the use of a specific PTO, indicating its workload and demand for its services. In the case of Sweden this includes not only the number of national Swedish applications, but also, for example, the number of PCT applications filed at the Swedish PTO and, perhaps more importantly, the use of the Swedish PTO as the International Searching Authority (ISA) for PCT applications (in two phases relating to a mandatory international search for prior art in phase I and an optional preliminary examination of patentability in phase II). The data gives an indication of a decreasing use of the Swedish PTO. *Third*, there is patent data relating to the productivity in terms of patent output from inventors/applicants in specific countries. This is indicated by the amount of various types of applications that are filed by applicants from those countries. While the number of Swedish national applications (to the Swedish PTO) from Swedish applicants decreased in the first decade of the 2000s, EPO and PCT applications from Swedish applicants increased. Consequently, Swedish innovators seem to have internationalized their patenting, by increasing the use of international patent application routes while decreasing the utilization of the Swedish national system.

---

[33] Note that patent statistics are commonly adjusted, and some of the numbers in Table 5.1 therefore differ marginally from what is presented in Paper I. Also note that patent statistics from different sources sometime differ marginally, such as statistics provided by WIPO as compared to statistics provided by national PTOs.

[34] The number of national Swedish applications includes the PCT applications that have proceeded to the national phase in Sweden. In the national phase, they are treated as national applications.

**Table 5.1 Patent application streams related to Sweden (extended from Paper I)**

| Application type[1)] | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| National Swedish applications | **4 938** | 4 625 | 4 870 | 4 920 | 4 460 | 3 882 | 3 604 | 3 216 | 2 943 | 2 845 | 2 881 | 2 777 | 2 604 | 2 549 |
| - from Swedish applicants[2)] | - | - | - | **4 135** | 3 789 | 3 308 | 3 003 | 2 728 | 2 498 | 2 429 | 2 517 | 2 386 | 2 151 | 2 195 |
| PCT applications filed globally | 57 064 | 67 061 | 76 358 | 93 239 | 108 229 | 110 394 | 115 204 | 122 632 | 136 750 | 149 641 | 159 926 | 163 236 | 155 399 | **163 938** |
| PCT applications filed at the Swedish PTO | 2 208 | 2 465 | 2 500 | 2 691 | **2 915** | 2 455 | 2 097 | 2 053 | 2 048 | 2 123 | 2 246 | 2 317 | 2 046 | 1 775 |
| - share of PCT applications filed globally | **3.87%** | 3.68% | 3.27% | 2.89% | 2.69% | 2.22% | 1.82% | 1.67% | 1.50% | 1.42% | 1.40% | 1.42% | 1.32% | 1.08% |
| PCT applications using the Swedish PTO as ISA for phase I | - | - | - | 3 976 | **4 273** | 3 987 | 3 522 | 3 334 | 3 366 | 3 150 | 3 160 | 2 407 | 2 042 | 2 050 |
| PCT applications using the Swedish PTO as ISA for phase II | - | - | - | 3 441 | **3 576** | 3 466 | 2 630 | 1 615 | 988 | 689 | 671 | 626 | 457 | 350 |
| PCT applications from Swedish applicants filed globally[2)] | 2 212 | 2 589 | 2 715 | 3 090 | 3 422 | 2 989 | 2 606 | 2 851 | 2 884 | 3 336 | 3 655 | **4 137** | 3 567 | 3 313 |
| - share of PCT applications filed globally | **3.88%** | 3.86% | 3.56% | 3.31% | 3.16% | 2.71% | 2.26% | 2.32% | 2.11% | 2.23% | 2.29% | 2.53% | 2.30% | 2.02% |
| EPO applications[3)] | 72 904 | 82 087 | 89 359 | 100 701 | 110 117 | 106 348 | 116 831 | 123 748 | 128 709 | 135 399 | 141 423 | 146 644 | 134 542 | **150 961** |
| EPO applications validated in Sweden | - | - | - | 8 455 | 6 798 | 12 077 | **13 225** | 12 317 | 10 892 | 11 980 | 10 565 | 10 063 | 9 185 | 8 844 |
| - from Swedish applicants[2)] | - | - | - | 236 | 227 | 339 | **487** | 470 | 397 | 413 | 447 | 419 | 356 | 437 |
| EPO applications from Swedish applicants[2), 3)] | 1 455 | 1 742 | 1 977 | 2 314 | 2 536 | 2 545 | 2 591 | 2 487 | 2 516 | 2 540 | 2 738 | 3 134 | 3 147 | **3 560** |
| - share of EPO applications | 2.00% | 2.12% | 2.21% | 2.30% | 2.30% | **2.39%** | 2.22% | 2.01% | 1.95% | 1.88% | 1.94% | 2.14% | 2.34% | 2.36% |

Notes: 1) The highest values (over time in each row) are written bold and the lowest values are underlined
2) "Swedish applicant" means Swedish first named applicant, who is not necessarily a Swedish inventor
3) Includes European applications and Euro-PCT applications entering the regional phase

*Source*: Swedish PTO statistics, WIPO-statistics, EPO Annual Reports

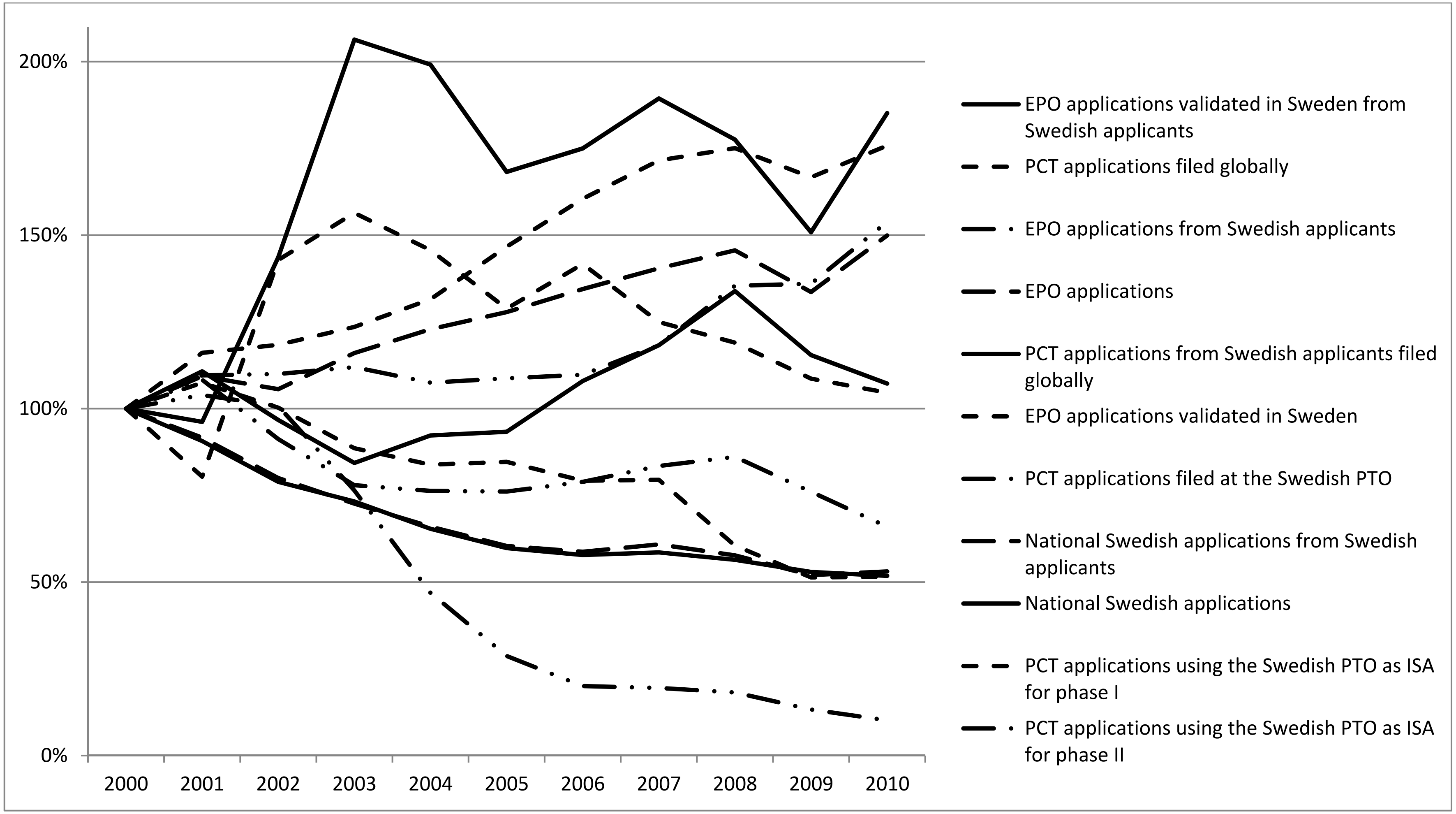



**Figure 5.1 Normalized patent application streams (legend in order of normalized value for 2010, from highest to lowest)**

All in all, the data in Table 5.1 and the graphs in Figure 5.1 indicate that the importance of the Swedish PTO decreased from the late 1990s to 2010, and probably also the importance of patent protection on the Swedish market for innovators around the world. Despite decreasing numbers of national Swedish patent applications, Swedish innovators and patentees did not necessarily decrease their patenting in general, as indicated by increasing numbers of international patent applications by Swedish applicants. However, the patenting strategies seem to have been internationalized [see also Paper I and Granstrand (forthcoming)].

### *5.1.3 Convergence of international patenting*

Looking at internationalization and globalization more broadly, it is on one hand possible that globalization in general leads to worldwide convergences of different types, for instance in terms of consumption and investment preferences (i.e., actors of different nationalities become increasingly similar). On the other hand it is possible that globalization and decreasing transaction costs leads to increasing specialization (i.e., actors of different nationalities focus on what they do best) due to economies of scale (Cantwell & Vertova, 2004; Krugman, 1987).[35]

The results above indicate that patenting strategies have been internationalized for the case of Sweden and its innovators. A subsequent question is then if innovators of other nationalities also internationalize their patenting strategies, and, if so, whether the sets of preferred country markets for patent protection are becoming increasingly similar, i.e., whether there is market convergence globally in terms of preferred markets for patent protection. Another related question is whether the sets of technological areas (measured by patent classes) developed and patented by inventive firms/individuals around the world become increasingly similar, i.e., whether there is technology convergence globally.

A number of concepts and distinctions are important in this context (see Paper III). First, the processes in which different nations and their inventors become increasingly similar in terms of their focus on various markets and technologies for patenting, respectively, are here denoted *inter-national market convergence* and *inter-national technology convergence*, since they denote processes in which the differences *between* nations decrease. The opposite processes, i.e., the processes of increasing differences, are denoted *inter-national market specialization* and *inter-national technology specialization*, respectively. Second, the processes in which a specific nation and its inventors focuses more narrowly

[35] In this connection, it is important to separate between the consumer (demand) side and the producer (supply) side, since convergence in consumer preferences can for instance co-exist with specialization and increased trade among producers.

on a smaller set of markets and technologies for patenting (but not necessarily different markets and technologies than other nations) are denoted *intra-national market specialization* and *intra-national technology specialization,* respectively. The opposite processes, i.e., the processes in which a specific nation focuses wider on a larger set of markets and technologies, respectively, are denoted *intra-national market diversification* and *intra-national technology diversification*.

Inter-national convergence is here defined as a decrease in differences between countries in terms of patenting (while inter-national specialization is oppositely defined as an increase in differences), and in order to study inter-national convergence six difference indexes are introduced in Paper III, three for inter-national market convergence and three for inter-national technology convergence. The Herfindahl-Hirschman index is used as a measure of intra-national market/technology diversification/specialization.[36]

Analysis of the market difference indexes ($d^{MS}$, $d^{RMA}$, and $d^{RSMA}$) shows that there is an inter-national market convergence; all three difference indexes decreased over time (see Table 5.2). This means that inventors from different nations around the world increasingly file patent applications in similar sets of nations. The results further show a decreasing concentration as measured by the Herfindahl-Hirschman index ($H^M$). This means that there is an intra-national market diversification, i.e., that inventors from different nations around the world widen their sets of output markets for patenting.

In this development, it is likely that a general set of important nations for patenting will emerge among worldwide inventors, for example, the US in North America, France, Germany and the UK in Europe, and China, Japan, Korea, and Taiwan in Asia. An interview with a chief IP officer (CIPO) at a multinational corporation (MNC) with one of the largest patent portfolios in its business

---

[36] The market-related indexes are based on all patent applications worldwide from 1995 through 2004, as reported by WIPO. The technology-related indexes use the US market as a reference market and are based on all national patent applications to the USPTO from 2005 through 2009. The time spans were chosen mainly based on the availability of data. The WIPO dataset typically lags for some countries, which is why an older time period had to be chosen for the market-related indexes than for the technology-related ones in order to avoid analyzing convergence based on an incomplete dataset. It is assumed that the US is a highly prioritized nation for foreign patenting, and that the distribution of US patents in various patent classes from inventors of a specific nation therefore mirrors the distribution of patents in general (not only US ones) over various patent classes by inventors in that nation. However, US patenting is of course not a perfect proxy for patenting in general. Nevertheless, using the US as a reference market in patent information analysis is common practice (e.g., Granstrand et al., 1997; Patel & Pavitt, 1994).

revealed that the selection of nations for patent protection in that firm was made based on the most important nations for production on one hand and the most important output market nations on the other hand. Patent protection for important R&D nations is less important, since R&D activities are less likely to be hit by suits and possible damage claims and injunctions.

**Table 5.2 Statistical results on market convergence and concentration (Paper III)**

| Index | n | 1995 Mean | 2004 Mean | Mean change | % Change | Estimated median of change |
|---|---|---|---|---|---|---|
| $d^{MS}$ | 2080 | 0.65578 | 0.51853 | -0.13724*** | -20.93% | -0.1647### |
| $d^{RMA}$ | 2080 | 288.7 | 142.0 | -146.61*** | -50.81% | -58.77### |
| $d^{RSMA}$ | 2080 | 22.825 | 18.787 | -4.038*** | -17.69% | -4.047### |
| $H^{M}$ | 65 | 0.4817 | 0.2996 | -0.1821*** | -37.80% | -0.1548### |

Notes:
* Mean change different from zero with 0.05 significance (paired t-test)
** Mean change different from zero with 0.01 significance (paired t-test)
*** Mean change different from zero with 0.001 significance (paired t-test)
# Median change different from zero with 0.05 significance (Wilcoxon signed-rank test)
## Median change different from zero with 0.01 significance (Wilcoxon signed-rank test)
### Median change different from zero with 0.001 significance (Wilcoxon signed-rank test)

There is not as clear results regarding inter-national technology convergence (see Table 5.3). On one hand, some results indicate an inter-national technology specialization ($d^{RTA}$). On the other hand, other results indicate an inter-national technology convergence ($d^{TS}$). Considering how the different indexes are constructed (see Paper III), the varying results regarding inter-national technology convergence could be explained by a process in which the same technological fields are becoming increasingly important in different countries (in terms of patent quantity) at the same time as differences in relative technological specialization in the various fields (including minor technological areas in terms of patent quantity) are increasing. This process thus involves both technology convergence and specialization. Apart from the inter-national measures, the results indicate an intra-national technology diversification, meaning that nations around the world focus on a wider set of technologies. Note however that technology diversification does not necessarily imply business diversification, and that businesses might very well be concentrated and specialized while at the same time being supported by an increasing number of technologies (Gambardella & Torrisi, 1998; Granstrand & Oskarsson, 1994; Granstrand et al., 1997; Oskarsson, 1993).

To summarize sections 5.1.2 and 5.1.3, the patent data gives various indications of internationalized patenting strategies in general. The data shows a decreasing importance for the Swedish PTO and the Swedish market for patent protection. Swedish inventors seem to have internationalized their patenting strategies. On the global level, different nations and their inventors focus on a wider but increasingly similar set of nation markets for patenting. Different nations and their inventors also focus on increasingly diversified sets of technologies, which are also to some extent becoming increasingly similar across nations.

**Table 5.3 Statistical results on technology convergence and concentration (Paper III)**

| Index | n | 2005 Mean | 2009 Mean | Mean change | % Change | Estimated median of change |
|---|---|---|---|---|---|---|
| $d^{TS}$ | 3570 | 0.91999 | 0.89610 | -0.02389*** | -2.60% | -0.01728### |
| $d^{RTA}$ | 3570 | 609.0 | 681.3 | 72.3*** | 11.87% | -37.30### |
| $d^{RSTA}$ | 3570 | 65.628 | 65.768 | 0.140 | 0.21% | 0.2758# |
| $H^{T}$ | 85 | 0.2631 | 0.2021 | -0.0610* | -23.19% | -0.01658# |

Notes:
* Mean change different from zero with 0.05 significance (paired t-test)
** Mean change different from zero with 0.01 significance (paired t-test)
*** Mean change different from zero with 0.001 significance (paired t-test)
# Median change different from zero with 0.05 significance (Wilcoxon signed-rank test)
## Median change different from zero with 0.01 significance (Wilcoxon signed-rank test)
### Median change different from zero with 0.001 significance (Wilcoxon signed-rank test)

### *5.1.4 A change in patenting strategies*

The decrease in Swedish national patenting during the 2000s as described above raises questions about the reasons for such a decline, possibly including increasing internationalization of patenting as indicated above. Results from a questionnaire survey among Swedish patentees are presented in Paper I and Table 5.4, and cast additional light on this issue. The questions focus on causes behind changes in the number of priority patent applications among the responding firms. A *priority patent application* (first filing) is the first patent application for a specific invention (which can then be followed by subsequent applications to other PTOs), and changes in the number of priority patent applications thus indicate changes in either R&D output or changes in patenting strategies. In contrast to changes in the number of all patent applications as studied above, changes in the number of priority patent applications do not incorporate changes in the number of protected nation markets for individual inventions.

**Table 5.4 Explanatory factors behind a decrease and/or increase of first filings (priority patent applications) in different time periods (Paper I)**

| Weights of various factors as explanations for a decrease in first filing applications (scale: 0 = no weight, 4 = of decisive weight) 1) | **Large patentees 1998-2004** | **Small patentees 1998-2004** | **Patent consultancy firms 2001-2005 2)** | **Large patentees 1998-2004** | **Large patentees 1990-1997** | **Small patentees 1990-1997** | **Patent consultancy firms 1990-2000 2)** | Weights of various factors as explanations for an increase in first filing applications1) |
|---|---|---|---|---|---|---|---|---|
| 1. Reduction of R&D resources globally | | | | | | | | 1. Increase of R&D resources globally |
| a. for business-trend reasons | 1.55 | 0.82 | 1.38 | 1.36 | 1.33 | **1.90(2)** | **3.20(1)** | a. for business-trend reasons |
| b. for other (e.g., structural) reasons | **2.36(3)** | **1.55(3)** | **1.63(4)** | **2.15(5)** | **2.42(4)** | **1.80(3)** | 1.40 | b. for other (e.g., structural) reasons |
| 2. Reduction of R&D resources in Sweden | | | | | | | | 2. Increase of R&D resources in Sweden |
| a. for business-trend reasons | 1.55 | 1.09 | **1.50(5)** | 1.18 | 1.09 | 1.56 | **3.20(1)** | a. for business-trend reasons |
| b. for other (e.g., structural) reasons | **2.27(4)** | 1.36 | **1.50(5)** | **2.25(3)** | **2.58(3)** | **1.70(4)** | 1.40 | b. for other (e.g., structural) reasons |
| 3. Reduction of patenting resources | | | | | | | | 3. Increase of patenting resources |
| a. globally | 1.64 | 0.55 | 1.25 | 1.83 | 2.09 | 1.10 | 2.60 | a. globally |
| b. in Sweden | 1.55 | 0.82 | **2.00(2)** | **2.58(2)** | **2.38(5)** | 1.56 | **2.80(5)** | b. in Sweden |
| 4. Decrease in number of patentable inventions per R&D dollar | 1.27 | **1.45(5)** | 1.00 | 1.86 | 1.58 | 1.40 | 1.80 | 4. Increase in number of patentable inventions per R&D dollar |
| 5. Decrease of patenting propensity per patentable invention | **1.73(5)** | **2.09(1)** | 1.38 | **2.15(5)** | **2.83(2)** | **2.10(1)** | 1.40 | 5. Increase of patenting propensity per patentable invention |
| 6. Increase of R&D in areas with fewer possibilities of patenting (e.g., R&D in areas with service or social-science orientation) | 0.55 | 0.36 | 0.88 | 1.77 | 1.83 | 0.89 | 1.40 | 6. Increase of R&D in areas with greater possibilities of patenting |
| 7. Change in patent application strategy in the form of: | | | | | | | | 7. Change in patent application strategy in the form of: |
| a. More secrecy protection | 0.78 | 0.40 | 0.88 | 0.83 | 0.67 | 0.78 | 1.20 | a. Less secrecy protection |
| b. More selective patenting | **2.91(2)** | **1.55(3)** | **2.25(1)** | 1.33 | 1.83 | 1.00 | 2.40 | b. Less selective patenting |
| c. Increased demands on patent quality instead of patent quantity | **3.09(1)** | 1.18 | **1.75(3)** | 1.17 | 1.67 | 0.89 | 2.40 | c. Decreased demands on patent quality to the advantage of patent quantity |
| 8. Change in patents' role and economic importance in the form of: | | | | | | | | 8. Change in patents' role and economic importance in the form of: |
| a. Lower economic value | 0.40 | 0.91 | 0.63 | **2.18(4)** | 2.31 | 1.20 | **3.00(3)** | a. Higher economic value |
| b. Less importance for financing of continued R&D | 0.30 | **1.82(2)** | 0.75 | 1.27 | 1.58 | 1.10 | **2.80(5)** | b. Greater importance for financing of continued R&D |
| c. Less strategic importance in the branch of industry | 0.55 | 1.09 | 0.75 | **2.75(1)** | **2.92(1)** | **1.70(4)** | **3.00(3)** | c. Greater strategic importance in the branch of industry |
| 9. Higher total patent-application costs | 1.64 | 1.00 | 1.00 | 0.64 | 0.42 | 1.30 | 0.40 | 9. Lower total patent-application costs |
| 10. The patents' importance compared to other ways of exploiting an invention (secrecy, speed and efficiency in production and marketing etc.) has decreased | 1.09 | 1.00 | 0.88 | 1.92 | 2.00 | 1.20 | 1.80 | 10. The patents' importance compared to other ways of exploiting an invention (secrecy, speed and efficiency in production and marketing etc.) has increased |
| 11. Other factors | | | | | | | | |
| a. Disclosure through patents is more disadvantageous | 0.55 | 0,55 | 0.75 | | | | | |
| b. Change in the product range towards less patent-intensive products | 1.00 | 0.82 | 0.75 | | | | | |
| c. Shift in comprehensive product generations (e.g., 3G – 4G) | 0.82 | 0.27 | 0.75 | | | | | |
| d. Reduced government support to R&D | 0.00 | 0.45 | 0.88 | | | | | |
| e. Increased product specialization (i.e., less product diversification) | 1.27 | 0.55 | 0.88 | | | | | |
| f. Reduced risk of imitation | 0.09 | 0.55 | 0.75 | | | | | |

Notes: 1) The five most important factors for each company group are marked in bold (ranking within parenthesis).
2) While large patentees and small patentees were asked about first filings in general (FFs), the patent consultancy firms were asked about first filings to the Swedish PTO (SFFs). In addition, the patent consultancy firms were asked to specify factors behind a decrease during 2001-2005, compared to during 1998-2004 for large patentees and small patentees.

The results show that changes in R&D and patenting resources impact patenting frequency, confirming previous results (e.g., Scherer, 1983). In addition, a rise in the strategic importance of patents during the 1990s led to increased patenting, most probably partly as a result of macro level changes and the pro-patent era, while the decrease in patenting during the early 2000s is explained by more selective and more quality-oriented patenting, especially among large firms. This indicates that firms have adopted more efficient strategies, which goes in line with results by Ernst et al. (forthcoming) showing that proper patent management rather than patent quantity is conducive for firm success.

Results from questions that are not reported in Table 5.4 (see Paper I) further confirm the picture of internationalized patenting (especially among large patentees) that emerged from the patent statistics above. The decrease in patenting in general combined with the increased internationalization of patenting then led to the sharp fall in Swedish national patenting during the 2000s. Similar causes could probably be found for the declines in national patenting among other small European countries [see also Paper I as well as SOU (2006) and Granstrand (forthcoming)].

### *5.1.5 IP governance and IP assembly – cases from mobile telecommunications*

The case of Nokia is a case in point of internationalized intellectual property management practices of a dominant technology-based MNC in a small country, in this case Finland (see Paper I). Nokia was one of the largest patentees worldwide around the millennium shift, and the company held the largest portfolio of patents related to the major mobile telecommunications standards (see Paper IV). In the early 1990s Nokia's patenting had exploded as a result of disputes with Motorola and other large American firms. US patenting had caught up pace already in the early 1980s, partly due to the "patent wars" with Japanese firms (Granstrand, 1999). In the late 1980s and 1990s the aggressive strategies that were developed in these wars hit European firms, many of which at that time had not put sufficient emphasis on patents and IP management. This wakeup call led to Nokia starting to patent as much as possible in the early 1990s, partly to build retaliatory power, in turn leading to significant IP management learning. In the early 2000s (most probably as a result of the previous learning) this shifted to a focus on selective patenting with emphasis on quality instead of quantity, also with increased internationalization and use of the PCT system.

Nokia is a case in point also of the IP developments in the innovation system related to mobile telecommunications systems more generally. Ericsson, Nokia, and other European telecommunications firms had in many aspects been driving the developments of GSM and other mobile telecommunications standards. Despite involving multiple actors and major investments, the innovation system had been informally governed with limited patenting (see Paper IV). The case of the mobile telecommunications innovation system then illustrate how an innovation system initially characterized by implicit contracting and informal governance of technological resources is unstable and vulnerable to opportunistic strategy shifts of incumbents or new entrants that employ aggressive patenting strategies. There is typically no way to fight a patent but with a patent (Granstrand, 1999), and when Motorola entered the game, with aggressive patenting and enforcement, its European competitors quickly had to pick up pace in terms of their patenting to gain retaliation power, forcing the entire innovation system to move from informal to formal governance. Thus, emergences of pro-patent eras do not only take place at national level (see Paper III), but also at industry level. Subsequently, after the shift to formal governance, the case illustrates the emergence of a number of strategies to deal with hold-up problems and transaction costs, including cross-licensing schemes, patent acquisitions, horizontal integration, and institutional setups in form of FRAND requirements on licensing. Thus, the case illustrates the importance for strategic IP management to deal with the IP assembly problem and tragedies of the anticommons, as well as different managerial solutions for enabling freedom to operate.

### *5.1.6 The IP disassembly problem – cases from the automotive industry*

Another problem that strategic IP management must deal with is the *IP disassembly problem* (a concept coined in Paper VI), referring to the problem of separating and disintegrating IPRs for enabling a transaction or transfer of a part of a company, business, or project. Thus, the IP disassembly problem is of a reverse nature compared to the IP assembly problem. However, the IP disassembly problem could also be argued to consist of a number of assembly problems, since both the divesting unit and the divested unit must collect (assemble) the necessary rights in relation to each other to continue their businesses as separate units. Two cases of the management of IP disassembly problems in the automotive industry are reported here (see also Paper VI), the case of Saab Automobile and the case of Volvo Car Corporation (VCC).

The automobile production of SAAB AB was initiated after the end of World War II, when the firm needed to diversify its business to offset decreasing airplane orders, which was its main business before that. SAAB AB later merged with another Swedish automotive firm, Scania-Vabis, under the name Saab-Scania. In the 1990s the Saab cars division, Saab Automobile, was divested in two subsequent steps and sold to General Motors (GM). This first divestment process did not present any major IP disassembly problems. There were not many large technological overlaps that were patented, so the few patents that were held by the firm could fairly easily be divided between Saab Automobile and Saab-Scania. The shared trademark had to be handled, however. This issue was solved by trademark licenses to Saab Automobile, enabling the firm to use both the Saab name and the griffin logo. When Saab Automobile was integrated with GM, the technological interdependencies between the firm and its owner grew considerably, also since GM centralized its IP ownership in 2005. Thus, when Saab Automobile was to be divested from GM during 2008-2010, the IP disassembly problem became evident, also due to GM's resistance to sell Saab Automobile to potential competitors. Nevertheless, a deal was finally closed with Spyker Cars in 2010, a deal which included licenses to the GM technologies that were necessary for running the business of Saab Automobile. However, these licenses included change of control clauses (CCCs), meaning that GM could terminate the license agreements in case of a change of control of Saab Automobile. After the acquisition by Spyker Cars the sales of cars did not pick up pace fast enough, leading to continued losses within the firm. In order to finance the ongoing business, Spyker Cars needed to raise capital, implying a change of control of Saab Automobile. However, GM clearly stated its intention to execute the termination rights in the CCCs, limiting both financing and exit opportunities, and Saab Automobile eventually had to file for bankruptcy in the late 2011. Thus, in the acquisition from GM, Spyker Cars had not sufficiently disentangled Saab Automobile from its previous owner, clearly illustrating the potentially severe consequences of the IP disassembly problem.

The case of VCC has many resemblances with the case above. AB Volvo started automobile production in 1926/1927 as a unit within the Swedish bearing manufacturer SKF. In 1935 AB Volvo was divested and listed on the Swedish stock exchange, and the firm diversified into trucks, buses, construction equipment, marine engines, and aircraft engines. In 1999, AB Volvo divested its passenger cars business, VCC, to Ford. The IP disassembly problem was handled by a review process in which the IP was sorted according to its main belonging (to passenger cars or to something else). IP, and mainly patents, that clearly related to passenger cars were transferred to Ford while the rest were kept within AB Volvo. Any dependence on IP kept within AB Volvo was cleared by a collective license stipulating that VCC and Ford could keep using all IP that was used by VCC at the time of the divestment. The trademarks of joint importance were handled separately and put in a holding company co-owned by AB Volvo and Ford/VCC. Roughly a decade after the purchase, Ford initiated a divestment process of VCC in connection with the financial crisis and economic downturn around 2008, similar to GM and Saab Automobile. Ford had already divested Aston Martin, Jaguar, and Land Rover, and was therefore well prepared to handle the IP disassembly problem. The trademark issues could be easily handled by transferring Ford's share of the trademark holding company to VCC. The technological IP was categorized according to where it was developed (within VCC or within the rest of Ford) and according to its importance to Ford. This categorization was then matched by different IP transfers and IP license agreements (see Paper VI), solving the IP disassembly problem. Compared to GM and Saab Automobile, Ford's divestment of VCC was less pressured by time and separation agreements could be established *ex ante*, limiting transaction costs and hold-ups in connection to negotiation with the preferred buyer Geely Holding Group, who finally acquired VCC in 2010.

These cases illustrate not only the existence of the IP disassembly problem, but also some of its causes and potential consequences. It is likely that, with increasing technological complexity, diversification, and interrelatedness, the problem will increase in both importance and frequency in conjunction with the ensuing need to conduct various forms of open innovation (e.g., MADs, JVs). This will then probably lead to increased transaction costs and potential hold-ups, if not matched by improved management. It is clear that while the presence of IPRs here constitutes a problem, IP-related contracts such as licenses are also part of the solution. The cases then illustrate such remedies, and these will be further discussed in section 5.2.2.

### *5.1.7 Patent management in entrepreneurial SMEs*

This chapter has hitherto had an implicit focus on large firms. Previous research has showed that IP management in SMEs is quite different from that in large firms (e.g., Arundel & Kabla, 1998; Brouwer & Kleinknecht, 1999; Chabchoub & Niosi, 2005; Friesike et al., 2009; Iversen, 2003; Keupp et al., 2009; Mansfield, 1986), a difference that has not yet been sufficiently explained. Paper II addresses this gap by studying patent management in entrepreneurial SMEs. The empirical findings, summarized in Table 5.5, point at low patent competence among the studied firms, and limited resources for monitoring and enforcing their patents, leading to a limited protective function of the patents. Therefore, patenting was not primarily undertaken to deter imitation, contrasting previous studies (Arundel et al., 1995; Blind et al., 2006; Cohen et al., 2000; Duguet & Kabla, 1998; Granstrand, 1999; Keupp et al., 2009; Thumm, 2004). However, many of the entrepreneurial SMEs used patents for attracting customers (using patents as marks of the inventions' / products' qualities), and in the subsample of hi-tech SMEs patents were crucial for attracting venture capital (VC). Albeit contrasting previous results, these motives for patenting are in line with some of the main issues that entrepreneurial SMEs typically deal with; to find customers and to survive financially (Storey & Tether, 1998).

**Table 5.5 Results on patent management in entrepreneurial SMEs (Paper II)**

| **Sub-study** | **Type of firms** | **Empirical results** |
|---|---|---|
| Entrepreneurial hi-growth SMEs | Service as well as manufacturing firms of different ages | Most firms were not active in patenting |
| | | Patent competence was low |
| | | Patenting was of little or no perceived importance since a majority of the firms were not based on patentable innovations |
| | | When available, patents were used for customer marketing purposes |
| | | When used for customer marketing, the protective function of patents is not important and one patent per product is therefore enough |
| | | SMEs do not have enough resources for monitoring and enforcing patents |
| | | Costs and disclosure of information are main drawbacks with patenting |
| | | Patents are not prerequisites for high growth |
| Entrepreneurial hi-tech SMEs | Young (below twelve years) hi-tech firms within mechanical, electrical, computer, and chemical (and biotech) engineering | The firms were active in patenting and technical inventions were of major importance for firm growth |
| | | Patent competence was low |
| | | Patents were of little perceived importance for competitiveness and growth |
| | | Patents were of major importance for attracting investors/financiers |
| | | Patents were used for customer marketing purposes |
| | | SMEs do not have enough resources for monitoring and enforcing patents |
| | | Costs and disclosure of information are main drawbacks with patenting |
| Entrepreneurial region | Old firms (above 30 years) within mechanical and materials engineering | The firms were active in patenting |
| | | The larger firms had more patenting resources and competence than the smaller ones |
| | | The larger firms also put more trust than the smaller ones on patents' ability to deter imitation and patents were of more importance for their competitiveness |
| | | When internal patent resources were removed, the efficient and effective use of the patent system became limited |
| | | Patents were used for customer marketing purposes |
| | | SMEs do not have enough resources for monitoring and enforcing patents |
| | | Product quality and related manufacturing techniques and process technologies (protected by trade secrets) were more important for competitiveness than product patents |
| | | Patents were perceived unnecessary by some of the SMEs, and imitation was instead met by outstanding inventiveness and entrepreneurial spirit |
| | | A low inventive step requirement is a drawback for SMEs |

## 5.2 Prescriptive results for IP management in open innovation

IP management and patent protection have often been assumed to be closely linked to the “closed innovation paradigm”, aiming to protect technologies that have been developed in-house to enable high (monopolistic) margins on innovative products and services that are commercialized by in-house production and sales. However, this is an all too simplified picture as it misses out the relation between IP and innovation openness, and this interrelatedness has in recent years caught increasing attention (e.g., Alexy et al., 2009; Bader, 2006). IP and open innovation are not at all contradicting; IP is rather at the core for many types of open innovation, such as technology trade, licensing, and collaborative R&D, but developments in IP management are needed to decrease the related transaction costs.

### *5.2.1 Managing innovation openness*

To understand the role of IP in open innovation, it is first necessary to understand what open innovation actually is. The research literature provides a range of definitions, typically referring to innovation activities or processes crossing some form of organizational boundary (e.g., Chesbrough, 2003), although some definitions focus on innovations’ characteristics in terms of non-excludability (e.g., Baldwin & von Hippel, 2011). Technological innovation processes then include invention processes which result in new technologies, and commercialization processes which lead to market sales or in-house use of these new technologies (see section 2.1 and Figure 5.2). These processes are supported by resources $R$ (Penrose, 1959; Richardson, 1972) that may include human resources, financial resources, physical resources, background knowledge, etc.

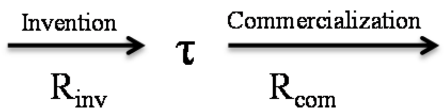



**Figure 5.2 The innovation process**

Considering the wide range of definitions of open innovation it is clearly not a one-dimensional concept, and a multidimensional framework of innovation openness is developed to better understand the different dimensions of it. The first dimension of innovation openness, as identified in Paper IV, refers to the distribution of resources involved in the innovation process, $R = R_{inv} + R_{com}$, over few or many resource holders (e.g., Granstrand et al., 1997; von Hippel, 2007). The second dimension refers to the governance of the technological resources, $\tau$, being developed in the innovation process. The governance mode relates to whether the focal technology is governed by explicit contracting enforceable by law, implicit contracting enforceable by markets (Klein et al., 1978) or social norms (Ostrom, 1999; Ostrom et al., 1999), or (possibly) no contracting at all. The mode of governance is important, since it impacts appropriability as well as tradability within the innovation system. The third and final dimension refers to the accessibility of the invented technologies, $\tau$, denoting how easy or cheaply the technology can be accessed and used by agents other than inventors and/or technology owners/holders. Thus, an innovation system can, deliberately or not, be designed to allow for access and use of technologies by external actors to various extents. The framework is illustrated in Figure 5.3. Note that this framework uses innovations as the unit of analysis rather than firms. See Paper IV for more details.

| | | | | |
|---|---|---|---|---|
| **Many resource holders** | 1) Informal innovation alliance/network | 2) Uncontrolled sharing | 3) Formal innovation alliance/network | 4) Controlled sharing |
| **Few resource holders** | 5) Closed (informal) innovation | 6) Open for uncontrolled sharing | 7) Closed (proprietary) innovation | 8) Open for controlled sharing |
| | **Low accessibility** | **High accessibility** | **Low accessibility** | **High accessibility** |
| | **Implicit contracting/informal governance** | | **Explicit contracting/formal governance** | |

**Figure 5.3 Framework for innovation openness (Paper IV)**

With the framework for innovation openness at hand, it is clear that IP management has an important role to play in open innovation (as well as in many other management areas, increasingly being penetrated by IP issues). For example, IP can be managed to enable high excludability and high direct returns from product or service sales, or to enable low excludability leading to cumulative and complementary innovations and indirect returns from complementary sales. Formal contracting is then typically less vulnerable to opportunistic strategy shifts among incumbents or new actors, as illustrated by the case of mobile telecommunications in section 5.1.5, and an important question for IP management is if and how to set up IP-based contracts to formally govern, coordinate, and incentivize actions and actors in the innovation system. A special case of this is dealt with in section 5.2.2, while section 5.2.3 deals with another pressing issue for IP management, namely how to divide the value created and captured by the innovation system among the involved resource holders.

### *5.2.2 Managing the IP disassembly problem*

The IP disassembly problem is introduced in section 5.1.6 in connection with cases from the automotive industry, and refers to the problem of separating and disintegrating IPRs for enabling a transaction or transfer of a part of a company, business, or project. The IP disassembly problem occurs when disintegrating two or more units of some form, thus shifting from a more to a less integrated organizational form, for instance by divesting a unit from a parent firm or by terminating a joint R&D venture. IP management must then provide a solution that enables the disintegrated units to continue their businesses as separate units, despite the fact that IPRs are spread across multiple agents. Paper VI provides a general framework for managing the IP disassembly problem in case of a divestment. This framework is presented in Figure 5.4, and the approach is to structure the IP related to the divestment in accordance with its importance for the selling firm and for the business for sale, respectively, resulting in a number of combinations. These combinations are then matched with different types and combinations of various provisions, including IP ownership transfers, IP licenses, and IP holding JVs.

The distribution of access and control of IP (cf. section 5.2.1) by the use of various contract provisions should preferably be matched with the distribution of techno-economic importance across the actors. An IP of core importance to the business for sale but of non-core importance to the selling firm should for instance be transferred to the business for sale in order to move the main control of the IP to the agent to whom it is of most importance, while the selling firm receives a license to the IP. These provisions can be fine-tuned to deal with various issues, such as uncertainty and dynamics (for instance in terms of varying importance of IP over time, as illustrated in the figure) by stipulating CCCs, grant-back clauses, sub-licensability, etc. (see Paper VI). All of this is subject to pricing and negotiation, however, which is illustrated by the case of Saab Automobile (see section 5.1.6).[37]

---

[37] Note that “on-diagonal” combinations are difficult to handle, and especially IP of core importance for both actors. Note also that this framework has not listed all contractual options, but rather the most important generic types.

| Importance for business for sale (BFS) \ Importance for selling firm (SF) | Core ⇄ *t* | Non-core ⇄ *t* | No importance |
|---|---|---|---|
| **Core** ⇅ *t* | License<br>IP holding JV | Transfer to / keep with BFS and license to SF | Transfer to / keep with BFS |
| **Non-core** ⇅ *t* | Transfer to / keep with SF and license to BFS | License<br>IP holding JV | Transfer to / keep with BFS |
| **No importance** | Transfer to / keep with SF | Transfer to / keep with SF | Divest<br>License to 3rd party<br>Store |

**Figure 5.4 Framework for managing the IP disassembly problem with dynamics over time *t* (Paper VI)**

### 5.2.3 *Proper IP pricing and value sharing*

Designing IP contract provisions, for instance as discussed above, is one important issue for IP management in open innovation. An equally important issue is how to price IP and share value across multiple stakeholders. Establishing fair and reasonable principles for value sharing has potential to decrease negotiations and transaction costs, leading to increased efficiency for both markets and quasi-integrated organizational forms such as partnerships. Fairness is a difficult concept however, and establishing new principles of fairness itself falls outside the scope of this thesis. Instead, the most common prevailing fairness principle in contemporary business is used to derive a model for determining FRAND royalties, namely the one that says that returns from a stock company should be divided among its shareholders according to their shares of the firm, i.e., according to their amount of invested capital. If applying the same principle to a licensing deal, the rate of ROI of the licensor(s) should equal the rate of ROI of the licensee(s), enabling the development of a multilateral investment-based method for determining FRAND royalties (see Paper V):

$$L_{ik} = \left(\pi_{op_{b_i}} - \frac{I_{b_i}}{I_{b.} + I_{s.}} \pi_{op_{b.}}\right) \frac{I_{s_k}}{I_{s.}} \quad , \quad where$$

$L_{ik}$ = license royalty to be paid by licensee $i$ to licensor $k$

$\pi_{op_{b_i}}$ = operating profit of licensee $i$

$\pi_{op_{b.}}$ = total operating profit of all licensees

$I_{b_i}$ = investment of licensee $i$

$I_{b.}$ = total investments of all licensees

$I_{s_k}$ = investment of licensor $k$

$I_{s.}$ = total investments of all licensors

While providing a simple and fair (in some sense) method for royalty determination, this model also suffers from its simplicity since licensing cases in practice might involve technologies with investments and operating profits that are difficult to separate from the ones of other technologies. However, adjustments can be made to the model to account for this, as described in Paper V. It can then also be argued that a FRAND model, like the one above, should be used as base case for further adjustments despite its limitations, rather than simple rules of thumb, such as the 25% rule of thumb (Goldscheider, 2011, 2012). That rule essentially says that a licensee should pay 25% of the related profits to the licensor, and thus lacks any connection to what could be viewed as fair in most cases, not the least in multilateral licensing.

Further, the investment-based method proposed above benefits from aligning the objective functions (profits) of the licensor(s) and licensee(s), meaning that there is less risk for opportunism by moral hazard (hidden action). There is however a risk for another type of opportunism in that the licensor(s) and/or licensee(s) can overestimate their investment levels and underestimate their profit levels in relation to other actors in order to impact royalty payments, and this needs to be monitored.

Similar to the situation with IP contracting in various forms, much advancement in the area of royalty determination and IP pricing is yet to come. The investment-based method for determining FRAND royalties then provides a first step in a promising direction towards fair models based on economic rationale.

# 6 Discussion

Strategic management of technological IP refers to formulating and executing strategies related to technological IP, including (1) how to acquire and create IP, (2) how to govern IP, and (3) how to exploit and extract value from IP. Figure 6.1 relates these different elements of strategic management of technological IP to the technology base of a focal firm by building on a framework of generic technology acquisition and exploitation strategies by Granstrand (e.g., Granstrand, 1982; 2010; Granstrand & Sjölander, 1990) and on TCT (Williamson, 1996). Different strategies to acquire and create technological IP include internal R&D, acquisition of innovative projects, units, or firms, joint ventures, technology in-licensing and/or purchasing, and technology scanning and intelligence. Different strategies to exploit and extract value from IP include internal exploitation (in-house production and marketing), creation and/or sales of innovative projects, units, or firms, joint ventures, technology out-licensing and/or sales. Additionally, IP can be stored without exploitation, or possibly leak. These strategies for IP acquisition and exploitation, respectively, can be ordered in accordance with their level of organizational integration (Granstrand, 2010), with the opposite then representing some form of "openness".[38]

Figure 6.1 relates the different strategies to the empirical and/or conceptual focus of the various appended papers. Paper IV has a wide focus on different forms of innovation openness, and it is therefore not surprising that it has relations to most of the strategies for acquiring and exploiting IP in Figure 6.1. Other examples include Paper II, focusing mainly on internal R&D and internal exploitation, Paper V, focusing mainly on licensing, and Paper VI, focusing mainly on corporate transactions (acquisitions and sales of innovative firms). All in all, this thesis covers most generic IP acquisition and exploitation strategies in Figure 6.1, albeit to various extent. Additionally, Paper III and to some extent Paper I are related to the institutional environment which has close interdependencies with IP strategies (see below).

[38] Note that while Figure 6.1 illustrates a situation for a focal firm, Figure 5.3, presenting the innovation openness framework from Paper IV, illustrates a situation for a focal innovation or set of innovations.

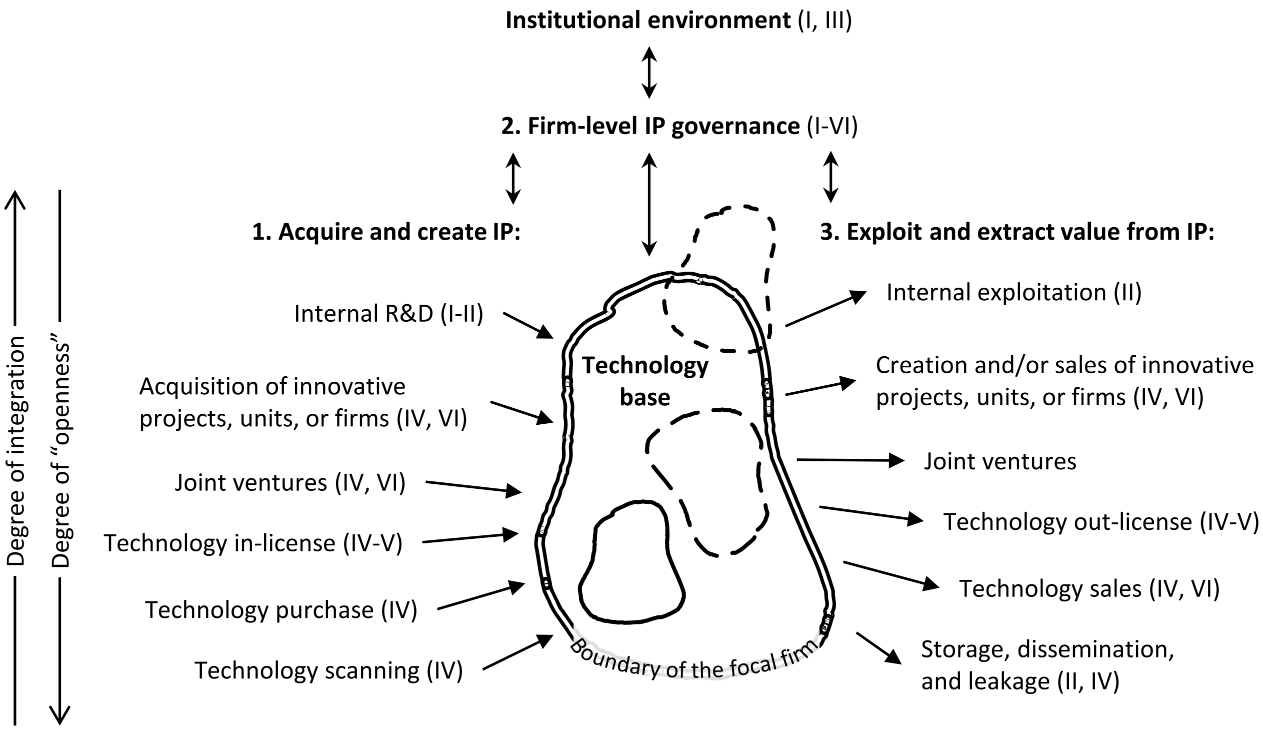



**Figure 6.1 Elements of strategic management of technological IP (with parentheses indicating relations to the appended papers)**

Firm-level IP governance is an overarching element of strategic IP management. The concept of governance is subject to ambiguity, but could be thought of "as an institutional framework in which the integrity of a transaction, or related set of transactions, is decided" aiming to "effect good order" and "workable arrangements" (Williamson, 1996, p. 11). Governance can relate to different levels, such as the governance of an innovation system or the governance of a firm within an innovation system (Andersen, 2006; Granstrand, 2006b), and is "the means by which *order* is accomplished in a relation in which potential *conflict* threatens to undo or upset opportunities to realize *mutual* gains" (Williamson, 1996, p. 12, emphasis in original).

Firm-level IP governance, which is the focus here, includes how to control and coordinate the technological IP of firms. This element is then interdependent with strategies for both IP acquisition and IP exploitation. As an example, technology out-licensing is easier to undertake with IP controlled by patents than with IP controlled solely by trade secrets. Thus, an out-licensing strategy both impacts and is impacted by the sort of control that is used for the relevant IP. Firm-level IP governance also includes monitoring and enforcing IPRs. Additionally, it relates to the accessibility of the technology base for outside agents, which is illustrated by the various types of boundaries for different sets of IP in Figure 6.1. The explicit focus on *firm-level* does not mean that interactions between firms and interorganizational relationships are excluded from the concept. On the contrary, firm-level IP governance, as any type of governance, is always incorporating an agent's relations to other agents. Therefore, firm-level IP governance is closely related to innovation openness. This is further discussed in section 6.2.

Two important parts of firm-level IP governance are of special interest for this thesis: (a) IP contracting and (b) IP pricing and value sharing (see also section 5.2). Papers I-IV and VI relate to IP contracting of various types (propertization of intellectual resources through various informal and formal means, contractual designs between agents, etc.), while mainly Papers IV-V relate to IP pricing and value sharing (e.g., royalty determination).

As illustrated by Figure 6.1, IP governance is related to macro level factors and the institutional environment, such as available IPR systems (e.g., laws) for different types of technologies, enforcement systems (e.g., courts), and other policies (e.g., incentive systems), but also norms and customs. Thus, the element of firm-level IP governance depends on the institutional environment (see also Williamson, 1996). This is further discussed in section 6.1.

When incorporating IP management into the framework for acquisition and exploitation of the technology base of a firm, questions arise regarding the boundary of the firm. Intellectual resources, not being tied to physical objects, can be acquired, created, controlled, and exploited by multiple agents simultaneously and also independently (e.g., by independent, simultaneous discovery or invention). Additionally, intellectual resources can be controlled by multiple agents, raising uncertainties about ownership. In a similar fashion as RBT (Penrose, 1959), PRT says that a firm is composed by the resources it owns (Grossman & Hart, 1986), defining the owner as the holder of the residual rights. Since intellectual resources might span organizational boundaries (see Figure 6.1), for instance due to shared or unclear ownership or weak enforceability (as illustrated by the SMEs in Paper II), the boundaries of firms become blurred. This issue is further discussed in section 6.3.

A number of important aspects are naturally left out from the figure for simplicity reasons. Two left out aspects can be mentioned here. The important connection between IP management and general management is not explicitly illustrated in the figure. Strategic management of technological IP is an important part of (strategic) technology management, which in turn is an important part of general/corporate management. The second aspect left out is the interdependencies between the strategic IP management of the focal firm and the IP management of other agents (see, e.g., Paper IV). IP issues are always handled in relation to others. Both IP acquisitions and IP exploitations involve outside agents, and the governance of IP always relates to other agents, as described above.

### 6.1 Institutions, governance, and learning

In connection to increasing internationalization and globalization, including internationalized patenting strategies as identified in Papers I and III, firms have started to rely upon an increasing number of different institutions across the globe. Although large differences still exist across nations, some of these institutions, such as patent and copyright laws, have been subject to harmonization efforts since decades and even centuries in some cases (Granstrand, 1999, 2003). These harmonization efforts have been pushed by, for instance, the WTO and interest organizations such as the International Association for the Protection of Intellectual Property (AIPPI). Harmonization then refers both to harmonization of laws and to harmonization of law enforcement, law adherence, and court practices (see Paper III).

The institutional environment in a nation has important implications for the management of firms on that nation market (Porter, 1990). The national IPR system can be used for promoting nationalistic interests and the management of the system is thus of importance for the competitiveness of the nation and its firms. In that context, the competitiveness of the nation's firms relative foreign firms might be more important to promote when designing IPR systems than the dynamic and static competition among firms in general. Strong and weak IP regimes might therefore be of different use throughout the industrialization process of a country.  Weak IP regimes are then typically useful when catching up while strong IP regimes are typically more beneficial when forging ahead, at least in certain industries. Therefore, IPR systems typically co-evolve with the level of industrialization in the country (see also Paper III).

Changes in IP regimes and institutions are currently occurring in China and India, essentially strengthening the protection of IP. Chinese and Indian firms and inventors are increasingly active in worldwide patenting (Paper III). Both countries have set targets on highest political levels to become innovation-based nations until year 2020, and IP issues are set high on the agenda. As an example, Chinese patentees are financially rewarded when applying for patents, a measure taken to spur Chinese patenting. Doubts have been raised regarding the quality of Chinese and Indian patents (just as the Japanese patent quality was once doubted), and such doubts might very well be justified in the short run. In the longer run the quality of current patent applications is secondary, however, since both China and India engage in learning processes that will likely lead to increased quality of technologies, innovations, and patents, similar to what has happened in other nations (e.g., Sweden) where pro-patent eras have emerged. The use of utility model systems (complementing the patent systems), enabling a simpler, cheaper, and weaker type of patents, can further spur the learning process (Kim et al., 2012). Such a system is in place in China, and India is currently discussing whether or not to introduce a similar one. Spillovers from foreign direct investments (FDIs) in these countries will likely be conducive for the learning process as well (Cheung & Lin, 2004). Learning then occurs both in relation to how institutions should be designed (e.g., Kim et al., 2012) and in relation to how IP should be managed within an institutional environment (e.g., Keupp et al., 2010), and these issues co-evolve. IP management continuously adapt to institutional changes (e.g., van Zeebroeck et al., 2009), and institutional designs need to adapt to changes on firm level. These changes may in turn relate to foreign institutions, as exemplified by the consequences for the Swedish PTO from the increased use of foreign and international institutions, and thereby decreased use of domestic institutions, by Swedish patentees (see Paper I).

There are then different phases of learning IP management, as indicated by Paper I for the case of patenting. In a first phase, characterized by learning-by-doing, patenting is steeply increasing after the recognition of its importance. As firms and patentees gain knowledge about patenting, focus shifts to more selective, quality-oriented, and resource efficient patenting through a second phase of learning.[39] Earlier findings also support the argument that patenting is learnt over time, although the sources of learning are unclear (Mowery et al., 2002).

The internationalized and converging patenting behaviors as identified in Papers I and III, be they emergent or deliberate strategy developments, will likely lead to an increasing number of competitive IP encounters, such as license offers, infringement litigations, and hold-up problems, between firms of different nationalities. Thus, firms need to develop international IP management skills, adapted to various institutions, to mitigate transaction costs as they become increasingly diversified across markets and technologies and are subject to an increasing number of international competitive IP encounters. These encounters are then also sources for inter-organizational learning, and they will therefore likely further spur management convergence through knowledge transfer and competitive exclusion of inferior management. In addition to such consequences, the internationalization leads to higher requirements on IP management skills, and it could therefore further increase the relative disadvantage of SMEs, since they often have too few resources for IP management (Paper II).

[39] Further developments (subsequent phases) are yet to be identified.

## 6.2 IP management and open innovation

Strategic management of technological IP is (probably) always related to issues of innovation openness. In fact, one of the main purposes of a patent system is to stimulate the disclosure and diffusion of new knowledge, as described in section 2.2. On the strategic level, all three elements of strategic IP management in Figure 6.1 are related to innovation openness, as argued below.

*First*, strategic management of technological IP partly deals with controlling technologies and the accessibility to them (Paper IV) by firm-level IP governance. Technologies, being a subset of knowledge in general, are impure public goods (Stiglitz, 1999), and one important issue for IP management is then to handle the excludability dimension of technological resources; what degree of excludability (or oppositely accessibility) should be related to specific technologies. This dimension can be controlled by various forms of informal or formal IP governance, or in other terms implicit or explicit contracting (Klein et al., 1978). Formal IP governance, by the use of patents, copyrights, explicit contracts, etc., is then not limited to enable exclusivity, as is commonly assumed, but can also enable and ensure accessibility to innovations, as illustrated by open source software and the use of the General Public License (GPL). Open source software relies not only on formal governance through various license agreements to ensure high accessibility, but also on informal governance through social norms that are of importance for enforcing the GPL (O'Mahony, 2003), and these different forms of governance are often complements rather than substitutes.

Informal governance of technologies and innovation openness is however likely vulnerable to opportunistic actions of other agents (Paper IV). Since informal governance (implicit contracting) relies upon enforcement by markets (Klein et al., 1978), recurrent contracting may mitigate some of these problems. However, recurrent contracting might eventually lead to asset specificities and small-numbers conditions, again possibly leading to opportunism (Williamson, 1975, 1983, 1985), for instance in cases of cumulative and complex technologies with high invent-around costs in which an inventor can switch to formal governance and patent its inventions to create a hold-up position. This is illustrated by the case of mobile telecommunications in Paper IV. Such a strategic move will then likely force other actors to also move to formal governance in order to create retaliatory power, in turn possibly leading to increasing integration due to increasing (market) transaction costs and hold-up problems (Hart, 1995).

Opportunism is however not limited to informal governance. Hold-up problems can emerge when the bargaining power is very skew, as exemplified by the post-divestment relation between GM and Saab Automobile in Paper VI. Another, more extreme, example is when a non-producing entity (NPE) holds a patent necessary to a producing firm (e.g., Ewing & Feldman, 2012). The NPE has no business that could be harmed by retaliation, and can without risk create severe hold-up costs for the producing firm in order to maximize licensing revenues or damages. Part of the solution to this problem is tools for FRAND royalty determination, which is central also in open innovation in general since value needs to somehow be shared across multiple actors (Paper V). Proper tools for calculating FRAND royalties are thus important for both open innovation initiatives and courts.

Courts are then important for enforcing FRAND and other principles, and in the longer run the principles enforced by courts will likely spread to markets, leading to an increased share of market solutions to hold-up problems, infringement cases, and IP assembly problems, and thereby fewer court cases and lower transaction costs. It is likely that immature technological areas are subject to relatively more court cases than mature ones, since court cases are needed to establish the "rules of the game" (North, 1990; Williamson, 1996), for instance in terms of what rights the IPRs actually give to its owner. If courts rely upon predictable, visible, and transparent principles, those principles will likely transfer to the market faster than if they are difficult to see and/or understand. Thus, courts have an important role to play in mitigating transaction costs on the market and enabling various forms of open innovation (see also Eggertsson, 1990). Similarly, firms and markets can create institutions that mitigate transaction costs, such as ETSI and FRAND principles in the case of mobile telecommunications (see Paper IV).

*Second*, strategic management of technological IP deals with the acquisition of technological IP to the firm, or in other terms inbound open innovation (Dahlander & Gann, 2010; Enkel et al., 2009; Laursen & Salter, 2006). Such acquisition can refer both to acquiring technological capabilities that enable new business opportunities in combination with resources already available internally, and to mitigating the IP assembly problem by enabling freedom to operate. The former is then related to value creation by enabling new combinations of technologies and other resources (Moran & Ghoshal, 1999; Penrose, 1959; Porter, 1985; Schumpeter, 1934), while the latter is related to mitigating tragedies of the anticommons (Heller, 1998; Heller & Eisenberg, 1998), and these processes are often related and combined (e.g., Paper VI).

A related issue is that new and improved markets for technologies and IP (e.g., Benassi & Di Minin, 2009) enable new forms of IP management. Besides providing a source of technologies, such markets can enable defendants to buy retaliatory power "off the shelf", meaning that in-house invention and patenting for retaliatory purposes could possibly decrease, while patent purchasing would probably increase. In an infringement case in 2012 in which Yahoo (plaintiff) accused Facebook (defendant) for patent infringement, Facebook counterclaimed that Yahoo was infringing ten of Facebook's patents. Eight of these ten patents had been purchased by Facebook with the sole purpose to gain retaliatory power, according to Yahoo. This case eventually ended with a settlement, probably under terms much different from what Yahoo had hoped.[40]

*Third*, strategic management of technological IP deals with the exploitation of technological IP through various channels, or in other terms various forms of outbound open innovation (Dahlander & Gann, 2010; Enkel et al., 2009; Tranekjer & Knudsen, 2012). IP management then provides new commercialization channels for firms (Chesbrough, 2003). These can enable IP value extraction and commercialization on markets and/or for applications that would be economically infeasible to undertake by in-house production and marketing, leading to additional value for both inventors and customers.

As described above, IP management must deal with these issues by providing (implicit or explicit) contractual solutions to the acquisition and exploitation of IP (e.g., Papers IV and VI) and pricing and value sharing principles (e.g., Paper V). There is a multitude of IPR contracts available [see, e.g., Bogers et al. (2012) for various generic licensing schemes], and there is also most likely a multitude of IPR contracts that will or can be designed to better govern various types of open innovation. Papers IV-VI provide frameworks, models, and tools that contribute to this area, but much more research is needed. This is further discussed below.

### 6.3 IP management and economic organization

While the preceding section focused on the relation between IP management and open innovation, this section focuses on the relation between IP management and economic organization more generally, albeit with close connections to innovation openness. Both RBT and PRT place resources at the core of the firm, essentially saying that the firm consists of the resources (assets) it owns (Grossman & Hart, 1986; Penrose, 1959).[41] Ownership can then be defined as control of residual rights (Grossman & Hart, 1986). Since strategic IP management partly deals with the control of technological resources, as described above, IP management clearly has direct implications for the boundaries of firms, as identified by PRT and RBT.

However, considering the uncertainties surrounding the control of IP, for instance in terms of validity and enforceability of IPRs, the boundary of the firm is subject to uncertainties and ambiguity. Additionally, even when ownership is clear, strategic IP management can be directed for the firm to tap into external resources

---

[40] See, for example, Ewing (2012) for a more detailed account on this case.

[41] Note however that Penrose (1959) expresses concerns related to the ambiguity of the concept of the firm.

by the use of various strategies (see, e.g., Figure 6.1), related to various degrees of integration, also subject to uncertainties due to bounded rationality (Simon, 1947) and incomplete/imperfect contracting (Coase, 1988; Hart, 1995; Williamson, 1985, 1996). Thus, when technological resources are involved, or intellectual resources more generally, the boundaries of the firm are unclear, and subject to strategic IP management decisions. This places IP management at core for general management, and IP strategies must thus be integrated with general corporate strategies.[42]

Developments and learning in three interdependent IP-related areas can be identified as of importance for economic organization (see also section 6.1). First, *technological developments and learning* (for instance in ICTs and transportation technologies) impact transaction costs, both on the market and within the firm (management costs). It is difficult to say, however, whether these technological changes will persistently promote integration or disintegration in the long run. Second, *developments and learning in IP management* impact economic organization, most likely towards increased use of different types of quasi-integrated organizational forms. This is at least likely in the nearest future, spurred by various open innovation initiatives in which quasi-integrated IP management skills will be developed, not the least from learning-by-doing. Third, *developments and learning in IP contracting and law* will impact possibilities for quasi-integration. Private ownership as well as ownership transfers are since long well established institutions and related to integration (hierarchy) and trade (market). It is therefore likely that developments in the contractual and legal area will rather improve the relative efficiency of quasi-integrated organizational forms, as illustrated by co-ownership structures, JVs, licensing and cross-licensing schemes, etc. As new contracts are standardized, and possibly also automated, transaction costs will decrease. While the effects of technological developments on economic organization are difficult to forecast, a hypothesis forwarded here is thus that IP management innovations and IP contract innovations will lead to relatively more efficient and more use of quasi-integrated organizational forms. This, in turn, will lead to increased innovativeness at large due to, for example, increased combinatorial possibilities of resources.

This section is now concluded by returning to the two trends underlying this thesis, i.e., the increased use and importance of patents in the pro-patent era and

[42] At this point, it should be clear that IP management is much more than patent management in specialized patent departments, although the latter is of course an important function for IP and general management, also in cases of distributed IP management, as in a corporate patent culture where patenting is a concern for all engineers.

the increased focus on open (and collaborative) innovation (see chapter 2.3). In such an environment, IP management and IP contracting become key issues for handling interorganizational technology relationships (including both IP control and IP value sharing issues). A firm's network competence, i.e., the "ability to handle, use, and exploit interorganizational relationships" (Ritter & Gemünden, 2003, p. 745), is thus dependent on its IP management and IP contracting competences. The fact that network competence impacts both the extent of technological collaborations across firms and innovation success positively (*ibid.*) then supports the above hypothesis that IP management and contracting skills will foster quasi-integration and thereby innovativeness.

### 6.4 Implications for management and policy

The results of this thesis have multiple implications for both management and policy. On the management side, SMEs need to at least gain basic insight and knowledge about IP issues, while larger firms need to build international IP management skills to meet competitive challenges in the (converging) international business landscape with increasing IP encounters. Especially, interorganizational IP management skills useful for different forms of open innovation are needed. Contractual developments and value sharing principles are then useful for enabling interorganizational technological relationships and quasi-integration, which will likely enable increased innovativeness and firm success. This thesis contributes to this area by providing a number of different frameworks, models, and tools (Papers IV-VI).

Considering the importance of technologies for contemporary businesses, and the importance of IP for managing the control of and access to the technology base of the firm, strategic IP management is a central issue for all technology-based firms. IP management has long-term effects on corporate strategies and future business opportunities, not the least due to the lifetimes of patents, trade secrecy rights, copyrights, trademarks, and other IPRs. Top management should recognize this fact and integrate IP management with technology/innovation management and general corporate management.

When it comes to open innovation, multiple dimensions of openness can be managed to foster the technical, commercial, and economic success of firms (Paper IV). Rather than "opening up" their innovation processes in general, firms should consider these dimensions and evaluate what combination of different types of openness that suit them, and develop IP strategies accordingly. Any open innovation activity might then eventually be subject to terminations or exits. Therefore, management must consider the IP disassembly problem at an early stage, since subsequent exit opportunities can be strictly limited if the problem is mismanaged. This necessity seems not to be sufficiently attended to by the many promoters of open innovation.

On the legal institutional level, uncertainties can and should be decreased in order to mitigate opportunism and transaction costs. Such uncertainties may relate to validity of patents, ownership of IP, damage and license calculations, etc. It is therefore of importance that courts enable transparency, leading to improved predictability and decreased uncertainty. Currently, many IP court cases are subject to record sealing, meaning that (at least part of) the case documentation remains confidential, typically due to requests from the involved parties. Due to this and the fact that settlements are common and typically not published, a large share of court cases lack transparency of value to learning by third parties. Especially the field of IP pricing and value sharing would benefit from increased transparency. Fairness principles established by courts could then diffuse on the market and be implemented in negotiations and treaties; leading to lower transaction costs, including fewer cases ending up in court. It is then of course of utmost importance that courts employ methods and models based on sound economic rationales. Thus, the dismissal of the 25% rule of thumb by the US CAFC in 2011 was a step in the right direction (Paper V).

Additionally, since IP negotiations are costly it is important for policy to properly design the system to avoid “over-propertization” and tragedies of the anticommons. Especially SMEs have navigation problems with a decreasingly maneuverable IPR landscape (Paper II), although it raises problems for large firms as well. Actions to “raise the bar” in terms of inventive step requirements for patentability can be mentioned as just one example of legal actions that can mitigate some of these problems.

Finally, the internationalization and market convergence of patenting (Papers I and III) lead to decreased importance for PTOs in small nations, such as the Swedish PTO. This in turn has implications for domestic patent consultancy industries, since they are typically oriented towards the national PTOs regarding legal competence, language preferences, etc. Both national PTOs and patent consultancy firms need to adapt to this changing patenting landscape.

## 6.5 Directions for future research

This thesis has pointed at the intertwined processes of on one hand managing intellectual property and on the other hand managing innovation in general and more specifically managing innovation openness (ranging from “closed” to “open” in some sense). A one-dimensional view of innovation openness is overly simplistic, and this thesis (Paper IV) provides researchers with a multi-dimensional framework that is possible to operationalize and that incorporates some of the most important issues for innovation openness. Precise assessments of "degree of openness" or quasi-integration on one hand and technical and economic performance on the other hand are by and large absent (with some exceptions). More research is thus needed, including more research on how IP should be managed with increasing interorganizational technological relationships of various forms, in light of the probably industry and technology specific links between openness and techno-economic performance.

This leads to the importance of advancements in interorganizational IP governance. As argued above, developments are needed both on the contractual side and on the pricing side. Future research should develop new contractual solutions and IP pricing and value sharing principles. This thesis has made a couple of contributions to this area (Papers V and VI). However, further developments and more research is needed, and scholars, practitioners, and courts must continuously contribute to institutional and contractual innovations to mitigate transaction costs.

IP management and policy issues might then need to be addressed individually for specific technological areas, industries, and types of firms. For example, the area of IPR issues in an environmental and sustainability context is especially interesting, incorporating problems with both impure public goods (technologies) and common goods (natural resources). Transaction costs, hold-ups, and opportunistic behavior might have especially severe consequences in this area, inhibiting the diffusion of environmental technologies. Researchers should take a proactive role in mitigating this. A second important area is how the IP system and innovation and IP policies can be altered to decrease the relative disadvantage for SMEs (Paper II). This is not limited to changes in law and court practices, but also includes awareness and teaching campaigns, financial support, external advisors, etc. Research is then needed on how such modifications and systems should be designed.[43]

Internationalized and converging patenting will likely lead to a concentration of patenting, patents, and related issues (such as infringement cases and licensing deals) to certain nation markets (Papers I and III). This relates to a number of questions open for further research. Which nation markets will rise as the dominant IP nation markets (if any, market convergence might eventually slow down and even change direction, even though the latter is unlikely)? How will this affect institutions and management in these and other nations?

A final suggestion relates to the use of patent statistics in general R&D and innovation studies. Patents are commonly used to measure the inventive

[43] See SOU (2006) for suggestions in this area.

productivity of firms and nations. The results of this study contain a number of reasons to question the validity of this measure. There is indeed a relation between invention production and the number of patents (of which many if not most are never commercialized), but due to differences in IP strategies over nations, industries, firms, and time, this relation is not easy to assess. Any results obtained from patent data must therefore be analyzed with great care before drawing conclusions for innovativeness and R&D productivity.

# 7 Conclusions

This thesis has dealt with the field of strategic management and economics of technological IP. This field has been of growing importance among practitioners and (later) researchers alike since the advent of the pro-patent era in the 1980s. This era originated by and large as a result of macro level policy changes in the US, in turn gradually leading to broad-based changes in micro level firm strategies and increased importance of IP for businesses around the world. In addition, the field has become increasingly important in the management of various types of open innovation processes, leading to new requirements on the management of technological IP. This thesis has contributed to this field, with the purposes (1) to explore and explain strategic and innovation related intellectual property management practices and their consequences, and (2) to develop managerial and economic frameworks, models, and tools to be used in the intersection between intellectual property management and open innovation practices.

These purposes have been addressed in this cover part and in six appended papers. The papers can be structured and matched according to their relevance for different elements of the strategic IP management concept, all in all relating to the acquisition of IP, the governance of IP, and the exploitation of IP. These elements, in turn, can be related to different degrees of organizational integration, indicating the close link between the field of IP management and theories of the firm, and between IP management and innovation openness.

The thesis shows that large firms have shifted focus from quantity-oriented to more selective and quality-oriented patenting and that IP management practices have become internationalized. Results suggest that not only IPR laws tend to converge internationally, but also IP management practices, for instance in terms of output markets for patenting and to some extent the technological areas that are patented. Although convergences in IP management practices on a general level can be identified, the IP management skills of SMEs seem to have fallen behind those of large firms, not the least due to limited resources for acquiring, monitoring, and enforcing IPRs.

The convergence in market and technology selections, in combination with an increasing importance of IP in general, will likely lead to an increasing number of IP-based business encounters, be they litigation-related, licensing-related, or something else. In combination with the use of different forms of open innovation, this puts increasing emphasis on interorganizational IP management skills to improve the governance of technologies and open innovation systems and to decrease transaction costs. IP management is then not (and has never been) only about maximizing excludability, and strategic IP management must therefore be integrated with corporate management, strategies, and business models. A consequence is that IP management responsibilities cannot be limited to specialist departments, such as patent departments, but must be distributed across all relevant functions of the firm.[44]

In order to mitigate transaction costs in connection to interorganizational and technological relationships this thesis argues for the need of new IP contracts on one hand and new IP pricing and value sharing (fairness) principles and models on the other hand. On the contractual side, the thesis provides a framework with contractual combinations suitable for managing the IP disassembly problem. On the pricing and value sharing side, an investment-based method for FRAND royalty determination is provided as a promising tool for enabling fairness in licensing deals. Further developments in this area are needed, however, and not only in terms of new contracts and new value sharing principles (as separates), but also in terms of matching contracts with valuation and fairness principles.

With increasing learning and developments in IP management skills in general, and contracting, pricing, and valuation skills more specifically, it is likely that the transaction costs related to quasi-integrated organizational forms will decrease, leading to an increased use of these forms of organization (everything else – e.g., technology – equal). By enabling new resource combinations, interorganizational technological relationships and quasi-integration will, in turn, have a positive impact on innovativeness.

Learning and developments in IP management are therefore conducive for economic growth and welfare developments, despite a possible parallel emergence of new types of abuse and opportunism. Thus, scholars and practitioners, as well as courts, should aim for developing and diffusing new and useful IP management practices and IP contracts. Despite the fact that these types of innovations are typically not of technical character, and probably not patentable, they might very well be the most important types of innovations for future technological developments.

---

[44] This does not mean that there should be no IPR-related specialist departments. These are most probably necessary to enable economies of scale and cross-fertilization across units, divisions, etc. However, the responsibilities for strategic IP management on a general level should not be limited to such a department, but should rather be distributed to engage all relevant functions, in turn interacting with any available specialist departments.

## List of references

Abramovitz, M. 1986. Catching up, forging ahead, and falling behind. *The Journal of Economic History*, 46(02): 385-406.
Adner, R., & Kapoor, R. 2010. Value creation in innovation ecosystems: How the structure of technological interdependence affects firm performance in new technology generations. *Strategic Management Journal*, 31(3): 306-333.
Ahuja, G. 2000a. Collaboration networks, structural holes, and innovation: A longitudinal study. *Administrative Science Quarterly*, 45(3): 425-455.
Ahuja, G. 2000b. The duality of collaboration: inducements and opportunities in the formation of interfirm linkages. *Strategic Management Journal*, 21(3): 317-343.
Alchian, A. A., & Demsetz, H. 1972. Production, information costs, and economic organization. *The American Economic Review*, 62(5): 777-795.
Alchian, A. A., & Demsetz, H. 1973. The property right paradigm. *The Journal of Economic History*, 33(1): 16-27.
Alexy, O., Criscuolo, P., & Salter, A. 2009. Does IP strategy have to cripple open innovation? *MIT Sloan Management Review*, 51(1): 71-77.
Almeida, P., & Kogut, B. 1999. Localization of knowledge and the mobility of engineers in regional networks. *Management Science*, 45(7): 905-917.
Andersen, B. (Ed.). 2006. *Intellectual Property Rights: Innovation, Governance and the Institutional Environment*. Cheltenham: Edward Elgar Publishing.
Archibugi, D., & Pianta, M. 1992. Specialization and size of technological activities in industrial countries: The analysis of patent data. *Research Policy*, 21(1): 79-93.
Archibugi, D., & Pianta, M. 1994. Aggregate convergence and sectoral specialization in innovation. *Journal of Evolutionary Economics*, 4(1): 17-33.
Arora, A. 1997. Patents, licensing, and market structure in the chemical industry. *Research Policy*, 26(4–5): 391-403.
Arora, A., & Ceccagnoli, M. 2004. Patent protection, complementary assets, and firms' incentives for technology licensing, *Working Paper Series. Social Science Research Network.*
Arora, A., Fosfuri, A., & Gambardella, A. 2001. *Markets for Technology: The Economics of Innovation and Corporate Strategy*. Cambridge, MA: MIT Press.
Arrow, K. J. 1962. Economic welfare and the allocation of resources for invention. In National Bureau of Economic Research (Ed.), *The Rate and Direction of Inventive Activity: Economic and Social Factors*: 609-625. Princeton, NJ: Princeton University Press.
Arrow, K. J. 1974. *The Limits of Organization*. New York: Norton.
Arundel, A. 2001. The relative effectiveness of patents and secrecy for appropriation. *Research Policy*, 30(4): 611-624.
Arundel, A., & Kabla, I. 1998. What percentage of innovations are patented? Empirical estimates for European firms. *Research Policy*, 27(2): 127-141.
Arundel, A., van de Paal, G., & Soete, L. 1995. *Innovation Strategies of Europe's Largest Industrial Firms: Results of the PACE Survey for Information*

*Sources, Public Research, Protection of Innovations and Government Programmes*. Maastricht: MERIT.

Bader, M. A. 2006. *Intellectual Property Management in R&D Collaborations: The Case of the Service Industry Sector*. Heidelberg: Physica-Verlag.

Balassa, B. 1965. Trade liberalization and "revealed" comparative advantage. *The Manchester School of Economic and Social Studies*, 33(June).

Baldwin, C. Y., & von Hippel, E. 2011. Modeling a paradigm shift: From producer innovation to user and open collaborative innovation. *Organization Science*, 22(6): 1399-1417

Barney, J. B. 1991. Firm resources and sustained competitive advantage. *Journal of Management*, 17(1): 99-120.

Barney, J. B. 1997. *Gaining and Sustaining Competitive Advantage*: Addison-Wesley.

Barney, J. B. 2001. Is the resource-based "view" a useful perspective for strategic management research? Yes. *Academy of Management Review*, 26(1): 41-56.

Barney, J. B., & Hesterly, W. S. 2005. *Strategic Management and Competitive Advantage: Concepts*. New Jersey: Pearson Education.

Baumol, W. J. 2002. *The Free-Market Innovation Machine: Analyzing the Growth Miracle of Capitalism*. Princeton and Oxford: Princeton University Press.

Bekkers, R., Duysters, G., & Verspagen, B. 2002. Intellectual property rights, strategic technology agreements and market structure: The case of GSM. *Research Policy*, 31(7): 1141-1161.

Benassi, M., & Di Minin, A. 2009. Playing in between: patent brokers in markets for technology. *R&D Management*, 39(1): 68-86.

Bessen, J. 2004. Holdup and licensing of cumulative innovations with private information. *Economics Letters*, 82(3): 321-326.

Bessen, J., & Maskin, E. 2009. Sequential innovation, patents, and imitation. *The RAND Journal of Economics*, 40(4): 611-635.

Bessen, J., & Meurer, M. J. 2008. *Patent Failure: How Judges, Bureaucrats, and Lawyers Put Innovators at Risk*. Princeton, NJ: Princeton University Press.

Bhaskar, R. 1989. *Reclaiming Reality: A Critical Introduction to Contemporary Philosophy*. London: Verso.

Björkdahl, J. 2009. Technology cross-fertilization and the business model: The case of integrating ICTs in mechanical engineering products. *Research Policy*, 38(9): 1468-1477.

Blind, K., Edler, J., Frietsch, R., & Schmoch, U. 2006. Motives to patent: Empirical evidence from Germany. *Research Policy*, 35(5): 655-672.

Blind, K., & Thumm, N. 2004. Interrelation between patenting and standardisation strategies: Empirical evidence and policy implications. *Research Policy*, 33(10): 1583-1598.

Bogers, M., Bekkers, R., & Granstrand, O. 2012. Intellectual property and licensing strategies in open collaborative innovation. In C. de Pablos Heredero, & D. López (Eds.), *Open Innovation at Firms and Public Administrations: Technologies for Value Creation*: 37-58. Hershey, PA: IGI Global.

Bontis, N. 2002. *World Congress on Intellectual Capital Reading*. Boston: Butterworth Heinemann.
Bound, J., Cummins, C., Griliches, Z., Hall, B. H., & Jaffe, A. B. 1984. Who does R&D and who patents? In Z. Griliches (Ed.), *R&D, Patents, and Productivity*: 21-54: University of Chicago Press.
Brouwer, E., & Kleinknecht, A. 1999. Innovative output, and a firm's propensity to patent.: An exploration of CIS micro data. *Research Policy*, 28(6): 615-624.
Bryman, A., & Bell, E. 2007. *Business Research Methods*. Oxford, NY: Oxford University Press.
Burns, T., & Stalker, G. M. 1961. *The Management of Innovation*. London: Tavistock.
Cantwell, J. 1989. *Technological Innovation and Multinational Corporations*. Oxford: Blackwell.
Cantwell, J. 1991. Historical trends in international patterns of technological innovation. In J. Foremand-Peck (Ed.), *New Perspectives on the Late Victorian Economy*: 37-72. Cambridge: Cambridge University Press.
Cantwell, J., & Vertova, G. 2004. Historical evolution of technological diversification. *Research Policy*, 33(3): 511-529.
Cassiman, B., & Veugelers, R. 2006. In search of complementarity in innovation strategy: Internal R&D and external knowledge acquisition. *Management Science*, 52(1): 68-82.
Chabchoub, N., & Niosi, J. 2005. Explaining the propensity to patent computer software. *Technovation*, 25(9): 971-978.
Chandler, A. D., Jr. 1962. *Strategy and Structure: Chapters in the History of Industrial Enterprise*. Cambridge, MA: MIT Press.
Chandler, A. D., Jr. 1990. *Scale and Scope: The Dynamics of Industrial Capitalism*. Cambridge, MA: Harvard University Press.
Chesbrough, H. 2007. Why companies should have open business models. *MIT Sloan Management Review*, 48(2): 22-28.
Chesbrough, H. W. 2003. *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Boston, MA: Harvard Business School Press.
Chesbrough, H. W., & Crowther, A. K. 2006. Beyond high tech: Early adopters of open innovation in other industries. *R&D Management*, 36(3): 229-236.
Cheung, K.-y., & Lin, P. 2004. Spillover effects of FDI on innovation in China: Evidence from the provincial data. *China Economic Review*, 15(1): 25-44.
Coase, R. H. 1937. The nature of the firm. *Economica*, 4: 386-405.
Coase, R. H. 1960. The problem of social cost. *Journal of Law and Economics*, 3(Oct.): 1-44.
Coase, R. H. 1988. *The Firm, the Market, and the Law*. Chicago: University of Chicago Press.
Cohen, W. M., & Levinthal, D. A. 1989. Innovation and learning: The two faces of R&D. *The Economic Journal*, 99(397): 569-596.
Cohen, W. M., & Levinthal, D. A. 1990. Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, 35(1): 128-152.

Cohen, W. M., Nelson, R. R., & Walsh, J. P. 2000. Protecting their intellectual assets: Appropriability conditions and why US manufacturing firms patent (or not), *NBER Working Paper 7552*.

Copeland, T. E., Weston, J. F., & Shastri, K. 2005. *Financial Theory and Corporate Policy* (4 ed.): Pearson Addison Wesley.

Creswell, J. W. 2008. *Research design: Qualitative, quantitative, and mixed methods approaches*. Thousand Oaks, CA: Sage Publications.

Dahlander, L., & Gann, D. M. 2010. How open is innovation? *Research Policy*, 39(6): 699-709.

Dahlander, L., & Wallin, M. W. 2006. A man on the inside: Unlocking communities as complementary assets. *Research Policy*, 35(8): 1243-1259.

Damodaran, A. 2002. *Investment Valuation: Tools and Techniques for Determining the Value of Any Asset* (2 ed.). New York: John Wiley & Sons.

Davenport, T. H., De Long, D. W., & Beers, M. C. 1998. Successful knowledge management projects. *Sloan Management Review*, 39(2): 43-57.

David, P. A. 1993. Intellectual property institutions and the panda's thumb: Patents, copyrights, and trade secrets in economic theory and history. In M. B. Wallerstein, M. E. Mogee, & R. a. Schoen (Eds.), *Global Dimensions of Intellectual Property Rights in Science and Technology*: 19-61. Washington DC: National Academy Press.

Davis, L. 2008. Licensing strategies of the new "intellectual property vendors". *California Management Review*, 50(2): 6-30.

Davis, L. N. 2006. Why do small high-tech firms take out patents, and why not? In B. Andersen (Ed.), *Intellectual Property Rights: Innovation, Governance and the Institutional Environment* 148-176. London: Edward Elgar.

de Rassenfosse, G. 2012. How SMEs exploit their intellectual property assets: evidence from survey data. *Small Business Economics*, 39(2): 437-452.

Demsetz, H. 1967. Toward a theory of property rights. *The American Economic Review*, 57(2): 347-359.

Dittrich, K., & Duysters, G. 2007. Networking as a means to strategy change: The case of open innovation in mobile telephony. *Journal of Product Innovation Management*, 24(6): 510-521.

Domeij, B. 2003. *Patentavtalsrätt*: Norstedts Juridik.

Dosi, G., Pavitt, K., & Soete, L. 1990. *The Economics of Technical Change and International Trade*. New York: Harvester Wheatsheaf.

Duguet, E., & Kabla, I. 1998. Appropriation strategy and the motivations to use the patent system: An econometric analysis at the firm level in French manufacturing. *Annals of Economics and Statistics / Annales d'Économie et de Statistique*(49/50): 289-327.

Edvinsson, L. 1997. Developing intellectual capital at Skandia. *Long Range Planning*, 30(3): 366-373.

Eggertsson, T. 1990. *Economic Behavior and Institutions*. Cambridge, UK: Cambridge University Press.

Encyclopedia Britannica. 2010. Strategy. [Online] Available at: http://search.eb.com/eb/article-9110191 [Accessed 16 February 2010].

Enkel, E., Gassmann, O., & Chesbrough, H. W. 2009. Open R&D and open innovation: Exploring the phenomenon. *R&D Management*, 39(4): 311-316.

Ernst, H., Conley, J. G., & Omland, N. forthcoming. How to create commercial value from patents: The role of patent management. *Research Policy*.

Ewing, T. 2012. Facebook: A soldier of fortune? Tom Ewing investigates. [Online] Available at: http://anewdomain.net/2012/04/13/facebook-a-patent-privateer-or-a-soldier-of-fortune/ [Accessed 16 October 2012].

Ewing, T., & Feldman, R. 2012. The giants among us. *Stanford Technology Law Review*, 2012(1): 1-61.

Faems, D., de Visser, M., Andries, P., & van Looy, B. 2010. Technology alliance portfolios and financial performance: Value-enhancing and cost-increasing effects of open innovation. *Journal of Product Innovation Management*, 27(6): 785-796.

Fairfield Resources International. 2005. 3G Cellular Standards and Patents. Available for download at company website: http://www.frlicense.com/.

Fairfield Resources International. 2007. Analysis of Patents Declared as Essential to GSM as of June 6, 2007. Available for download at company website: http://www.frlicense.com/.

Fairfield Resources International. 2009a. Review of Patents Declared as Essential to LTE and SAE (4G Wireless Standards) through June 30, 2009. Available for download at company website: http://www.frlicense.com/.

Fairfield Resources International. 2009b. Review of Patents Declared as Essential to WCDMA through December, 2008. Available for download at company website: http://www.frlicense.com/.

Flick, U. 2009. *An Introduction to Qualitative Research* (4th ed.). London: SAGE Publications Ltd.

Ford, D., Gadde, L.-E., Håkansson, H., Lundgren, A., Snehota, I., Turnbull, P., & Wilson, D. 1998. *Managing Business Relationships*. Chichester: John Wiley & Sons.

Freeman, C. 1982. *The Economics of Industrial Innovation* (2nd ed.). Cambridge, MA: MIT Press.

Friesike, S., Hafezi, N., Jamali, N., Iorno, N., Bader, M., Schreiner, E., & Ziegler, N. 2009. *SME-IP 3rd Report: Case Studies on SMEs and Intellectual Property in Switzerland*: Publication No 6 (07.09), Swiss Federal Institute of Intellectual Property.

Gadde, L.-E., & Håkansson, H. 2001. *Supply Network Strategies*. Chichester: John Wiley & Sons.

Gambardella, A., & Torrisi, S. 1998. Does technological convergence imply convergence in markets? Evidence from the electronics industry. *Research Policy*, 27(5): 445-463.

Garcia, R., & Calantone, R. 2002. A critical look at technological innovation typology and innovativeness terminology: A literature review. *Journal of Product Innovation Management*, 19(2): 110-132.

Gartner, W. B. 1990. What are we talking about when we talk about entrepreneurship? *Journal of Business Venturing*, 5(1): 15-28.

Gemünden, H. G., Heydebreck, P., & Herden, R. 1992. Technological interweavement: a means of achieving innovation success. *R&D Management*, 22(4): 359-376.

Gilbert, R., & Shapiro, C. 1990. Optimal patent length and breadth. *The RAND Journal of Economics*, 21(1): 106-112.

Giuri, P., Mariani, M., Brusoni, S., Crespi, G., Francoz, D., Gambardella, A., Garcia-Fontes, W., Geuna, A., Gonzales, R., Harhoff, D., Hoisl, K., Le Bas, C., Luzzi, A., Magazzini, L., Nesta, L., Nomaler, Ö., Palomeras, N., Patel, P., Romanelli, M., & Verspagen, B. 2007. Inventors and invention processes in Europe: Results from the PatVal-EU survey. *Research Policy*, 36(8): 1107-1127.

Goldscheider, R. 2011. The classic 25% rule and the art of intellectual property licensing. *les Nouvelles*, 46(3): 148-159.

Goldscheider, R. 2012. The current realities of the classic 25% rule: An attempt to put the house in order. *les Nouvelles*, 47(1): 1-7.

Granstrand, O. 1982. *Technology, Management and Markets: An Investigation of R&D and Innovation in Industrial Organizations*. London: Frances Pinter.

Granstrand, O. 1998. Towards a theory of the technology-based firm. *Research Policy*, 27(5): 465-489.

Granstrand, O. 1999. *The Economics and Management of Intellectual Property: Towards Intellectual Capitalism*. Cheltenham: Edward Elgar Publishing.

Granstrand, O. 2000. The shift towards intellectual capitalism: The role of infocom technologies. *Research Policy*, 29(9): 1061-1080.

Granstrand, O. (Ed.). 2003. *Economics, Law and Intellectual Property*. Dordrecht: Kluwer Academic Publishers.

Granstrand, O. 2004. The economics and management of technology trade: Towards a pro-licensing era? *International Journal of Technology Management*, 27(2,3): 209-240.

Granstrand, O. 2006a. Fair and reasonable royalty rate determination. *les Nouvelles*, 41(3): 179-181.

Granstrand, O. 2006b. Intellectual property rights for governance in and of innovation systems. In B. Andersen (Ed.), *Intellectual Property Rights: Innovation, Governance and the Institutional Environment*: 311-343. Cheltenham: Edward Elgar Publishing.

Granstrand, O. 2010. *Industrial Innovation Economics and Intellectual Property* (5th ed.). Gothenburg: Svenska Kulturkompaniet.

Granstrand, O. 2011. The economics of IP in the context of a shifting innovation paradigm, *Background Paper to World Intellectual Property Report 2011*: WIPO.

Granstrand, O. forthcoming. *Patents and Innovations for Growth and Welfare*. Cheltenham: Edward Elgar Publishing.

Granstrand, O., & Oskarsson, C. 1994. Technology diversification in "MUL-TECH" corporations. *IEEE Transactions on Engineering Management*, 41(4): 355-364.

Granstrand, O., Patel, P., & Pavitt, K. 1997. Multi-technology corporations: Why they have 'distributed' rather than 'distinctive core' competences. *California Management Review*, 39(4): 8-25.

Granstrand, O., & Sjölander, S. 1990. Managing innovation in multi-technology corporations. *Research Policy*, 19(1): 35-60.

Greenhalgh, C., & Rogers, M. 2010. *Innovation, Intellectual Property, and Economic Growth*. Princeton, NJ: Princeton University Press.

Griliches, Z. 1990. Patent statistics as economic indicators - A survey. *Journal of Economic Literature*, 28(4): 1661-1707.

Grossman, S. J., & Hart, O. D. 1986. The costs and benefits of ownership: A theory of vertical and lateral integration. *Journal of Political Economy*, 94(4): 691-719.

Guellec, D., & Potterie, B. v. P. d. l. 2007. *The Economics of the European Patent System*. Oxford: Oxford University Press.

Hall, B. H. 2005. Exploring the patent explosion. *Journal of Technology Transfer*, 30(1/2): 35-48.

Hall, B. H., & Ziedonis, R. H. 2001. The patent paradox revisited: An empirical study of patenting in the U.S. semiconductor industry, 1979-1995. *The RAND Journal of Economics*, 32(1): 101-128.

Hall, R. 1989. The management of intellectual assets: a new corporate perspective. *Journal of General Management*, 15(1): 53-68.

Hall, R. 1992. The strategic analysis of intangible resources. *Strategic Management Journal*, 13(2): 135-144.

Hanel, P. 2006. Intellectual property rights business management practices: A survey of the literature. *Technovation*, 26(8): 895-931.

Harabi, N. 1995. Appropriability of technical innovations an empirical analysis. *Research Policy*, 24(6): 981-992.

Hardin, G. 1968. The tragedy of the commons. *Science*, 162(3859): 1243-1248.

Harhoff, D., Scherer, F. M., & Vopel, K. 2003. Exploring the tail of patented invention value distributions. In O. Granstrand (Ed.), *Economics, Law and Intellectual Property*: 279-309. Dordrecht: Kluwer Academic Publishers.

Hart, O. 1995. *Firms, Contracts, and Financial Structure*. Oxford, UK: Clarendon Press.

Hausman, J. A., Hall, B. H., & Griliches, Z. 1984. Econometric models for count data with an application to the patents-R&D relationship. *Econometrica*, 52(4): 909-938.

Heller, M. A. 1998. The tragedy of the anticommons: property in the transition from Marx to markets. *Harvard Law Review*, 111(3): 621-688.

Heller, M. A., & Eisenberg, R. S. 1998. Can patents deter innovation? The anticommons in biomedical research. *Science*, 280(5364): 698-701.

Henry, M. D., & Turner, J. L. 2006. The Court of Appeals for the Federal Circuit’s impact on patent litigation. *The Journal of Legal Studies*, 35(1): 85-117.

Hu, A. G. 2010. Propensity to patent, competition and China's foreign patenting surge. *Research Policy*, 39(7): 985-993.

Hu, A. G., & Jefferson, G. H. 2009. A great wall of patents: What is behind China's recent patent explosion? *Journal of Development Economics*, 90(1): 57-68.

Interbrand. 2009. Best Global Brands. [Online] Available at: http://www.interbrand.com/best_global_brands_intro.aspx [Accessed 1 December 2009].

Itami, H., & Roehl, T. W. 1987. *Mobilizing Invisible Assets*. Cambridge, MA: Harvard University Press.

Iversen, E. 2003. *Norwegian Small and Medium-Sized Enterprises and the Intellectual Property Rights System: Exploration and Analysis*. Oslo: STEP Center for Innovation Policy.

Jacobides, M. G., & Winter, S. G. 2005. The co-evolution of capabilities and transaction costs: Explaining the institutional structure of production. *Strategic Management Journal*, 26(5): 395-413.

Jaffe, A. B. 1986. Technological opportunity and spillovers of R&D: Evidence from firms' patents, profits and market value. *American Economic Review*, 76(5): 984-999.

Jaffe, A. B., & Lerner, J. 2004. *Innovation and Its Discontents: How Our Broken Patent System Is Endangering Innovation and Progress, and What to Do About It*. Princeton, NJ: Princeton University Press.

Jaffe, A. B., Trajtenberg, M., & Henderson, R. 1993. Geographic localization of knowledge spillovers as evidenced by patent citations. *Quarterly Journal of Economics*, 108(3): 577-598

Jick, T. D. 1979. Mixing qualitative and quantitative methods: Triangulation in action. *Administrative Science Quarterly*, 24(4, Qualitative Methodology): 602-611.

Keupp, M. M., Beckenbauer, A., & Gassmann, O. 2010. Enforcing intellectual property rights in weak appropriability regimes. *Management International Review*, 50(1): 109-130.

Keupp, M. M., Lhuillery, S., Garcia-Torres, M. A., & Raffo, J. 2009. *SME-IP 2nd Report: Economic Focus Study on SMEs and Intellectual Property in Switzerland*: Publication No 5 (06.09), Swiss Federal Institute of Intellectual Property.

Kim, Y. K., Lee, K., Park, W. G., & Choo, K. 2012. Appropriate intellectual property protection and economic growth in countries at different levels of development. *Research Policy*, 41(2): 358-375.

Kitching, J., & Blackburn, R. 1998. Intellectual property management in the small and medium enterprise (SME). *Journal of Small Business and Enterprise Development*, 5(4): 327-335.

Klein, B., Crawford, R. G., & Alchian, A. 1978. Vertical integration, appropriable rents, and the competitive contracting process. *Journal of Law and Economics*, 21(2): 297-326.

Klemperer, P. 1990. How broad should the scope of patent protection be? *The RAND Journal of Economics*, 21(1): 113-130.

Kodama, F. 1986. Technological diversification of Japenese industry. *Science*, 233(4761): 291-296.

Kogut, B., & Zander, U. 1992. Knowledge of the firm, combinative capabilities, and the replication of technology. *Organization Science*, 3(3, Focused Issue: Management of Technology): 383-397.

Koktvedgaard, M., & Levin, M. 2004. *Lärobok i Immaterialrätt* (8 ed.). Stockholm: Norstedts Juridik.

Kortum, S., & Lerner, J. 1998. Stronger protection or technological revolution: what is behind the recent surge in patenting? *Carnegie-Rochester Conference Series on Public Policy*, 48(0): 247-304.

Krugman, P. 1987. The narrow moving band, the Dutch disease, and the competitive consequences of Mrs. Thatcher: Notes on trade in the presence of dynamic scale economies. *Journal of Development Economics*, 27(1–2): 41-55.

Lanjouw, J. O., Pakes, A., & Putnam, J. 1996. How to count patents and value intellectual property, *NBER Working Paper No. 5741*.

Laursen, K., & Salter, A. 2006. Open for innovation: The role of openness in explaining innovation performance among U.K. manufacturing firms. *Strategic Management Journal*, 27(2): 131-150.

Lawson, T. 1997. *Economics and Reality*. New York, NY: Routledge.

Lawson, T. 2003. *Reorienting Economics*. New York, NY: Routledge.

Layton, E. 1977. Conditions of technological development. In D. de Solla Price, & I. D. Spiegel-Rosing (Eds.), *Science, technology, and society*. Beverly Hills, CA: Sage Publications.

Leiponen, A., & Byma, J. 2009. If you cannot block, you better run: Small firms, cooperative innovation, and appropriation strategies. *Research Policy*, 38(9): 1478-1488.

Lemley, M. A., & Shapiro, C. 2007. Patent holdup and royalty stacking. *Texas Law Review*, 85: 1991-2049.

Lev, B. 2001. *Intangibles: Management, Measurement, and Reporting*. Washington, DC: Brookings.

Levin, R. C., Klevorick, A. K., Nelson, R. R., & Winter, S. G. 1987. Appropriating the returns from industrial research and development. *Brookings Papers on Economic Activity*, 14(3): 783-831.

Lichtenthaler, U. 2010. Intellectual property and open innovation: an empirical analysis. *International Journal of Technology Management*, 52(3): 372-391.

Lippman, S. A., & Rumelt, R. P. 1992. Demand uncertainty and investment in industry-specific capital. *Industrial and Corporate Change*, 1(1): 235-262.

Machlup, F. 1958. *An Economic Review of the Patent System*. Washington, DC: US Government Printing Office.

Machlup, F. M., & Penrose, E. T. 1950. The patent controversy in the nineteenth century. *Journal of Economic History*, 10(1): 1-29.

Mahoney, J. T. 2005. *Economic Foundations of Strategy*. Thousand Oaks, CA: Sage Publications.

Mansfield, E. 1986. Patents and innovation: An empirical study. *Management Science*, 32(2): 173-181.

Mansfield, E., Rapoport, J., Romeo, A., Wagner, S., & Beardsley, G. 1977. Social and private rates of return from industrial innovations. *Quarterly Journal of Economics*, 91(2): 221-240.
Mansfield, E., Schwartz, M., & Wagner, S. 1981. Imitation costs and patents: An empirical study. *The Economic Journal*, 91(364): 907-918.
March, J. G. 1991. Exploration and exploitation in organizational learning. *Organization Science*, 2(1, Special Issue: Organizational Learning: Papers in Honor of (and by) James G. March): 71-87.
Marr, B., & Adams, C. 2004. The balanced scorecard and intangible assets: similar ideas, unaligned concepts. *Measuring Business Excellence*, 8(3): 18-27.
Maskus, K. E. 2000. *Intellectual Property Rights in the Global Economy*. Washington, DC: Institute for International Economics.
McConnachie, G. 1997. The management of intellectual assets: Delivering value to the business. *The Journal of Knowledge Management*, 1(1): 56-62.
Merges, R. P., & Nelson, R. R. 1990. On the complex economics of patent scope. *Columbia Law Review*, 90(4): 839-916.
Merz, J. F., & Pace, N. M. 1994. Trends in patent litigation: The apparent influence of strengthened patents attributable to the Court of Appeals for the Federal Circuit. *Journal of the Patent and Trademark Office Society*, 76: 579-590.
Mintzberg, H. 1978. Patterns in strategy formation. *Management Science*, 24(9): 934-948.
Mintzberg, H., & Waters, J. A. 1985. Of strategies, deliberate and emergent. *Strategic Management Journal*, 6(3): 257-272.
Moran, P., & Ghoshal, S. 1999. Markets, firms, and the process of economic development. *Academy of Management Review*, 24(3): 390-412.
Mowery, D. C., Nelson, R. R., Sampat, B. N., & Ziedonis, A. A. 2001. The growth of patenting and licensing by US universities: An assessment of the effects of the Bayh-Dole act of 1980. *Research Policy*, 30(1): 99-119.
Mowery, D. C., Oxley, J. E., & Silverman, B. S. 1996. Strategic alliances and interfirm knowledge transfer. *Strategic Management Journal*, 17(Special Issue: Knowledge and the Firm): 77-91.
Mowery, D. C., Sampat, B. N., & Ziedonis, A. A. 2002. Learning to patent: Institutional experience, learning, and the characteristics of U. S. university patents after the Bayh-Dole Act, 1981-1992. *Management Science*, 48(1): 73-89.
Mun, J. 2006. *Real Options Analysis: Tools and Techniques for Valuing Strategic Investments and Decisions* (2 ed.). Hoboken, NJ: John Wiley & Sons.
Nelson, R. R., & Winter, S. G. 1982. *An Evolutionary Theory of Economic Change*. Cambridge, MA: The Belknap Press of Harvard University Press.
North, D. C. 1990. *Institutions, Institutional Change, and Economic Performance*. Cambridge, UK: Cambridge University Press.
O'Mahony, S. 2003. Guarding the commons: How community managed software projects protect their work. *Research Policy*, 32(7): 1179-1198.
Oskarsson, C. 1993. *Technology Diversification - The Phenomenon, its Causes and Effects*. Chalmers University of Technology, Gothenburg, Sweden.

Ostrom, E. 1999. Coping with tragedies of the commons. *Annual Review of Political Science*, 2(1): 493.

Ostrom, E., Burger, J., Field, C. B., Norgaard, R. B., & Policansky, D. 1999. Revisiting the commons: Local lessons, global challenges. *Science*, 284(5412): 278-282.

Owen-Smith, J., & Powell, W. W. 2004. Knowledge networks as channels and conduits: The effects of spillovers in the Boston biotechnology community. *Organization Science*, 15(1): 5-21.

Patel, P., & Pavitt, K. 1987. Is Western Europe losing the technological race? *Research Policy*, 16(2–4): 59-85.

Patel, P., & Pavitt, K. 1991. Large firms in the production of the world's technology: An important case of "non-globalisation". *Journal of International Business Studies*, 22(1): 1-21.

Patel, P., & Pavitt, K. 1994. Uneven (and divergent) technological accumulation among advanced countries: Evidence and a framework of explanation. *Industrial and Corporate Change*, 3(3): 759-787.

Pavitt, K. 1982. R&D, patenting and innovative activities: A statistical exploration. *Research Policy*, 11(1): 33-51.

Pavitt, K. 1990. What we know about the strategic management of technology. *California Management Review*, 32(3): 17-26.

Pavitt, K., Robson, M., & Townsend, J. 1989. Technological accumulation, diversification and organisation in UK companies, 1945-1983. *Management Science*, 35(1): 81-99.

Penrose, E. T. 1959. *The Theory of the Growth of the Firm*. Oxford: Basil Blackwell.

Phelps, M., & Kline, D. 2009. *Burning the Ships: Transforming Your Company's Culture through Intellectual Property Strategy*. Hoboken NJ: John Wiley & Sons.

Pisano, G. 2006. Profiting from innovation and the intellectual property revolution. *Research Policy*, 35(8): 1122-1130.

Pisano, G. P., & Teece, D. J. 2007. How to capture value from innovation: Shaping intellectual property and industry architecture. *California Management Review*, 50(1): 278-296.

Porter, M. E. 1980. *Competitive Strategy: Techniques for Analyzing Industries and Competitors*. New York, NY: The Free Press.

Porter, M. E. 1985. *Competitive Advantage: Creating and Sustaining Superior Performance*. New York: Free Press.

Porter, M. E. 1990. *The Competitive Advantage of Nations*. New York, NY: The Free Press.

Prahalad, C. K., & Hamel, G. 1990. The core competence of the organization. *Harvard Business Review*, (May-June): 79-90.

Priem, R. L., & Butler, J. E. 2001. Is the resource-based "view" a useful perspective for strategic management research? *The Academy of Management Review*, 26(1): 22-40.

Reitzig, M. 2004. Strategic management of intellectual property. *MIT Sloan Management Review*, 45(3): 35-40.

Reitzig, M. 2007. How executives can enhance IP strategy and performance. *MIT Sloan Management Review*, 49(1): 37-43.
Richardson, G. B. 1972. The organisation of industry. *The Economic Journal*, 82(327): 883-896.
Ritter, T., & Gemünden, H. G. 2003. Network competence: Its impact on innovation success and its antecedents. *Journal of Business Research*, 56(9): 745-755.
Rockman, H. B. 2004. *Intellectual Property Law for Engineers and Scientists*. Hoboken, NJ: IEEE Press.
Romer, P. 2002. When should we use intellectual property rights? *The American Economic Review*, 92(2): 213-216.
Roos, J., Roos, G., Edvinsson, L., & Dragonetti, N. C. 1997. *Intellectual Capital: Navigating the New Business Landscape*. Basingstoke: Macmillan.
Rosenberg, N. 1963. Technological change in the machine tool industry, 1840-1910. *The Journal of Economic History*, 23(4): 414-443.
Rosenberg, N. 1982. *Inside the Black Box: Technology and Economics*. Cambridge: Cambridge University Press.
Rosenberg, N., & Birdzell, L. E. 1986. *How the West Grew Rich: The Transformation of the Industrial World*. New York: Basic Books.
Samuelson, P. A. 1954. The pure theory of public expenditure. *The Review of Economics and Statistics*, 36(4): 387-389.
Scherer, F. M. 1983. The propensity to patent. *International Journal of Industrial Organization*, 1(1): 107-128.
Scherer, F. M. 1999. *New Perspectives on Economic Growth and Technological Innovation*. Washington D.C.: Brookings Institution Press.
Schumpeter, J. A. 1934. *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle*. Cambridge, MA: Harvard University Press.
Schumpeter, J. A. 1942. *Capitalism, Socialism, and Democracy*. New York, NY: Harper and Row.
Scotchmer, S. 2004. *Innovation and Incentives*. Cambridge, MA: MIT Press.
Shapiro, C., & Varian, H. R. 1999. *Information Rules: A Strategic Guide to the Network Economy*. Boston, MA: Harvard Business School Press.
Simon, H. A. 1947. *Administrative Behavior*. New York: Macmillan.
Smith, M. J. 1998. *Social Science in Question*. London: SAGE Publications Ltd.
Soete, L. 1981. Technical change, catching up and the productivity slowdown. In O. Granstrand, & J. Sigurdson (Eds.), *Technological and Industrial Policy in China and Europe*. Lund: Research Policy Institute.
Soete, L. 1987. The impact of technological innovation on international trade patterns: The evidence reconsidered. *Research Policy*, 16(2–4): 101-130.
Solow, R. M. 1956. A contribution to the theory of economic growth. *Quarterly Journal of Economics*, 70(1): 65-94.
Solow, R. M. 1957. Technical change and the aggregate production function. *Review of Economics and Statistics*, 39(3): 312-321.
Somaya, D. 2012. Patent strategy and management. *Journal of Management*, 38(4): 1084-1114.

Somaya, D., Teece, D. J., & Wakeman, S. 2011. Innovation in multi-invention contexts: Mapping solutions to technological and intellectual property complexity. *California Management Review*, 53(4): 47-79.

SOU. 2006. *Patent och Innovationer för Tillväxt och Välfärd*. Stockholm: Statens Offentliga Utredningar.

Spence, M. 2007. *Intellectual Property*. New York: Oxford University Press.

Stiglitz, J. E. 1999. Knowledge as a global public good. In I. Kaul, I. Grunberg, & M. A. Stern (Eds.), *Global Public Goods*: 308-325. Oxford: Oxford University Press.

Storey, D. J., & Tether, B. S. 1998. New technology-based firms in the European union: an introduction. *Research Policy,* 26(9): 933-946.

Stuart, T. E. 2000. Interorganizational alliances and the performance of firms: A study of growth and innovation rates in a high-technology industry. *Strategic Management Journal*, 21(8): 791-811.

Sveiby, K. E. 1997. *The New Organizational Wealth: Managing and Measuring Knowledge-Based Assets* (1. ed.). San Francisco: Berrett-Koehler.

Teece, D. J. 1986. Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. *Research Policy*, 15(6): 285-305.

Teece, D. J. 2006. Reflections on 'profiting from innovation'. *Research Policy*, 35(8): 1131-1146.

Teece, D. J. 2009. *Dynamic Capabilities & Strategic Management: Organizing for Innovation and Growth*. Oxford: Oxford University Press.

Teece, D. J., Pisano, G., & Shuen, A. 1997. Dynamic capabilities and strategic management. *Strategic Management Journal*, 18(7): 509-533.

Thumm, N. 2004. Motives for patenting biotechnological inventions: an empirical investigation in Switzerland. *International Journal of Technology, Policy and Management*, 4(3): 275-285.

Thurow, L. C. 1997. Needed: A new system of intellectual property rights. *Harvard Business Review*, 75(5): 94-103.

Trajtenberg, M. 1990. A penny for your quotes: Patent citations and the value of innovations. *The RAND Journal of Economics*, 21(1): 172-187.

Tranekjer, T. L., & Knudsen, M. P. 2012. The (unknown) providers to other firms' new product development: What's in it for them? *Journal of Product Innovation Management*, 29(6): 986-999.

Trott, P. 2008. *Innovation Management and New Product Development* (4th ed.). Harlow: Pearson Hall.

Trott, P., & Hartmann, D. 2009. Why 'open innovation' is old wine in new bottles. *International Journal of Innovation Management*, 13(4): 715-736.

Utterback, J. M. 1994. *Mastering the Dynamics of Innovation*. Boston, MA: Harvard Business School Press.

Wallerstein, M. B., Mogee, M. E., & Schoen, R. a. 1993. *Global Dimensions of Intellectual Property Rights in Science and Technology*. Washington DC: National Academy Press.

van de Vrande, V., Vanhaverbeke, W., & Duysters, G. 2009. External technology sourcing: The effect of uncertainty on governance mode choice. *Journal of Business Venturing*, 24(1): 62-80.

van Zeebroeck, N., van Pottelsberghe de la Potterie, B., & Guellec, D. 2009. Claiming more: The increased voluminosity of patent applications and its determinants. *Research Policy*, 38(6): 1006-1020.

Veer, T., & Jell, F. 2012. Contributing to markets for technology? A comparison of patent filing motives of individual inventors, small companies and universities. *Technovation*, 32(9–10): 513-522.

Wernerfelt, B. 1984. A resource-based view of the firm. *Strategic Management Journal*, 5(2): 171-180.

West, J., & Gallagher, S. 2006. Challenges of open innovation: The paradox of firm investment in open-source software. *R&D Management*, 36(3): 319-331.

Wigren, C. 2003. *The Spirit of Gnosjö*. Jönköping International Business School, Jönköping.

Williamson, O. E. 1975. *Markets and Hierarchies: Analysis and Antitrust Implications*. New York, NY: Free Press.

Williamson, O. E. 1983. Credible commitments: Using hostages to support exchange. *American Economic Review*, 73(4): 519-540.

Williamson, O. E. 1985. *The Economic Institutions of Capitalism: Firms, Markets, Relational Contracting*. New York, NY: Free Press.

Williamson, O. E. 1991. Comparative economic organization: The analysis of discrete structural alternatives. *Administrative Science Quarterly*, 36(4): 269-296.

Williamson, O. E. 1996. *The Mechanisms of Governance*. New York: Oxford University Press.

von Hippel, E. 1988. *The Sources of Innovation*. New York, NY: Oxford University Press.

von Hippel, E. 1994. 'Sticky information' and the locus of problem solving: Implications for innovation. *Management Science*, 40(4): 429-439.

von Hippel, E. 2005. *Democratizing Innovation*. Cambridge, MA: MIT Press.

von Hippel, E. 2007. Horizontal innovation networks--by and for users. *Industrial and Corporate Change*, 16(2): 293-315.

von Hippel, E., & von Krogh, G. 2003. Open source software and the 'private-collective' innovation model: Issues for organization science. *Organization Science*, 14(2): 209-223.

Wright, B. D. 1983. The economics of invention incentives: Patents, prizes, and research contracts. *The American Economic Review*, 73(4): 691-707.

Paper I

Granstrand, O. and Holgersson, M. (2012) ‘The anatomy of rise and fall of patenting and propensity to patent: The case of Sweden’, *International Journal of Intellectual Property Management*, Vol. 5, No. 2, pp. 169-198.

# The anatomy of rise and fall of patenting and propensity to patent: The case of Sweden

Ove Granstrand[a) b)] and Marcus Holgersson[a) c)]

[a)] Industrial Management and Economics Research Group
Department of Technology Management and Economics
Chalmers University of Technology
SE-412 96 Gothenburg, Sweden

[b)] Corresponding author
Phone: +46-31-772 12 09
E-mail: ovegra@chalmers.se

[c)] Phone: +46-31-772 52 88
E-mail: marhol@chalmers.se

## Abstract

Fluctuations in patenting frequency and propensity to patent have caught increasing interest, not the least since the emergence of a worldwide pro-patent era. In this paper fluctuations in Swedish patent frequency are described and analyzed, based on statistics and questionnaire survey studies among large and small patentees as well as among IP consultancy firms, complemented with interviews. The results confirm the importance of size of R&D and size of patenting resources for both large and small firms and for both positive and negative growth of patenting. In addition, some new determinants were found, of which some also discriminated between large and small firms. A shift to more quality-oriented patenting strategies with more selective patenting led to decreased patenting propensity and frequency, especially among large firms. As to propensity to patent using different routes, national first filings are declining in the longer run on average for small countries like Sweden and Finland, as especially large companies internationalize their IP operations and increasingly use the PCT route.

## Keywords

Patent; Intellectual property right; Management; Strategy; Policy; Frequency; Propensity; Appropriation; Innovation; Sweden

# 1 Problem

## 1.1 Background

Since the 1980s, a steady and steep growth in the number of yearly patent applications has been identified in many countries, including in the US, China, India, Japan, and Korea. However, far from all countries have experienced steady growth in patent applications throughout these decades. In Sweden and many other small industrialized countries patent applications to the domestic patent (and trademark) offices (PTOs) have on the contrary decreased substantially from time to time. This pattern has not yet been explained in the literature. Patent applications to the Swedish PTO declined in the 1980s and then grew during the 1990s, after which it declined rapidly in the 2000s. The reason(s) behind such growth and decline patterns is an important issue for the future of national PTOs. Processing patent applications has traditionally been the main task of these offices. Part of this task includes scrutinizing novelty, based on searches of prior art, as well as other aspects of patentability. The number of national priority patent applications submitted to national PTOs is of decisive interest for the survival of these offices, especially in countries with small domestic markets for which counterpart applications are less important for foreign companies and inventors.

## 1.2 Purpose

The purpose of this paper is to describe and explain these fluctuations in patenting frequency and patenting propensity, especially concerning national applications filed at the Swedish PTO (PRV). A statistical study and surveys of large and small patentees as well as of patent consultancy firms have therefore been carried out to explain the growth and decline in Swedish patenting, and relate these aggregate changes to changes in intellectual property (IP) strategies at firm level. Therefore, extensive descriptive statistics of Swedish patenting at aggregate and firm level is complemented with data on explanatory factors behind decreases as well as increases in patenting at firm level.

## 1.3 Concepts

A number of concepts are central for this paper. *Patenting frequency* concerns the number of patents per time unit (usually per year), while *patenting propensity* refers to the propensity (probability) to apply for and/or obtain a patent, given a patentable invention (Mansfield, 1986). A number of qualifying distinctions need to be made in connection with the concept of patenting frequency. Firstly, patenting frequency may relate to the number of patent applications being applied for at a specific receiving office (national, e.g. the Swedish PTO, or regional, e.g. EPO), by a specific applicant (firm or individual), or concerning inventions invented by a specific inventor. (The latter is not studied in this paper, however.) Secondly, patenting frequency may relate to the number of patents applied for or the number of patents granted. Thirdly, we also need to distinguish between basic patents and counterpart patents. A basic patent application, also called *priority patent application* or first filing (FF), is the first patent application for a specific invention, defining the priority date at which prior art should be evaluated. Counterpart patents in different selected countries are based on the same original invention as the priority patent, and the corresponding subsequent applications are referred to as *counterpart patent applications*/filings or subsequent filings. Every priority application (first filing) at some patent office in a country being a Paris Convention signatory state gives international priority to any counterpart filing for one year after the filing of the priority application at the patent offices of other Paris Convention signatory states. A *patent family* is a set of patents constituted by the priority patent and its corresponding counterpart patents, usually limited to countries of special importance and value to the *patentee* (the patent applicant), e.g. in Europe plus Japan and the US (so-called 'triad families'). Finally, a patent application can be a national application, a regional application (e.g. to EPO), or an international (PCT) application. The concept of patenting propensity can then also be broken down into (conditional) probabilities to apply for a patent, using different filing strategies in terms of preferred application routes. Note that the nationality of a patent application is ambiguous, since it can refer to the nationality of the receiving PTO, the nationality of the applicant(s), or the nationality of the inventors. Issues of multi-nationalities of applicants or inventors complicate the picture further (see also section 4).

### 1.4 Outline of paper

The paper is outlined as follows. This introduction is followed by a short review of previous research in order to find determinants of patenting. After that, the method and data are described. The empirical part of the paper then essentially consists of three sections; a section based on statistics from various patent and trademark offices (PTOs), mainly the Swedish one, a section based on questionnaire surveys to explain variations in Swedish patenting, and a section based on a company case study to illustrate company internal changes leading to changes in patenting. The paper ends with a discussion followed by summary and conclusions.

## 2 Previous research and determinants of patenting

Patent propensity has been researched in a number of studies following the seminal works of Scherer (1965; 1983). These studies have typically found differences in patent propensity over industries, innovation types (product/process), and firm sizes (Arundel and Kabla, 1998; Brouwer and Kleinknecht, 1999; Chabchoub and Niosi, 2005; Nicholas, 2011; Scherer, 1983), see Holgersson (2011; forthcoming) for literature reviews. Mansfield (1986) also identified differences in patent propensity over industries and time, and especially looked into reasons for the decline in US patenting during the 1970s. He found no evidence for the decline being due to a shift from patents to other forms of protection (including trade secret rights). Griliches (1988) found business cycles to be of importance for patenting, concluding that the economic downturn following oil price shocks was part of the explanation behind the decline in the 1970s. Thus, both changes in R&D and patenting resources due to business trend reasons, or other reasons, seem to impact patenting frequency.

Kortum and Lerner (1998) investigated the reasons behind the increase in US patenting during the 1980's and 1990's and concluded that the increase was driven by changes in R&D management and increases in innovative activities with more applied R&D, and not as a result of the establishment of the new, specialized Court of Appeals of the Federal Circuit (CAFC) in 1982. The latter had commonly been argued to impact patenting positively, as it strengthened US patents rights and thereby increased patent values in general. On the other hand, the study of US semiconductor firms by Hall and Ziedonis (2001) showed that this strengthening of patent rights had resulted in entry by specialized firms, vertical disintegration and patent portfolio races, and that it had actually spurred patenting.

A study by Granstrand (1999) of patenting developments in Japan, Sweden, and US pointed at a number of institutional factors behind growth of patenting, especially linked to the emergence of a pro-patent era in the 1980s in the US, due to the establishment of CAFC and a number of policy changes in government and big industry, to which Japanese industry (and later firms in other countries) responded in an escalatory way. ("There is no way to fight a patent but with a patent.") Reasons for increased patenting by Japanese large firms comprised both legal and economic institutional factors and changes, especially those directly related to the emergence of the pro-patent era, and changes in R&D, technology and IP management, including increased R&D and IP resources, more aggressive patent strategies and increased use of technology markets.

Other studies have focused on the increase in patenting in China, where the legal protection of intellectual property rights (IPRs) has traditionally been weak (with the first codified patent laws from the mid-1980s), although recently strengthening as described by e.g. Hu and Jefferson (2009). They found that the Chinese patent "explosion" in the early 2000s was mainly due to strengthened (pro-patent) legislation, foreign direct investments (FDIs), entry of non-state enterprises with more IPR awareness, and increased R&D intensity. Hu (2010) further found that the increase of foreign inward patenting in China was driven by competitive threats rather than by motives to protect the Chinese market.

A related area of research, also reviewed in Holgersson (2011; forthcoming), is focused on different innovation appropriation strategies, among which patenting is one. Again it has been found that there are differences between industries, innovation types, and firm sizes (Arundel, 2001; Cohen, Nelson, and Walsh, 2000; Granstrand, 1999; 2012; Levin et al., 1987).

At macroeconomic level, the aggregate patenting frequency is influenced by industry structure since patent propensity varies over industries (Arundel and Kabla, 1998; Mansfield, 1986; Scherer, 1965; 1983), R&D structure, and business cycles. The high level of R&D concentration in a few large firms in Swedish industry, furthermore, gives a strong dependence between patenting frequency at national level and patenting frequency in these large firms – not least the patenting frequency of Ericsson. The same applies for Finland, and its dependence upon Nokia.

The literature above has explicitly or implicitly pointed at a number of determinants of patenting frequency. Changes in R&D and patenting resources naturally have direct effects on patenting frequency. New technologies and patenting opportunities, shifts in R&D, product, or industry structures, leading to e.g. fewer patentable inventions per R&D dollar or shifts in the propensity to patent, also impact patenting. Studies (Granstrand, 1999; Hall and Ziedonis, 2001) have also shown that the role and importance of patenting might change, e.g. compared to other appropriation strategies, again affecting patenting frequency. These determinants were used for developing the questionnaire used in this study, as further described below.

## 3 Method and data

Patent statistics have been collected partly from the Swedish PTO as well as from WIPO and other foreign agencies, and partly from a survey questionnaire from frequent patentees in Sweden.[1] Assessments of the importance of various determinants behind frequency changes have been collected through surveys, prepared based on previous research, as described above, as well as through pilot interviews and pilot studies. It was then deemed as more relevant to collect assessments from technology and IP managers than to carry out econometric analyses due to rapid dynamics, industry differences, small populations and the need to explore a range of old as well as new variables of interest. Since available patent statistics showed that the decline in SFFs was a result from decreased patenting among large as well as small (in terms of patenting) applicants, two main samples were used; a) a sample of large firms and highly frequent patentees, and b) a sample of small patentees. In addition c) a sample of patent consultancy firms (patent agencies, patent bureaus) was used as a complement. The general sampling principle for the survey study was to cover a sufficiently large part of the upper tail in the distribution of absolute numbers of decrease, in order to be able to explain a major share of the overall decrease. Random sampling was hereby rendered unsuitable compared to tail sampling, due to skewness in the distribution.[2] While this choice limits generalizability in certain aspects, it also means that the results actually do present the main factors behind changes in patent frequency at the Swedish PTO.

The first sample was constructed from different sources. First, it included the 19 largest firms regarding patent application frequency[3]. These 19 firms all had more than 1% each of the total number of patent filings in Sweden over the years 1998-2003. Second, it included the 30 largest firms in terms of value on the Swedish stock market (OMXS30 as of March 8, 2005), a selection dominated by large industrial firms. Third, it included the 44 Swedish firms on the ranking of the top 500 EU companies by R&D investment in 2003, as identified by the 2004 EU Industrial Research Investment Scoreboard. Fourth and finally, the sample also included the corresponding sample surveyed in a previous study of 20 Swedish R&D intensive large companies (see e.g. Granstrand, 1999). Due to extensive overlaps the sample finally consisted of 73 unique essentially large companies by sales plus a few smaller companies by sales but with large patent portfolios or large R&D budgets. The companies in this sample will be referred to as 'large patentees'.

The second sample consisted of 51 smaller patentees. To avoid oversampling the bottom end of patenting firms (many only with one patent over the period 2000-2004), which would have

[1] All persons at the Swedish PTO and participating companies who have kindly provided their assistance are gratefully acknowledged.

[2] Assume that 1% of patentees cover 90% of patent applications. Chances are that the 1% patentees are not (sufficiently) sampled in a random sample.

[3] At the time the sampling was made SFF statistics were not available from the Swedish PTO so the sampling had to be based on the total number of submitted applications.

increased randomness in the explanations, the initial sample comprised firms with between five and 25 SFFs during 2000-2004. Since focus in the study lied on explaining the decline in patenting during the early 2000s, the 51 firms that had decreased their patenting from 2000 to 2004 were selected. The firms in this sample will be referred to as small patentees.

The third sample consisted of 14 of the largest patent consultancy firms in Sweden. These were identified in the records of the Swedish association of patent attorneys ("Svenska Patentombudsföreningen"). The 12 responding firms jointly corresponded to roughly 83% of the total patent consultancy industry in Sweden (in terms of sales).

The purpose of the surveys was partly to collect patenting statistics from the companies in order to validate and complement the Swedish PTO statistics, and partly to collect assessments of explanations of decreases and/or increases in patent application frequency. The survey questionnaire to the large patentees was sent out by paper to these firms in March 2005 and was then followed up by reminders via email and phone calls and in several cases by telephone interviews. To further increase response rate, a web-based version of the survey questionnaire was made available via Internet. At the end, 38 questionnaires were returned, resulting in a final response rate of 52%. The survey to the small patentees was sent out by e-mail in August 2005. 20 questionnaires were returned and the final response rate was thus 39%. The patent consultancy firm survey was sent out by paper in 2006 and the response rate was 86%.[4]

The statistics and surveys as described above are of central importance to this paper. As a complement, an interview-based case study of Nokia was undertaken, based on interviews with the research director. This case serves as an example of how company internal changes lead to changes in patenting activities and strategies. The case is not untypical for multinational corporations (MNCs) and a similar case of Ericsson is presented in Granstrand (1999). Such company cases then provide contextual information about how different explanatory factors may play out inside a company, enriching the picture of how dynamics as well as randomness is involved, and possibly indicating a stage-wise evolution of corporate patenting.

Three types of data sources have thus been used, statistics, survey questionnaires, and interviews. The use of mixed methods and triangulation in this sense gives a richer description and explanation of the studied phenomenon, and also increases validity and reliability.

## 4 The decline in Swedish patenting

In this section changes in the number of national priority patent applications filed at the Swedish PTO will be analyzed. These applications will be called 'Swedish first filings' (SFFs). It should be noted that a patent right with validity in Sweden as of 2012 (before a

[4] Note that some questions were not answered by all respondents, leading to some internal loss of responses.

possible European community patent/EU patent is implemented) can be obtained in any of four ways, namely via the grant of:[5]

1. A first filing filed at the Swedish PTO (SFF), i.e., a Swedish national priority application.
2. A counterpart filing filed at the Swedish PTO, i.e., a subsequent application which is based on a first filing filed somewhere else.
3. A PCT application filed at a PTO that is authorized by WIPO as a PCT receiving office, and eventually validated in Sweden.
4. An EP application filed at EPO, and eventually validated in Sweden.

The expression “number of filed applications” is thus ambiguous, partly because an application can be filed in many ways and partly because there are many types of applications as described above. The expression “Swedish applications” is also ambiguous since it may refer to either the nationality of the applicant or the nationality of the receiving patent office. With the exception of regional patent offices like the EPO, patent offices still have a clear nationality, while applicant companies often do not, e.g. in the case of foreign subsidiaries located in Sweden. These ambiguities naturally aggravate debate as well as analysis. In this section of the paper, focus lies on SFFs, i.e. applications of the first type in the list above. However, other types of applications must be considered as well in order to provide a full picture.

Figure 1 first shows the development of the total number of (priority + counterpart) national filings at the PTOs in a sample of countries during the period 1985–2008. This period by and large covers the pro-patent era. The growths in filings to the US, Japanese, Chinese, Korean and Indian PTOs are evident, as is the growth of PCT applications. The growth of applications to the Swedish PTO during the 1990s is also clear. This period of growth disrupted a previous strongly declining trend. The trend break in 1992 coincided with a deep recession in Sweden. In 2001, i.e. in the midst of a recession, another trend break occurred and growth was disrupted and a period of decrease followed. This period could possibly be seen as a continuation of the earlier period of decrease in the 1980s, since the rates of decrease in these two periods are surprisingly similar.

Thus, since 1992 the total number of national filings at the Swedish PTO (SFs) grew fairly continuously with a peak in 2000, from which a decrease by roughly a third occurred during a 4-year period. Table 1 besides SFs also shows the number of SFFs during 1998–2004. Similar to SFs, the number of SFFs decreased by roughly a third during 2000–2004. Further, the number of different applicants with SFFs also decreased with about 30% during the same period. The SFF share of the total number of submitted national filings (SFs) has been fairly constant during 1998–2004 and fluctuated between 87% and 89%.[6]

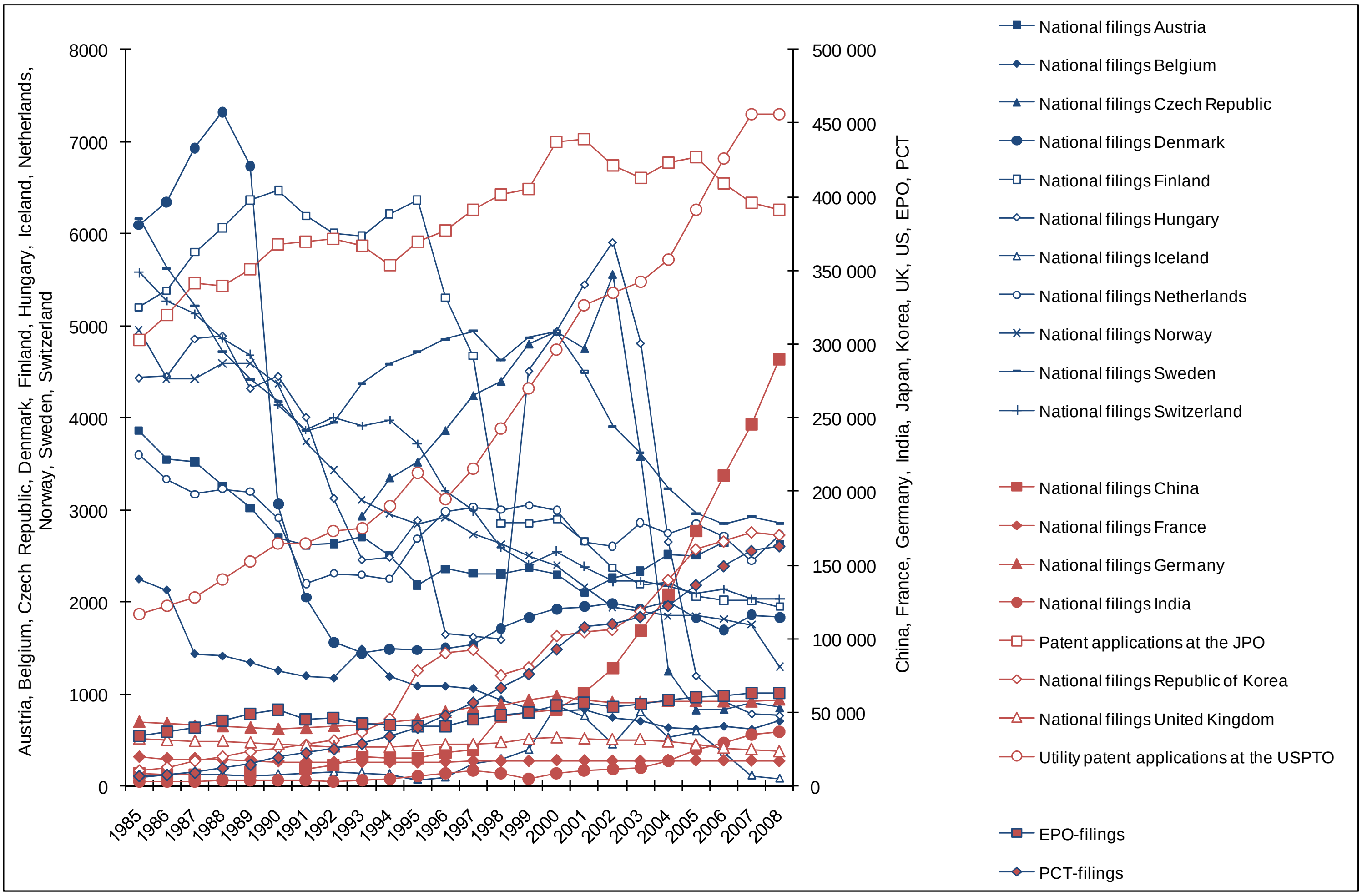
---

[5] Similar types of ways apply in principle to other countries as well, who have joined the EPC and the PCT, i.e. the systems allowing for EPC-applications and PCT-applications respectively.

[6] This appears as an odd observation, also to the Swedish PTO, who cannot substantiate or explain why this share is so consistently high despite fluctuations in the total.

Table 1 also shows a breakdown of SFFs into the nationalities of the applicants. As could be expected, Swedish applicants strongly dominate. However, their share is surprisingly constant during the years 1998–2004, and fluctuating in the narrow band 92–93%.

Finally, Table 1 shows a breakdown into corporate applicants and individual applicants. These two groups were roughly of equal size in 1998. By 2004, both groups had decreased. As might be expected, companies accounted for significantly more SFFs, but the SFFs of both groups decreased in the years 2000–2004 by percentages of roughly equal magnitude, 35% and 31% respectively, i.e. about a third.[7]




*Source*: Data and statistics collected from national PTOs and WIPO.

**Figure 1 The number of national filings in different countries and filings submitted to EPO and PCT during 1985–2008**

[7] Note that individual and corporate applicants correspond to autonomous and corporate entrepreneurship respectively.

**Table 1 Number of national first filings (SFFs) received by the Swedish PTO during 1998–2004**

| | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | Absolute change (2000–2004) | Relative change (2000–2004) |
|---|---|---|---|---|---|---|---|---|---|
| **Type of application:** | | | | | | | | | |
| Total number of applications (SFs) | 4 625 | 4 870 | **4 936** | 4 500 | 3 910 | 3 619 | <u>3 230</u> | -1 706 | -34.6% |
| Total number of SFFs | 4 095 | 4 262 | **4 348** | 3 996 | 3 456 | 3 159 | <u>2 863</u> | -1 485 | -34.2% |
| SFF share of total SFs | 88.5% | 87.5% | 88.1% | **88.8%** | 88.4% | <u>87.3%</u> | 88.6% | 0.55% | 0.6% |
| # of applicants with SFFs | 2 017 | 1 993 | **2 079** | 1 845 | 1 729 | 1 533 | <u>1 458</u> | -621 | -29.9% |
| **Nationality of SFF applicant:** | | | | | | | | | |
| 1 Sweden | 3 769 | 3 957 | **3 997** | 3 699 | 3 217 | 2 906 | <u>2 659</u> | -1 338 | -33.5% |
| 2 Switzerland | <u>62</u> | 75 | 75 | 77 | **88** | 78 | 76 | 1 | 1.3% |
| 3 Germany | 30 | **46** | 41 | 25 | 11 | 32 | <u>9</u> | -32 | -78.0% |
| 4 Finland | 21 | <u>17</u> | 24 | **41** | 27 | 27 | 20 | -4 | -16.7% |
| 5 Ukraine | 24 | 28 | **65** | 16 | 3 | <u>0</u> | 1 | -64 | -98.5% |
| 6 USA | **31** | 24 | 23 | 18 | <u>10</u> | 11 | 15 | -8 | -34.8% |
| 7 UK | **42** | 27 | 20 | 10 | <u>8</u> | 13 | 10 | -10 | -50.0% |
| 8 Netherlands | 19 | 12 | **26** | 17 | 22 | 12 | <u>11</u> | -15 | -57.7% |
| 9 Taiwan | 13 | 16 | 21 | **26** | 11 | <u>7</u> | 12 | -9 | -42.9% |
| 10 Denmark | 15 | 12 | <u>5</u> | **22** | 11 | 16 | 7 | 2 | 40.0% |
| 11 Other countries | **69** | 48 | 51 | 45 | 48 | 57 | <u>43</u> | -8 | -15.7% |
| Total annual # SFFs | 4 095 | 4 262 | **4 348** | 3 996 | 3 456 | 3 159 | <u>2 863</u> | -1 485 | -34.2% |
| Swedish SFF applicants’ share of SFFs | 92.0% | 92.8% | 91.9% | 92.6% | **93.1%** | 92.0% | 92.9% | 90.1% | |
| **Type of applicant:** | | | | | | | | | |
| Annual SFFs from corporate applicants | 2 785 | 2 945 | **3 094** | 2 938 | 2 539 | 2 275 | <u>2 001</u> | -1 093 | -35.3% |
| # corporate applicants | 1 004 | 1 012 | **1 168** | 1 044 | 982 | 868 | <u>786</u> | -382 | -32.7% |
| Annual SFFs/# corporate applicants | 2.77 | **2.91** | 2.65 | 2.81 | 2.59 | 2.62 | <u>2.55</u> | -0.10 | -3.9% |
| Annual SFFs from individual applicants | 1 310 | **1 317** | 1 254 | 1 058 | 917 | 884 | <u>862</u> | -392 | -31.3% |
| # individual applicants | **1 013** | 981 | 911 | 801 | 747 | <u>665</u> | 672 | -239 | -26.2% |
| Annual SFFs/# individual applicants | 1.29 | 1.34 | **1.38** | 1.32 | 1.23 | 1.33 | <u>1.28</u> | -0.09 | -6.8% |

Notes: Lowest annual value across years is underlined, highest value is bold.

*Source*: Swedish PTO data

Table 2 shows a further breakdown of the statistics for corporate applicants into three sub-groups, for each year corresponding to applicants who during the year have filed only one SFF, 2–10 SFFs, and more than 10 SFFs, respectively. The number of applicants in all three groups, as well as the number of SFFs, decreased.

**Table 2 Number of corporate SFF applicants by the number of filed applications during 1998-2004**

| # SFFs | | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | Absolute change (2000–2004) | Relative change (2000–2004) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | # applicants | 717 | 727 | 845 | 742 | 693 | 634 | 558 | -287 | -34.0% |
| | Annual SFFs | 717 | 727 | 845 | 742 | 693 | 634 | 558 | -287 | -34.0% |
| 2-10 | # applicants | 255 | 250 | 286 | 272 | 261 | 207 | 206 | -80 | -28.0% |
| | Annual SFFs | 779 | 791 | 902 | 879 | 870 | 643 | 653 | -249 | -27.6% |
| >10 | # applicants | 32 | 35 | 37 | 30 | 28 | 27 | 22 | -15 | -40.5% |
| | Annual SFFs | 1289 | 1427 | 1347 | 1317 | 976 | 998 | 790 | -557 | -41.4% |

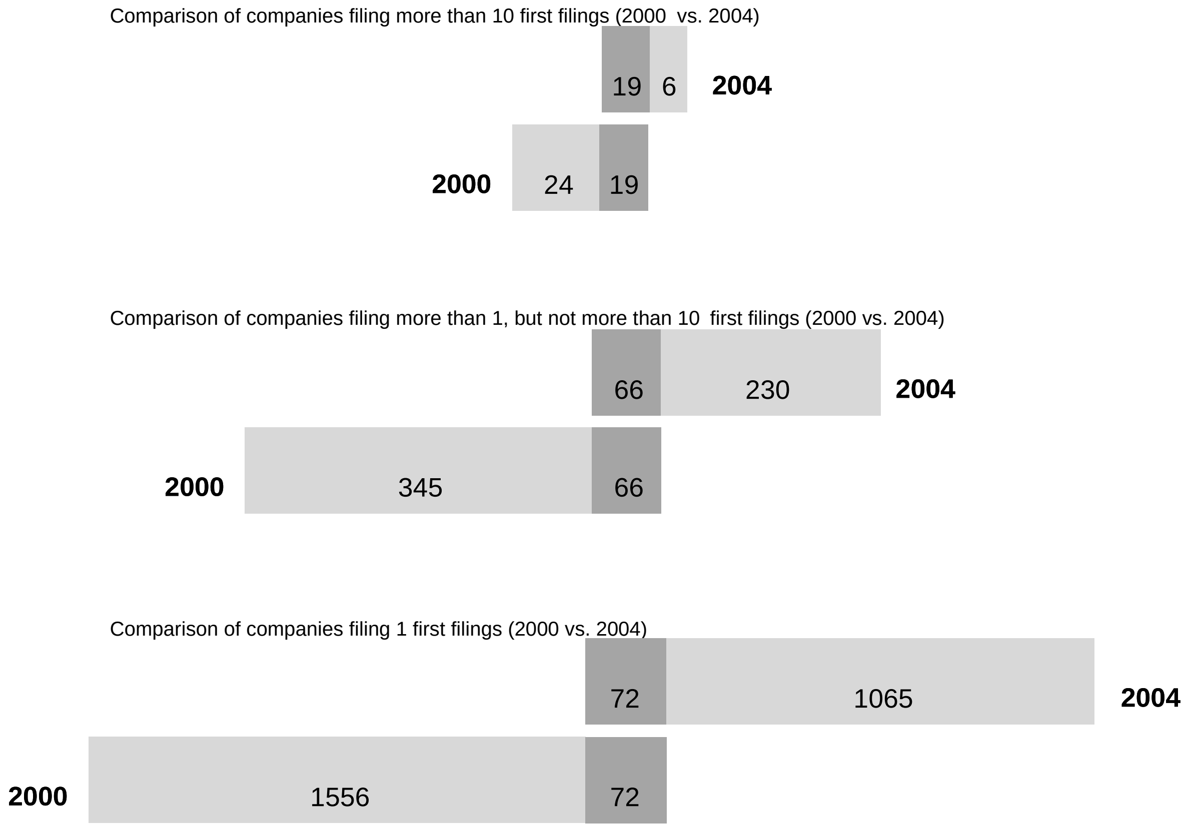
*Source:* Swedish PTO data

Analysis of data on individual patentee level shows how sporadically over time most applicants file SFFs, see Table 3. 90% of the applicants in the period 1998-2004 only file SFFs in one or two out of the seven years. 5% of the applicants file SFFs in three out of seven years and only 5% of the applicants thus file SFFs in four or more out of seven years. If distinguishing between corporate and individual applicants, the data shows that (as expected) corporate applicants are more likely than individuals to file SFFs in multiple years throughout the period. However, 86% of corporate applicants only file for SFFs in one or two out of seven years. This indicates that the turnover of applicants from year to year is quite large, a circumstance which makes it more difficult to find out the reasons behind a decrease in SFFs through a survey study of their applicants, a fact that also impacted sample design in this study. Figure 2 gives a clearer picture of this turnover. The figure e.g. shows that more than half of the applicants in the sub-group with the highest patent application frequency – that is applicants with more than 10 SFFs annually in year 2000 – had disappeared from this top sub-group in year 2004, while only 6 applicants (24%) had entered into the sub-group.

Figure 3 moreover shows SFF-statistics broken down into large, technological areas as these are defined in the IPC system at its first hierarchical level (i.e. the 'section level'). This breakdown shows a large variance of relative (percentage-wise) decrease rates from year 2000 to year 2004 with the largest decrease in the electricity area.

**Table 3 Number of applicants by the number of years out of seven that SFFs were filed from an applicant during 1998-2004**

| **Type of applicant:** | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
|---|---|---|---|---|---|---|---|
| # corporate applicants | 3031 | 697 | 279 | 117 | 76 | 58 | 58 |
| # individual applicants | 3540 | 585 | 159 | 71 | 35 | 17 | 6 |
| | | | | | | | |
| Corporate applicants | 70.2% | 16.1% | 6.5% | 2.7% | 1.8% | 1.3% | 1.3% |
| Individual applicants | 80.2% | 13.3% | 3.6% | 1.6% | 0.8% | 0.4% | 0.1% |
| | | | | | | | |
| Total | 75.3% | 14.7% | 5.0% | 2.2% | 1.3% | 0.9% | 0.7% |



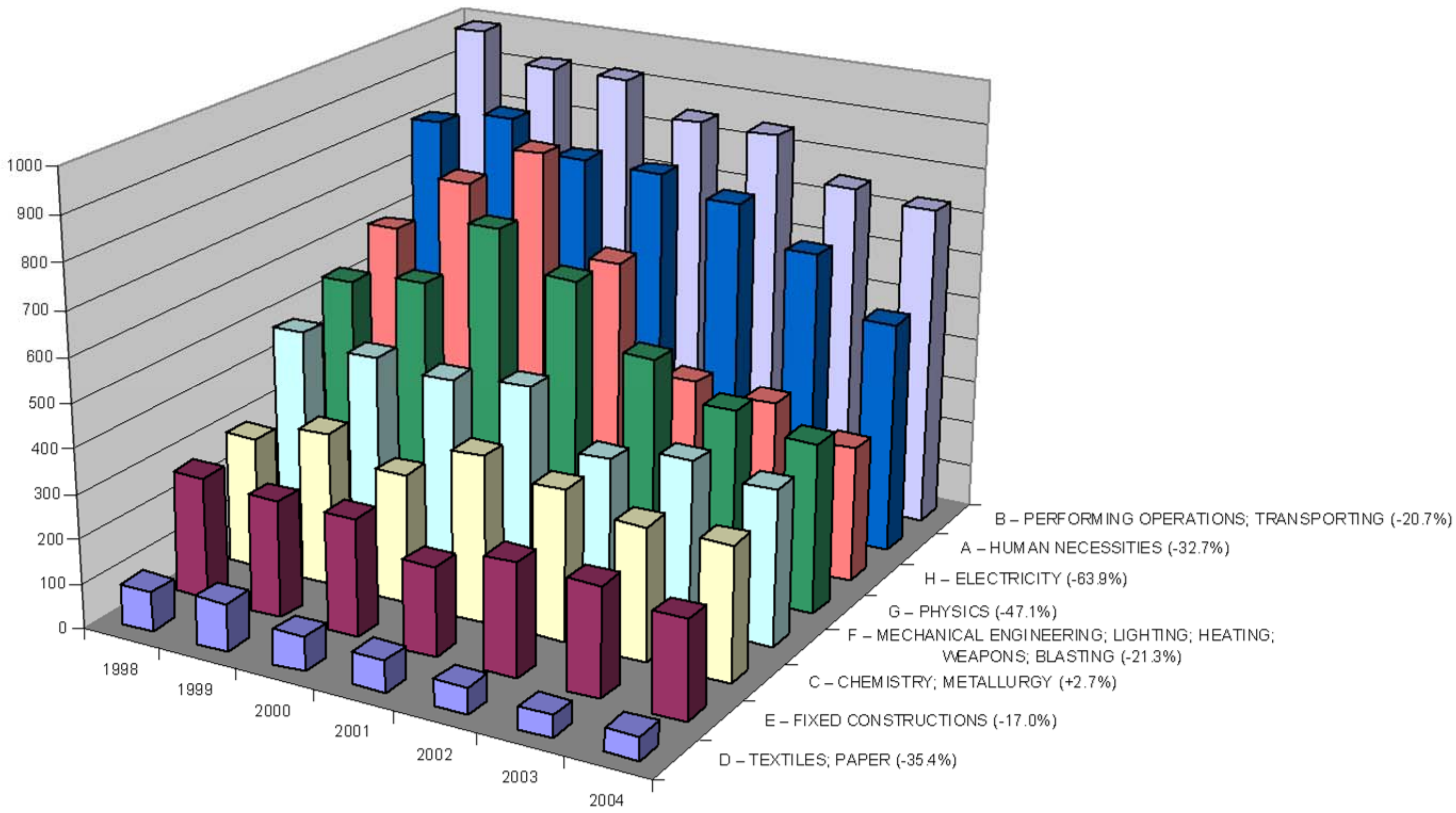

*Legend:*

Figures in dark area = number of applicants who belonged to the group in both 2000 and 2004.

Figures in light area = number of applicants who belonged to the group exactly one of the two years 2000 and 2004 (i.e. in one year but not the other)

*Notes:* Minor differences in total number of applicants occur due to statistical difficulties, e.g. in correcting for misspellings of applicant names.

**Figure 2 Turnover of SFF applicants from year 2000 to year 2004**




Notes: According to IPC classification version 7. Percentage-wise rates of change in # SFFs refer to the change from 2000 to 2004.

**Figure 3 Number of SFFs by different IPC sections in the period 1998–2004 (decrease in % from 2000 to 2004)**[8]

Table 4 shows a breakdown into the largest (i.e. most frequent) SFF applicants during the period 1998 – 2004, split into two 3-year periods before and after the year 2001 in order to make any multi-year change in connection with the turn of a business cycle more clear. Again there is a large variance among the applicants – mostly companies – in their relative (percentage-wise) rate of change from year 2000 to year 2004, a change that is mostly a decrease. There is also a large variance between different years for most companies, a variance that in several cases is not linked to any multi-year trend. However, some companies show clear trends. Especially interesting and dominant is Ericsson and ABB. The SFFs from these firms apparently constitute a large reason behind the decrease in SFFs in general. Altogether the electrical engineering companies (the E-companies) Ericsson, ABB, TeliaSonera, Siemens-Elema and Anoto as a sub-group shows a dominantly large decrease. The total sum of SFFs for the entire group of applicants in the table finally shows a fairly constant level the years 1998 – 2000 with a clear decrease to lower levels for the years 2002 – 2004. All in all, this indicates that a large decrease among highly frequent patent applicants was due to a business cycle recession, especially among the electronics companies. Expressed

[8] Figure 2 and Figure 3 have been provided by Dr. Frank Tietze.

in a very simplified way: the IT bubble burst and with it a "patent bubble". At the same time it should be noted that seven out of the 20 patent applicants, increased the number of SFFs from period 1 to period 2 and among them mainly business cycle sensitive engineering companies in the mechanical engineering area (M-companies), i.e. Volvo, Scania, Sandvik, Electrolux and Atlas Copco.

**Table 4 Number of SFFs from the top 20 SFF filers in the period 1998–2004**

| Rank | Company/applicant | Avg # SFFs/year 1998-2000 (period 1) | Avg # SFFs/year 2002-2004 (period 2) | Tot # SFFs 1998–2004 | Diff # SFFs from period 1 to period 2 | Relative change in # SFFs from period 1 to period 2 |
|---|---|---|---|---|---|---|
| 1 | Ericsson | 282 | 63 | 1224 | -219 | -77.7% |
| 2 | AstraZeneca | 130 | 150 | 1035 | 20 | 15.4% |
| 3 | ABB | 139 | 51 | 680 | -88 | -63.3% |
| 4 | Volvo | 61 | 91 | 550 | 30 | 49.7% |
| 5 | Scania | 46 | 72 | 412 | 26 | 57.7% |
| 6 | Sandvik | 56 | 61 | 402 | 6 | 10.2% |
| 7 | SCA | 58 | 34 | 358 | -24 | -41.1% |
| 8 | SAAB | 38 | 33 | 272 | -5 | -12.3% |
| 9 | Tetra Laval | 38 | 35 | 249 | -3 | -7.9% |
| 10 | TeliaSonera | 54 | 12 | 226 | -42 | -77.9% |
| 11 | Electrolux | 18 | 28 | 185 | 10 | 56.6% |
| 12 | DeLaval Holding | 32 | 22 | 183 | -10 | -32.3% |
| 13 | Atlas Copco | 10 | 35 | 157 | 25 | 246.7% |
| 14 | Alfa Laval | 31 | 13 | 147 | -18 | -59.1% |
| 15 | Alexander Prisyazhny | 38 | 1 | 135 | -37 | -96.5% |
| 16 | Metso | 13 | 21 | 130 | 8 | 65.8% |
| 17 | Siemens-Elema | 24 | 11 | 126 | -13 | -53.5% |
| 18 | Pharmacia | 27 | 9 | 125 | -19 | -68.3% |
| 19 | Anoto | 13 | 8 | 110 | -5 | -35.9% |
| 20 | Stridsberg Innovation | 17 | 15 | 105 | -2 | -12.0% |

*Legend:*

Avg # = Average number of
Tot # = Total number of
Diff # = Difference in number of

*Sourc*e: Swedish PTO data

Papahristodoulou (1987) provided a corresponding top twenty list of Swedish patentees for the period 1969-71, i.e. before the EPO and PCT routes were opened. Despite these two changes, the advent of the pro-patent era and many other more or less radical and possibly disruptive changes, there have been stability and relative low turnover in the top tier, taking M&As and splits into account. There are no entries of entirely new large Swedish companies formed after 1969 on the 1998-2004 list, while several old large companies have disappeared (e.g. the ship-building company Götaverken, the gas company AGA and the defense material company Bofors). Roughly 70% of the companies in 1969-71 list are present in one form or another on the 1998-2004 list, while roughly 30% on the latter list were not present at all in the 1969-71 list. So in very rough terms there are about 30% exits and 30% entries over a 30-year period. This low turnover is in stark contrast with the high turnover of small, infrequent patentees, as shown above.

## 5 Explanatory factors behind changes in firms' patenting frequency

The preceding section illustrated how Swedish national patenting has decreased among large as well as smaller patentees. Results from surveys among three samples (large patentees, small patentees and patent consultancy firms) will here be presented to illuminate determinants behind changes in Swedish patenting frequency.

A good half of the respondents in the large patentee sample displayed a decrease in FFs from year 2000 to year 2004, while a third displayed an increase and the rest neither a decrease nor an increase. Firms with decreased FFs were asked to indicate the importance of various factors behind the decrease, while firms with increased FFs were asked to indicate the importance of factors behind the increase. The small patentees were selected based on decreases in FFs, and therefore only factors behind decreasing patenting were included. The patent consultancy firms, finally, were asked about weights for different factors behind a decrease in SFFs among the clients who had decreased their SFFs. In addition, all samples were asked to weight factors behind an increase in patenting in the 1990s, if such an increase had taken place. It should be noted here that the responses from large patentees and small patentees concerned FFs regardless of the PTO where they had been filed, while responses from patent consultancy firms concerned SFFs specifically.

Table 5 shows the weight the responding companies attached to the various general explanatory factors in the questionnaire. A fairly consistent picture emerges, even if caution is necessary when comparing assessments of this kind across companies and samples.

Changes in the R&D resources and in the patenting resources are important factors behind changes in the patent application frequency, for large as well as small companies. This result is also in line with earlier studies of companies in US and Japan (cf. Scherer, 1983; Mansfield, 1986; Granstrand, 1999).[9] Changes in the patenting resources appear to be a more important factor for an increase than for a decrease, however. The same applies to the factor 'increased strategic importance'.

Besides decreases in R&D resources, important factors behind a decrease in patent application frequency in the period 1998-2004 were a decrease in patenting propensity and a more selective patent strategy, geared more towards patent quality than patent quantity. This statement is valid especially for the companies in the large patentee sample. For the small patentees a decreased role of patents for financing in addition played an important role behind a decrease. This factor is in turn connected to the decrease in supply of venture capital for early innovation phases after the IT bubble burst in year 2000.

[9] These studies show large variations across industries, however, variations which have not been possible to survey in these regards in this investigation.

## Table 5 Explanatory factors behind a decrease and/or increase of first filings in different time periods

| Weights of various factors as explanations for a decrease in first filing applications (scale: 0 = no weight, 4 = of decisive weight) 1) | **Large patentees 1998-2004** | **Small patentees 1998-2004** | **Patent consultancy firms 2001-2005 2)** | **Large patentees 1998-2004** | **Large patentees 1990-1997** | **Small patentees 1990-1997** | **Patent consultancy firms 1990-2000 2)** | Weights of various factors as explanations for an increase in first filing applications1) |
|---|---|---|---|---|---|---|---|---|
| 1. Reduction of R&D resources globally | | | | | | | | 1. Increase of R&D resources globally |
| a. for business-trend reasons | 1.55 | 0.82 | 1.38 | 1.36 | 1.33 | **1.90(2)** | **3.20(1)** | a. for business-trend reasons |
| b. for other (e.g. structural) reasons | **2.36(3)** | **1.55(3)** | **1.63(4)** | **2.15(5)** | **2.42(4)** | **1.80(3)** | 1.40 | b. for other (e.g. structural) reasons |
| 2. Reduction of R&D resources in Sweden | | | | | | | | 2. Increase of R&D resources in Sweden |
| a. for business-trend reasons | 1.55 | 1.09 | **1.50(5)** | 1.18 | 1.09 | 1.56 | **3.20(1)** | a. for business-trend reasons |
| b. for other (e.g. structural) reasons | **2.27(4)** | 1.36 | **1.50(5)** | **2.25(3)** | **2.58(3)** | **1.70(4)** | 1.40 | b. for other (e.g. structural) reasons |
| 3. Reduction of patenting resources | | | | | | | | 3. Increase of patenting resources |
| a. globally | 1.64 | 0.55 | 1.25 | 1.83 | 2.09 | 1.10 | 2.60 | a. globally |
| b. in Sweden | 1.55 | 0.82 | **2.00(2)** | **2.58(2)** | **2.38(5)** | 1.56 | **2.80(5)** | b. in Sweden |
| 4. Decrease in number of patentable inventions per R&D dollar | 1.27 | **1.45(5)** | 1.00 | 1.86 | 1.58 | 1.40 | 1.80 | 4. Increase in number of patentable inventions per R&D dollar |
| 5. Decrease of patenting propensity per patentable invention | **1.73(5)** | **2.09(1)** | 1.38 | **2.15(5)** | **2.83(2)** | **2.10(1)** | 1.40 | 5. Increase of patenting propensity per patentable invention |
| 6. Increase of R&D in areas with fewer possibilities of patenting (e.g. R&D in areas with service or social-science orientation) | 0.55 | 0.36 | 0.88 | 1.77 | 1.83 | 0.89 | 1.40 | 6. Increase of R&D in areas with greater possibilities of patenting |
| 7. Change in patent application strategy in the form of: | | | | | | | | 7. Change in patent application strategy in the form of: |
| a. More secrecy protection | 0.78 | 0.40 | 0.88 | 0.83 | 0.67 | 0.78 | 1.20 | a. Less secrecy protection |
| b. More selective patenting | **2.91(2)** | **1.55(3)** | **2.25(1)** | 1.33 | 1.83 | 1.00 | 2.40 | b. Less selective patenting |
| c. Increased demands on patent quality instead of patent quantity | **3.09(1)** | 1.18 | **1.75(3)** | 1.17 | 1.67 | 0.89 | 2.40 | c. Decreased demands on patent quality to the advantage of patent quantity |
| 8. Change in patents' role and economic importance in the form of: | | | | | | | | 8. Change in patents' role and economic importance in the form of: |
| a. Lower economic value | 0.40 | 0.91 | 0.63 | **2.18(4)** | 2.31 | 1.20 | **3.00(3)** | a. Higher economic value |
| b. Less importance for financing of continued R&D | 0.30 | **1.82(2)** | 0.75 | 1.27 | 1.58 | 1.10 | **2.80(5)** | b. Greater importance for financing of continued R&D |
| c. Less strategic importance in the branch of industry | 0.55 | 1.09 | 0.75 | **2.75(1)** | **2.92(1)** | **1.70(4)** | **3.00(3)** | c. Greater strategic importance in the branch of industry |
| 9. Higher total patent-application costs | 1.64 | 1.00 | 1.00 | 0.64 | 0.42 | 1.30 | 0.40 | 9. Lower total patent-application costs |
| 10. The patents' importance compared to other ways of exploiting an invention (secrecy, speed and efficiency in production and marketing etc.) has decreased | 1.09 | 1.00 | 0.88 | 1.92 | 2.00 | 1.20 | 1.80 | 10. The patents' importance compared to other ways of exploiting an invention (secrecy, speed and efficiency in production and marketing etc.) has increased |
| 11. Other factors | | | | | | | | |
| a. Disclosure through patents is more disadvantageous | 0.55 | 0,55 | 0.75 | | | | | |
| b. Change in the product range towards less patent-intensive products | 1.00 | 0.82 | 0.75 | | | | | |
| c. Shift in comprehensive product generations (e.g. 3G – 4G) | 0.82 | 0.27 | 0.75 | | | | | |
| d. Reduced government support to R&D | 0.00 | 0.45 | 0.88 | | | | | |
| e. Increased product specialization (i.e. less product diversification) | 1.27 | 0.55 | 0.88 | | | | | |
| f. Reduced risk of imitation | 0.09 | 0.55 | 0.75 | | | | | |

Notes: 1) The five most important factors for each company group are marked in bold (ranking within parenthesis).
2) While large patentees and small patentees were asked about first filings in general (FFs), the patent consultancy firms were asked about first filings to the Swedish PTO (SFFs). In addition, the patent consultancy firms were asked to specify factors behind a decrease during 2001-2005, compared to during 1998-2004 for large patentees and small patentees.

*Source*: Surveys

Interestingly, the factors most emphasized as being behind a decrease can be connected with an increased awareness about the economic and strategic value of patents, and an increased ability to focus on fewer but economically and strategically better patents. This picture is strengthened by the most emphasized factors behind an increase in patenting, which focus on increased value and strategic importance of patents, besides increased R&D and patenting resources (which are of importance for both decreases and increases in patenting).

Finally, one can note that the importance attached to various explanatory factors is on average lower for the small patentees than for the large patentees. What lies behind this is difficult to say. An interpretation near at hand is that small patentees have lower patenting frequencies, so their decreases in PF are smaller and more random, and therefore have explanatory factors that are perceived as less tangible and less important. Another interpretation is that patent awareness is lower on average among small patentees and that decreases in PF are indirect consequences of other decisions. A second observation is that the patent consultancy firms put higher weights on factors explaining increases in patenting than those explaining decreases. This might be due to the inherent pro-patent bias within patent consultancy firms.

The strong growth of the PCT system has already been pointed out. Table 6, Table 7 and Table 8 confirm and detail this important development. While increased use of PCT and EPO applications and other priority countries than Sweden are stated to be important factors for a decrease in the SFF share of FFs, the share of total PCT applications globally coming from Swedish applicants has decreased, probably partly as a result of the steep growth of patenting from US and Japanese applicants, as well as from applicants in newly industrialized countries. Swedish applicants' share of total EPO applications has however been fairly constant around 2% during the time period.

Figure 4 and Table 9 shows the development in the period 1998 – 2004 of the different routes for priority patent applications used by the responding large patentees. The growth of the PCT system and also the EPO system is confirmed here again, although the growth in PCT applications to the Swedish PTO is somewhat peculiar as the total number of PCT applications to the Swedish PTO on aggregate level actually decreases during the same time period (see Table 6). Notice however that Figure 4 and Table 9 present data on priority applications (FFs), the routes of which might differ from subsequent applications. The use of the national filing route for FFs is reduced in general, including the national route to the Swedish PTO and to USPTO. As is evident from Table 9, the SFF share of FFs is fairly constant, despite a significant decrease in absolute numbers. Also, the share of EPO applications is fairly constant during the years 2000–2004, but with a growth in the period 1998–2005. On the other hand, the growth of the share of PCT applications submitted to the Swedish PTO is evident, although it is a case of growth from low levels. (Note that the Swedish PTO's annual share of PCT applications globally has steadily decreased from 3.87% in 1997 to 1.08% in 2010 according to Table 6.) Finally, the share of FFs going directly to the USPTO is clearly declining, while the share of FFs going to other (non-Swedish) PTOs is fairly constant.

## Table 6 Swedish PCT and Swedish EPO applications in the period 1997–2010[1)]

| | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of PCT applications filed at the Swedish PTO | 2 208 | 2 465 | 2 500 | 2 691 | **2 915** | 2 455 | 2 097 | 2 053 | 2 048 | 2 123 | 2 246 | 2 318 | 2 045 | 1 774 |
| Share of total annual PCT applications filed globally | **3.87%** | 3.68% | 3.27% | 2.89% | 2.69% | 2.22% | 1.82% | 1.67% | 1.50% | 1.42% | 1.40% | 1.42% | 1.32% | 1.08% |
| Number of PCT applications from Swedish applicants globally[2)] | 2 212 | 2 589 | 2 715 | 3 090 | 3 422 | 2 989 | 2 606 | 2 851 | 2 884 | 3 336 | 3 655 | **4 137** | 3 567 | 3 313 |
| Share of total annual PCT applications filed globally | **3.88%** | 3.86% | 3.56% | 3.31% | 3.16% | 2.71% | 2.26% | 2.32% | 2.11% | 2.23% | 2.29% | 2.53% | 2.30% | 2.02% |
| Number of EPO applications from Swedish applicants[2), 3)] | 1 455 | 1 742 | 1 977 | 2 314 | 2 536 | 2 545 | 2 591 | 2 487 | 2 516 | 2 540 | 2 738 | 3 134 | **3 147** | |
| Share of total annual EPO applications | 2.00% | 2.12% | 2.21% | 2.30% | 2.30% | **2.39%** | 2.22% | 2.01% | 1.95% | 1.88% | 1.94% | 2.14% | 2.34% | |
| Total number of annual PCT applications filed globally | 57 064 | 67 061 | 76 358 | 93 239 | 108 229 | 110 394 | 115 204 | 122 632 | 136 750 | 149 641 | 159 926 | 163 236 | 155 399 | **163 938** |
| Number of total annual EPO applications[3)] | 72 904 | 82 087 | 89 359 | 100 701 | 110 117 | 106 348 | 116 831 | 123 748 | 128 709 | 135 399 | 141 423 | **146 644** | 134 542 | |

Notes: 1) The highest values (over time in each row) are written bold and the lowest values are underlined
2) "Swedish applicant" means Swedish first named applicant, who is not necessarily a Swedish inventor
3) Includes European applications and Euro-PCT applications entering the regional phase

*Source*: WIPO-statistics, EPO Annual Reports 1997–2009

## Table 7 Explanatory factors behind a decreased or increased Swedish PTO-share of first filings during 1998-2004

| Weights of different explanatory factors behind a **decreased share** of first-filing applications to the Swedish PTO (scale: 0 = no weight, 4 = of decisive weight) [1)] | **Small patentees** | **Large patentees** | **Large patentees** | Weights of different explanatory factors behind an **increased share** of first-filing applications to the Swedish PTO [1)] |
|---|---|---|---|---|
| 1. Decreased propensity to choose Sweden as priority country | **1.33(3)** | **2.06(2)** | **2.38(1)** | 1. Increased propensity to choose Sweden as priority country |
| 2. Increased use of PCT and EPO applications for first filings | **1.55(2)** | **2.75(1)** | **1.50(2)** | 2. Decreased use of PCT and EPO applications for first filings |
| 3. Poorer service from PRV compared to other patent offices | 0.36 | 0.67 | **1.33(3)** | 3. Better service from PRV compared to other patent offices |
| 4. The importance of the Swedish market has decreased | **1.82(1)** | **1.71(3)** | 1.00 | 4. The importance of the Swedish market has increased |
| 5. The national patenting has become less advantageous over PCT due to the comparatively early disclosure | 0.82 | 0.64 | | |

Notes: 1) The three most important factors for each company group are marked in bold (ranking within parenthesis).

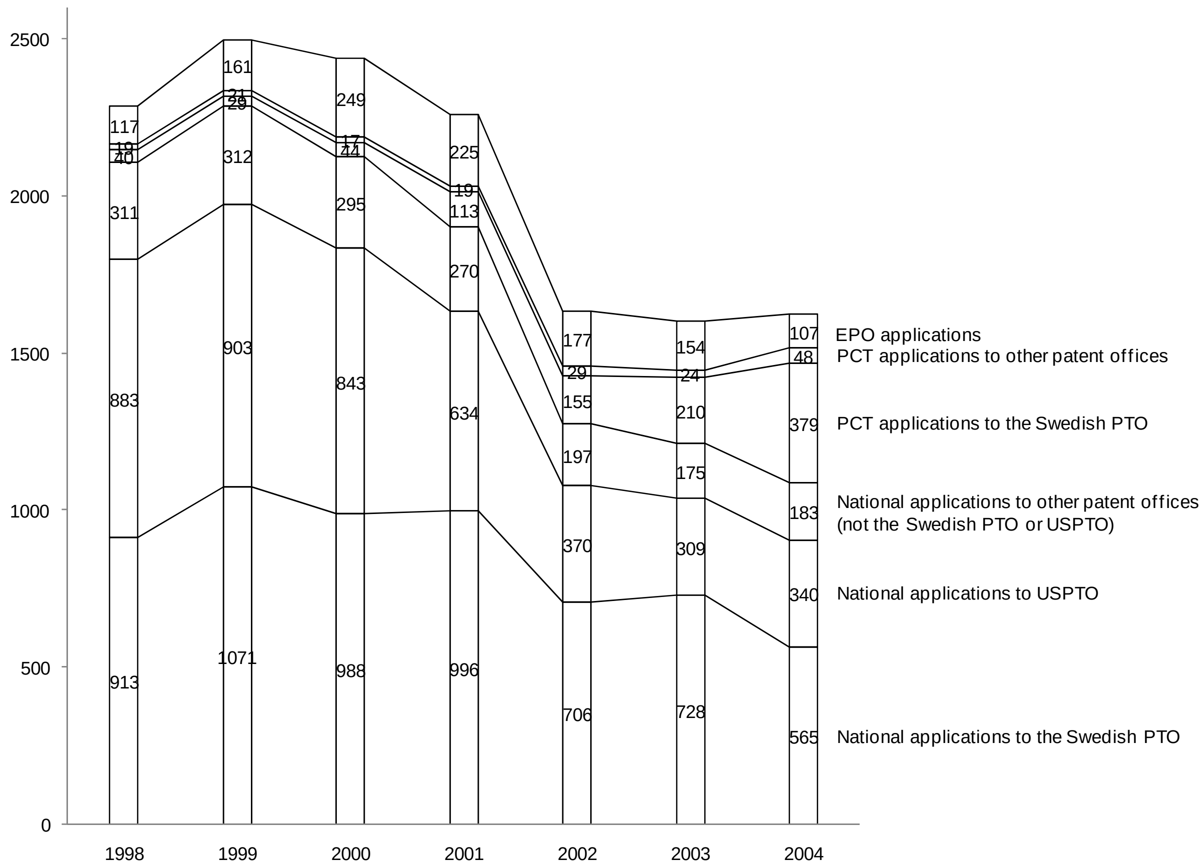
*Source*: Surveys

**Table 8 Explanatory factors behind decreased Swedish first filings during 2001-2005 among clients of patent consultancy firms**

| For your clients that have declined their annual SFFs from 2001 onwards, please estimate which weights the following factors have had on average as explanations for the decline in annual SFFs (scale: 0 = no weight, 4 = of decisive weight) [1)] | **Patent consultancy firms** |
|---|---|
| 1. Decreased propensity to choose Sweden as priority country | **1.78(2)** |
| 2. Increased use of PCT and EPO applications for first filings | **2.56(1)** |
| 3. Poorer service from PRV compared to other patent offices | 1.00 |
| 4. The importance of the Swedish market has decreased | **1.56(3)** |
| 5. The national patenting has become less advantageous over PCT due to the comparatively early disclosure | 0.89 |

Notes: 1) The three most important factors for each company group are marked in bold (ranking within parenthesis).

*Source*: Survey




*Source:* Survey

**Figure 4 Number of first filings along different patent application routes as used by responding Swedish large patentees**

**Table 9 Number of first filings along different patent application routes as used by responding Swedish large patentees**

| Year | SFF (#) | % | FF in USA (#) | % | Other. FF (#) | % | PCT to the Swedish PTO (#) | % | PCT to other PTOs (#) | % | EPO (#) | % | Tot FFs (#) | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1998 | 913 | 40 | 883 | 39 | 311 | 14 | 40 | 2 | 19 | 1 | 117 | 5 | 2282 | 100 |
| 1999 | 1071 | 43 | 903 | 36 | 312 | 13 | 29 | 1 | 21 | 1 | 161 | 6 | 2495 | 100 |
| 2000 | 988 | 41 | 843 | 35 | 295 | 12 | 44 | 2 | 17 | 1 | 249 | 10 | 2437 | 100 |
| 2001 | 996 | 44 | 634 | 28 | 270 | 12 | 113 | 5 | 19 | 1 | 225 | 10 | 2258 | 100 |
| 2002 | 706 | 43 | 370 | 23 | 197 | 12 | 155 | 9 | 29 | 2 | 177 | 11 | 1634 | 100 |
| 2003 | 728 | 45 | 309 | 19 | 175 | 11 | 210 | 13 | 24 | 1 | 154 | 10 | 1601 | 100 |
| 2004 | 565 | 34 | 340 | 20 | 183 | 11 | 379 | 22 | 48 | 3 | 167 | 10 | 1681 | 100 |
| 2005[1)] | 453 | 41 | 72 | 7 | 152 | 14 | 152 | 14 | 95 | 9 | 181 | 16 | 1105 | 100 |

Notes: 1) As estimated by respondents at the time of the survey (end of 2005)

*Source*: Survey

## 5.1 Patenting in the USA by Swedish large companies

Considering the availability of different patenting routes, the marked decrease in SFs and SFFs does not necessarily imply that Swedish large companies have decreased their patenting in general. Table 10 shows the number of patents granted in the US[10] by Swedish companies.[11] Although absolute numbers are roughly the same for 1999 and 2010, the sum of granted patents in the US from the top 10 Swedish firms showed a large decrease in 2007, roughly confirming the picture from Figure 4, with decreasing numbers of US patent applications between 1999 and 2004, since patent grants are typically delayed by several years due to backlogs at PTOs.

**Table 10 Top ten Swedish patentees (in terms of granted patents) in the US in 1999, 2003, 2007, and 2010**

| | **1999** | **Number** | **2003** | **Number** | **2007** | **Number** | **2010** | **Number** |
|---|---|---|---|---|---|---|---|---|
| 1 | Ericsson | 270 | Ericsson | 328 | Ericsson | 123 | Ericsson | 207 |
| 2 | Sandvik | 63 | AstraZeneca | 48 | Volvo Trucks | 35 | Sony Ericsson | 127 |
| 3 | Astra | 51 | SCA Hygiene Products | 46 | Sandvik | 31 | Sandvik | 48 |
| 4 | ABB | 35 | Sandvik | 40 | AstraZeneca | 26 | AstraZeneca | 42 |
| 5 | Volvo | 25 | ABB | 38 | Anoto | 19 | SCA Hygiene Products | 32 |
| 6 | Electrolux | 23 | Volvo Car Corp. | 22 | Sony Ericsson | 18 | SAAB | 30 |
| 7 | Pharmacia & Upjohn | 18 | De Laval Holding | 21 | ASEA Brown Boveri | 17 | Autoliv | 22 |
| 8 | Kvaerner Pulping | 17 | Volvo Cars | 16 | St. Jude Medical | 16 | Välinge Innovation | 22 |
| 9 | Siemens Elema | 16 | Electrolux | 15 | SCA Hygiene Products | 15 | Volvo Trucks | 21 |
| 10 | SCA Hygiene Products | 15 | Akzo Nobel | 15 | SAAB | 14 | Tetra Laval | 18 |

*Source:* USPTO statistics

[10] The term US patents is here used for utility patents in the US.

[11] It must be noted here, however, that patent granting in the US, as well as in many other countries, takes place on average at least 2 – 3 years after the patent application is filed, so a delay occurs in relation to e.g. business cycles and any reductions of R&D investment levels.

### 5.2 Patenting in the USA by top country patentees

Lastly, a look at a corresponding ranking of countries outside the US shows that Sweden occupied a position of no. 9 or 10 during the period 1996–2005, after which Sweden's position dropped, see Table 11. Japan and Germany have been on top throughout this period, followed by France and UK in the beginning of the period and by Taiwan and (South) Korea at the end of the period. Taiwan, Korea, China and India have most evidently risen in the table, both in terms of rankings and absolute numbers of granted US patents. The Asian countries' total share of patents granted in the US has also clearly increased in comparison to the total share of the European countries. Worth noticing is that while the number of SFs and SFFs decreased in the initial years of the 2000s, the number of granted US patents increased slightly over those years. As described above, however, patents are commonly granted a few years after the patent application is filed, and the decrease between 2003 and 2005 corresponds to a decrease in US patent applications from Swedish patentees in the early years of the 2000s (USPTO data on filed patent applications from Swedish patentees confirms this).

**Table 11 Top twenty countries regarding number of patents granted in the US**

| Rank | Country | 1996 | Country | 1999 | Country | 2003 | Country | 2005 | Country | 2007 | Country | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Japan | 23053 | Japan | 31104 | Japan | 35515 | Japan | 30341 | Japan | 33354 | Japan | 35501 |
| 2 | Germany | 6818 | Germany | 9337 | Germany | 11444 | Germany | 9011 | Germany | 9051 | Germany | 9000 |
| 3 | France | 2788 | France | 3820 | Taiwan | 5298 | Taiwan | 5118 | Korea | 6295 | Korea | 8762 |
| 4 | UK | 2454 | Taiwan | 3693 | Korea | 3944 | Korea | 4352 | Taiwan | 6128 | Taiwan | 6642 |
| 5 | Canada | 2232 | UK | 3576 | France | 3868 | UK | 3148 | Canada | 3318 | Canada | 3655 |
| 6 | Taiwan | 1897 | Korea | 3562 | UK | 3631 | Canada | 2894 | UK | 3292 | UK | 3175 |
| 7 | Korea[1)] | 1493 | Canada | 3226 | Canada | 3427 | France | 2866 | France | 3130 | France | 3140 |
| 8 | Italy | 1200 | Italy | 1492 | Italy | 1722 | Italy | 1296 | Italy | 1302 | China | 1655 |
| 9 | Switzerland | 1112 | **Sweden** | **1401** | **Sweden** | **1521** | **Sweden** | **1123** | Australia | 1265 | Israel | 1404 |
| 10 | **Sweden** | **854** | Switzerland | 1279 | Netherlands | 1325 | Switzerland | 995 | Netherlands | 1250 | Italy | 1346 |
| 11 | Netherlands | 797 | Netherlands | 1247 | Switzerland | 1308 | Netherlands | 993 | Israel | 1107 | Netherlands | 1288 |
| 12 | Belgium | 488 | Israel | 743 | Israel | 1193 | Israel | 924 | **Sweden** | **1061** | Australia | 1221 |
| 13 | Israel | 484 | Australia | 707 | Australia | 902 | Australia | 910 | Switzerland | 1035 | Switzerland | 1208 |
| 14 | Australia | 471 | Finland | 649 | Finland | 865 | Finland | 720 | Finland | 850 | **Sweden** | **1014** |
| 15 | Finland | 444 | Belgium | 648 | Belgium | 622 | Belgium | 519 | China | 772 | Finland | 864 |
| 16 | Austria | 362 | Denmark | 487 | Austria | 592 | Austria | 463 | India | 546 | India | 679 |
| 17 | Denmark | 241 | Austria | 479 | Denmark | 529 | China | 402 | Belgium | 520 | Belgium | 594 |
| 18 | Spain | 157 | Norway | 224 | Singapore | 427 | India | 384 | Austria | 457 | Austria | 503 |
| 19 | Norway | 139 | Spain | 222 | India | 342 | Denmark | 358 | Singapore | 393 | Singapore | 436 |
| 20 | Russia[2)] | 116 | Russia | 181 | Spain | 309 | Singapore | 346 | Denmark | 388 | Denmark | 390 |
| | 27 China[3)] | 46 | 24 India | 112 | 21 China | 297 | | | | | | |
| | 30 India | 35 | 27 China | 90 | | | | | | | | |

*Notes:* 1) Korea = Republic of Korea (South Korea)
2) Russia = Russian Federation
3) China, mainland excl. Hong Kong

*Source:* USPTO statistics

## 6 A case of changed patenting strategies – Nokia's new path to patents

Nokia has been a fairly young new entrant but nevertheless rapidly growing into a major player within the telecom industry with substantial R&D work carried out worldwide. Although being a Finnish company, the case of Nokia highlights shifts in patenting strategies that have also taken place in Swedish firms such as Ericsson (Granstrand, 1999; Holgersson, 2011), and thereby gives some understanding to strategy shifts that impact patent numbers on aggregate national level as well.

Nokia was ranked number 21 of foreign organizations in terms of granted US patents during 2006-2010 (with in total 2 857 granted US patents according to USPTO statistics), and holds the largest share of patents related to the telecommunications standards GSM, W-CDMA, and LTE Advanced, with roughly 25%-50% of all essential patents for these standards (Holgersson, 2011). Nokia's patent filings literally exploded in the early 1990s due to disputes with IBM and Motorola. The patent strategy in the beginning of Nokia's own internal "pro-patent era" was simple. Patents were taken on virtually everything possible, and quantity was put ahead of quality. Around 2000, a global IP organization was set up with recruitment and relocation of patent workers, functionally coupled to a global R&D organization although with a large R&D concentration still in Finland, especially in Nokia's long-term research. As of 2005 about 40% of Nokia's approximately 50 000 employees were involved in R&D, and around 50% of all R&D remained in Finland. The long-term research was conducted in Nokia Research Center (NRC) with 1 200 employees, of whom 900 were stationed in Finland. NRC in 2005 provided about 30% of Nokia's just over 1 200 priority applications.

Patents now were sought much more selectively than before, and (economic) patent quality had priority over quantity. The usual choice was the PCT path, which had grown greatly. Selection of patent offices and patent agencies (patent representatives, patent service companies) was largely a consequence of localization of the patent work, which in turn owed to the localization of R&D. There was not yet any overall company strategy for priority applications, but some behaviors were becoming established. To begin with, priority applications in the Finnish language were avoided, since writing patent texts in Finnish seemed meaningless and resulted in duplicative work. This was also due to the Finnish patent office's liberal attitude toward the patent applications' language, applications could besides in Finnish also be written in Swedish or English.[12] Priority applications to the Finnish patent office in English was thereby a somewhat useful option. Speculative applications (written in English) were e.g. rather often submitted as national applications which meant they were inexpensive and, once the priority time ran out, the Finnish application was killed without ever being translated, while the priority was exploited abroad or via the PCT path unless the project was stopped. This had the result that few Finnish patents were by the Finnish PTO granted to Nokia as Finnish first filings. The biggest patentees in Finland were then companies with a traditional model for first filings, companies such as Metso in traditional engineering and raw material (e.g. forestry) related industries.

[12] If filed in English, a translation is however required before the patent is published.

Further, Nokia built a structure for efficient patent management. An allocation matrix was constructed for allocation of patent applications to different patent agencies around the world – patent agencies that were evaluated with regard to a number of quality criteria as well as to risk of possible conflicts of interest. Of the approximately 50 representatives that were used globally, only 10% were Finnish. General contracts that stipulated price, quantity, quality, etc. were written with the respective chosen patent agencies. Certain large patent agencies in Europe and the US were selected in particular as specialists on behalf of Nokia (i.e. as a kind of 'out-house filing centers'). In the choice of patent agencies and representatives as well as choice of patent offices, national borders were irrelevant (while naturally not in the choice of national markets for counterpart applications). Thus, with respect to patent agencies and representatives, Nokia had now taken a more aggressive and considered role in a hierarchically built-up system for suppliers and sub-suppliers of patent services.

Finally, each unit in Nokia had its internally established goals and guidelines for patent work. Different routes or paths for applications were graded and weighted, and the choice of route was usually made by internal patent engineers. Nokia (like most large companies) had many different businesses with diverse patenting possibilities and cross-couplings between businesses and patents. There was a striving toward cluster or block formation of approximately ten patent applications for closely related items, which then went through the same patent agency. This yielded a simpler structure of patent clusters ('patent modules') and of their couplings to business units ('business modules'). All patent clusters belonged to one of four portfolios. The portfolios were relatively independent and had their own priorities and tasks. Depending on technology and Nokia's position, the patents and patent applications included in a portfolio were used differently. Typically, a cluster or block was offered for licensing (within a standard or bilaterally). Other clusters or individual patents were reserved for product differentiation. A third means of use was for defensive purposes, etc. Also the open-source alternative had increasingly entered the picture, but the decision-making for this purpose was not portfolio-based, at least not at the time, and was resolved higher up in the R&D organization.

## 7 Discussion

Traditionally, domestic companies and inventors in a country have chosen to submit first filings as national patents (i.e. not PCT applications or EP applications) to the patent office in the country in question. This traditional picture is changing, in that companies, especially large technology-intensive multinational companies such as Ericsson, ABB, and Nokia, internationalize their patent work and create managerial structures and processes for the submission of first filings of various types, e.g. for different product areas and technological areas, at different national and multinational patent offices through various routes (see Section 6). This change may quickly pick up pace, since patenting activities in large companies have become both more costly and more valuable during the pro-patent era, and have thereby also become a clearer target for thinking in terms of investments, cost savings, returns and economic efficiency and effectiveness. Such a change in turn quickly creates changing conditions especially for small patent offices in small countries with industries dominated by domestic large multinational companies, for example Holland, Switzerland and Sweden. This leads, other things being equal, to a decrease of incoming patent applications for patent offices in small countries with many large multinational companies, such as Sweden. Statistics also show that a decrease occurred for national applications in Sweden, Norway, Finland and many other small industrialized countries during the early 2000s, simultaneously with a steady rise during virtually the entire pro-patent era since the 1980s in the USA, Japan and Korea, and lately also China and India. The decrease in Sweden during the first half of the 2000s was primarily attributable to Swedish applicants and in great measure to the patenting of large companies.

The relative decrease, however, was roughly similar for corporate and individual applicants. SFFs from both groups decreased with roughly one third between 2000 and 2004. In addition, the yearly turnover in the population of applicants was very high. Of those who, at least in some year during the 7-year period 1998–2004, had submitted a first-filing application, only about 5% had applied in four or more out of the seven years, i.e. around 95% on average submitted first-filing applications more seldom than every other year. The turnover in the set of large patentees is fairly low on the other hand (roughly 30% entries and 30% exits in the top 20 list over a 30-year period). To the extent that history matters in technology and IP management, this substantial difference in turnover among patentees gives rise to a qualitative difference in the nature of explanations behind patenting changes in large and small firms, with more underlying path-dependency in the explanations for large firm behavior, and more random effects for small firm behavior. This adds to the asymmetry in reasons behind changes in large and small firms respectively.

It has previously been shown that patent propensity varies over industries and technologies (Arundel and Kabla, 1998; Brouwer and Kleinknecht, 1999; Granstrand, 1999; Mansfield, 1986; Scherer, 1983), and the decrease of national applications in Sweden also varied greatly with the technological area. There was a marked decrease in the electricity area (E-area) from 2000 until 2004. The large companies in this area – Ericsson, ABB and TeliaSonera – dominate the decrease in the area, as well as the decrease among the 20 largest patentees to the Swedish PTO in 1998-2004. This indicates that the decrease in patent applications to the Swedish PTO was partly due to a business downturn in the IT and telecom field.

This is not the sole reason, however. Statistics show a decrease that stretches both before and after the IT crisis years in the beginning of the 2000s. The results from the questionnaire survey among large patentees, small patentees, and IP consultancy firms, respectively, show that changes in R&D resources and patenting resources are important factors behind changes both upward and downward in patenting frequency for both large and small patentees. This result is in line with previous studies (see e.g. Scherer, 1983). Apart from these explanations the survey results point at the importance of a decrease in patenting propensity, in the form of a more selective and quality-oriented patent strategy. In many companies this strategy change replaced a period of quantity-oriented patenting during the 1990s, a time period during which the economic and strategic value of patenting increased a lot which spurred patenting.

Drawing also on previous research the results confirm the clear impact of macro changes in form of the pro-patent era upon companies’ technology and IP management at micro level (cf.

Granstrand and Holgersson, forthcoming), in turn reinforcing the pro-patent era due to the escalatory nature of patent rights, creating patent portfolio arms races (Hall and Ziedonis, 2001; Granstrand, 1999; Holgersson, forthcoming). This is especially so for large, technology-based firms, which in many cases have shifted from a weak to a strong internal IP regime, in other words entering a pro-patent era at corporate level. As is also the case at national level, these shifts to a strong IP regime at company level take place with different timings and for different reasons. The escalatory nature, subsumed in the saying “there is no way to fight a patent but with a patent”, in some aspects (but not all) resembles the mutual switch to a hawkish strategy by players in repetitive games, changing an equilibrium of dove strategies that becomes unstable as soon as a player plays hawkish, and especially so for large firms (as motives to patent varies between large firms and SMEs as described by Blind et al., 2006; Granstrand, 1988; Holgersson, 2011; forthcoming; Rassenfosse, forthcoming). This tend to create a ratchet effect in patenting that can only be offset by macro changes, changing the pay-offs for the players in the patent racing game. Even in case of generous licensing, patenting is favored as a means to offset royalties. To the extent that these escalatory features hold for patent games, a pro-patent era will not easily go away. However, this will not in turn necessarily translate into steady growth of patenting, as shown here, since patenting might after a first period of quantity focus and learning by doing decrease as a result of a shift to a focus on more selective and quality-oriented patenting.

From 1995 to 2005 Sweden on the whole maintained its tenth place among high-frequency patentee countries in the US (in terms of granted patents), but in the period 2005-2010 Sweden declined on the ranking. By contrast, several Asiatic countries climbed up in the list since 1995 – Taiwan, Korea, China, India and Singapore – and together with Japan they have come to dominate US inward patenting from foreign countries. In the absence of cross-country comparative research on patenting behavior, no explanations for the declines in various patent shares of Swedish patenting described above could be offered here, although the catch-up process of newly industrialized countries is likely an important reason behind decreasing relative numbers as well as the switch to more selective and quality-oriented patenting among Swedish firms.

It is worth mentioning that since patenting strategies change over time and vary over industries (with impact on patent propensity), patent numbers as indicators of inventiveness or innovativeness can be misleading. In the case of Sweden, the decrease in patenting during the first years of the 2000s was partly explained by a more selective and quality-oriented patenting strategy, as described above. Hence, differences in patent numbers over industries and/or over time could illustrate strategic differences impacting patent propensity, rather than differences in R&D or R&D yield (cf. Griliches, 1990). The impact of changing patent strategies upon patenting frequency is further illustrated by company cases, e.g. the case of Nokia.

## 8 Summary and conclusions

Researchers have become increasingly interested in fluctuations in patenting frequency and propensity to patent since the productivity and patenting slowdown in the US in the 1970s and then especially since the US shift to a stronger IP regime in the 1980s, triggering the emergence of a worldwide pro-patent era, with a subsequent rapid growth of patenting in many countries, especially in Asia. At the same time declines, temporary or not, can be observed in certain periods and places. Questions then arise as to reasons for these fluctuating or steady patterns of growth of patenting and how they relate to other growth patterns in R&D and patent resources and their management at micro level, the impact of institutional legal and economic changes at macro level, or technological changes, exogenous or not to firms, industries and countries, and whether reasons differ for positive or negative growth in patenting or between large and small firms and across sectors and across routes of patenting. This paper addresses such questions, based on questionnaire surveys to large and small patentees as well as to IP consultancy firms in Sweden, complemented with patent statistics and interviews. This study contributes to the available literature in that it includes a) both macro and micro factors, and the interaction between them; b) both increases and decreases in patenting frequency, and explanations to both trends; c) both large and small patentees; and d) the development of various application routes which strongly impacts the patenting frequency, especially in small countries.

The results point at the importance of size of R&D and size of patenting resources for both large and small firms across industries and for both positive and negative growth of patenting. Further, when large firms entered the pro-patent era, they did that by first implementing a quantity-oriented patent strategy (“patent wherever and whenever possible”). Then in a second phase, when IP awareness and resources had been raised, these firms emphasized a more selective and quality-oriented patent strategy. This type of shift in large firms then led to a decreased propensity to patent and a decline in patenting frequency, amplified in some cases by a business downturn. Thus, the patenting frequency of several large firms go through stages when they with different timings enter the pro-patent era with a rise in patenting (often from low levels) as they shift to a quantity oriented pro-patent strategy and then a bit of a fall as they subsequently shift to a quality oriented pro-patent strategy with stronger cost-benefit concerns. Among reasons discriminating between large and small firms this type of shift featured high. Further, a decreased importance of patents for financing R&D, related to a decline in the supply of venture capital following the business downturn in the early 2000s, led to decreased patenting frequency among small patentees. Patenting by small firms is infrequent on average, however, and in addition the population of small firms is heterogeneous, which makes the explanatory picture more complex and uncertain. The annual turnover of small patentees at the Swedish PTO was also very high.

In addition to the above factors, statistics show an increased use of both the PCT and EPO routes by Swedish applicants, further spurring the decrease in patenting to the Swedish PTO. It is then likely that national first filings are declining in the longer run on average for small countries like Sweden, Finland, Switzerland, and Holland, as especially large companies internationalize their IP operations and increasingly use the PCT route and as home markets become decreasingly important relative to foreign markets. This trend has serious implications for national patent policies and patent offices in small countries, since they to a large extent are dependent upon the number of national patent applications. At the same time the strong growth of patenting in major countries, especially in Asia, will strengthen the need for patent office resources, possibly opening up new opportunities for PTOs like the Swedish one through international collaborations, search services, and other service offers to firms as well as to foreign PTOs.

## Acknowledgements

The work with this paper has been conducted under the auspices of IMIT (Institute for Management of Innovation and Technology) at Chalmers University of Technology within the project “Patents and Innovations for Growth and Welfare”, financed by the Swedish government, and within the project “Management, Economics and IP Law of Open Distributed Innovation”, financed by Vinnova. The competent research assistance of Dr. Frank Tietze in data collection and data presentation is gratefully acknowledged.

## List of abbreviations

| | |
|---|---|
| CAFC | Court of Appeals of the Federal Circuit |
| FF | First filing (priority application of any type to any PTO) |
| IP | Intellectual property |
| IPR | Intellectual property right |
| MNC | Multinational corporation |
| PF | Patenting frequency |
| PCT | Patent cooperation treaty |
| PTO | Patent and trademark office |
| SF | Swedish filing (national patent application to the Swedish PTO) |
| SFF | Swedish first filing (national priority application to the Swedish PTO) |
| SME | Small and medium sized enterprise |
| USPTO | United States Patent and Trademark Office |

## Literature references

Arundel, A. (2001) ‘The relative effectiveness of patents and secrecy for appropriation’, *Research Policy*, Vol. 30, No. 4, pp.611-24.

Arundel, A. and Kabla, I. (1998) 'What percentage of innovations are patented? Empirical estimates for European firms', *Research Policy*, Vol. 27, No. 2, pp.127-41.

Blind, K., Edler, J., Frietsch, R., and Schmoch, U. (2006) 'Motives to patent: Empirical evidence from Germany', *Research Policy*, Vol. 35, No. 5, pp.655-72.

Brouwer, E. and Kleinknecht, A. (1999), 'Innovative output, and a firm's propensity to patent. An exploration of CIS micro data', *Research Policy*, Vol. 28, No. 6, pp. 615-624.

Chabchoub, N. and Niosi, J. (2005) 'Explaining the propensity to patent computer software', *Technovation*, Vol. 25, No. 9, pp. 971-978.

Cohen, W.M., Nelson, R.R., and Walsh, J.P. (2000) *Protecting their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or not)*, NBER Working Paper Series, Cambridge, MA.

Granstrand, O. (1988) *Patents and Innovation - A Study of Patenting Practices and Trends in Sweden with a Brief Outlook on the US*, CIM Working Paper 1988:04., Department of Industrial Management and Economics, Chalmers University of Technology, Gothenburg.

Granstrand, O. (1999) *The Economics and Management of Intellectual Property,* Edward Elgar Publishing, Cheltenham.

Granstrand, O. (2012) *Patents and Innovations for Growth and Welfare*, Edward Elgar Publishing, Cheltenham (forthcoming).

Granstrand, O. and Holgersson, M. (forthcoming) 'Multinational technology and intellectual property management - Is there global convergence and/or specialization?', *International Journal of Technology Management*.

Griliches, Z. (1988) 'Productivity puzzles and R&D: Another nonexplanation', *The Journal of Economic Perspectives*, Vol. 2, No. 4, pp. 9-21.

Griliches, Z. (1990) 'Patent statistics as economic indicators: A survey', *Journal of Economic Literature*, Vol. 28, No. 4, pp. 1661-707.

Hall, B.H. and Ziedonis, R.H. (2001), 'The patent paradox revisited: an empirical study of patenting in the U.S. semiconductor industry, 1979-1995', *RAND Journal of Economics*, Vol. 32, No. 1, pp. 101-28.

Holgersson, M. (2011) *Intellectual Property Strategies and Innovation: Causes and Consequences for Firms and Nations*, Licentiate thesis, Chalmers University of Technology, Gothenburg.

Holgersson, M. (forthcoming) 'Patent management in entreprenuerial SMEs: A literature review and an empirical study of innovation appropriation, patent propensity, and motives', *Under review*.

Hu, A.G. (2010) 'Propensity to patent, competition and China's foreign patenting surge', *Research Policy*, Vol. 39, No. 7, pp. 985-93.

Hu, A.G. and Jefferson, G.H. (2009) 'A great wall of patents: What is behind China's recent patent explosion', *Journal of Development Economics*, Vol. 90, No. 1, pp. 57-68.

Kortum, S. and Lerner, J. (1998) 'Stronger protection or technological revolution: What is behind the recent surge in patenting?' In *Carnegie-Rochester Conference Series on Public Policy 48*. North-Holland, Amsterdam.

Leiponen, A. and Byma, J. (2009) 'If you cannot block, you better run: Small firms, cooperative innovation, and appropriation strategies', *Research Policy,* Vol. 38, No. 9, pp. 1478-88.

Levin, R.C., Klevorick, A.K., Nelson, R.R., and Winter, S.G. (1987) 'Appropriating the Returns from Industrial Research and Development', *Brookings Papers on Economic Activity*, Vol. 1987, No. 3, pp. 783-820.

Mansfield, E. (1986) 'Patents and innovation: An empirical study', *Management Science*, Vol. 32, No. 2, pp. 173-81.

Nicholas, T. (2011) 'Did R&D Firms Used to Patent? Evidence from the First Innovation Surveys', *The Journal of Economic History*, Vol. 71, No. 4, pp. 1029-1056.

Papahristodoulou, C. (1987) *Inventions, Innovations and Economic Growth in Sweden: An Appraisal of the Schumpeterian Theory*. Almqvist & Wiksell International, Stockholm.

Rassenfosse, G. (forthcoming) 'How SMEs exploit their intellectual property assets: evidence from survey data', *Small Business Economics*, DOI: 10.1007/s11187-010-9313-4.

Scherer, F.M. (1965) 'Firm Size, Market Structure, Opportunity, and the Output of Patented Inventions', *The American Economic Review*, Vol. 55, No. 5, pp. 1097-125.

Scherer, F.M. (1983) 'The propensity to patent', *International Journal of Industrial Organization*, Vol. 1, No. 1, pp. 107-28.

# Paper II

# Patent management in entrepreneurial SMEs: A literature review and an empirical study of innovation appropriation, patent propensity, and motives

Marcus Holgersson

marhol@chalmers.se

Chalmers University of Technology / Institute for Management of Innovation and Technology

Gothenburg, Sweden

E-mail: marhol@chalmers.se
Telephone: +46-(0)31 772 5288
Mobile: +46-(0)73 943 1121
Fax: +46-(0)31 772 1240

This paper is accepted for publication in R&D Management, please refer to the paper as:
Holgersson, M. (forthcoming) 'Patent management in entrepreneurial SMEs: A literature review and an empirical study of innovation appropriation, patent propensity, and motives', forthcoming in *R&D Management*.

The definitive version will be made available here:
http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1467-9310

## Abstract

Managers make a number of strategic choices when trying to capture returns from innovation investments, including what appropriation strategy to use and whether or not to patent, strategic choices that depend among other things on firm size. Previous literature, being reviewed in this paper, shows that the patent propensity is lower in small and medium sized enterprises (SMEs) than in large firms and that patenting as means for appropriation is of less importance among SMEs. CEOs and/or R&D managers of 26 entrepreneurial SMEs have been interviewed to explain these differences and to provide insight on how patenting is used in SMEs. The patent competence was low among the studied SMEs, and internal patent resources were found to be important for effective and efficient use of the patent system; for application as well as monitoring and enforcement. While of limited perceived importance for protecting inventions in entrepreneurial SMEs, patents were used to attract customers and venture capital, which is of utmost importance for the survival and growth of these firms. Thus, patenting has an important role to play even in firms where the protective function of patents is secondary.

## Keywords:

Patents; Innovation; Intellectual property rights; Patent propensity; Appropriability; Motives to patent; Financing; SMEs

## 1 Introduction and concepts

Innovation is at core of contemporary business, and innovation investments are therefore central for the competitiveness of firms. All investments are by definition made with expectations of future benefits to the investor. Investments in R&D and innovation are special, since it is difficult for innovators to exclude others from also benefiting from the developed knowledge resources (Arrow, 1962; Stiglitz, 1999) and returns from innovation investments therefore tend to be captured by holders of complementary assets rather than by the innovator when imitation is easy (Teece, 1986). Managers of innovative firms, including small and medium sized enterprises (SMEs), therefore need to carefully choose strategies in order to appropriate the returns from innovation investments. One solution is to apply for a patent, which by the European Patent Office (EPO) is defined as “a legal title granting its holder the right to prevent third parties from commercially exploiting an invention without authorization”. The propensity of firms to use patents (i.e. the ‘patent propensity’) has been researched by a number of scholars following the works of Scherer (1965, 1983).

Patenting is however not the only means for appropriation – i.e. for capturing returns from R&D investments (Teece, 1986; Levin et al., 1987). For example, firms can also choose to protect their innovations by secrecy, sales or service efforts, lead time creation and/or low cost production (e.g., Levin et al., 1987). It has then been shown that although patents are frequently used by innovators, they are rated low in terms of how effectively they can protect innovations in relation to other means of appropriation (e.g., Mansfield 1986; Cohen et al., 2000).

So how come firms do apply for patents, if not for appropriation? There are in fact many other motives for innovative firms to patent than only to prevent imitation, including to improve corporate image, to motivate employees, and to avoid litigation by retaliation power (e.g., Arundel et al., 1995; Blind et al., 2006), and patents can therefore be used as tools not only for protection in innovation management, but also for incentives creation, collaboration, negotiation, licensing, tax-planning, etc. (Granstrand, 1999).

Thus, the concepts of patent propensity, appropriation strategies, and motives for patenting are closely interrelated, as illustrated in Figure 1. The purpose of this paper is to review empirical literature on these concepts and to empirically study how patenting is used by R&D management in entrepreneurial SMEs. The first research question in this paper is related to the literature review:

RQ1: What is the current state of empirical research of patent propensity, appropriation strategies, and motives for patenting?

As the literature review in Chapter 2 will show, previous studies indicate that there are differences between large firms and SMEs. Current literature offers limited explanations to how and why SMEs use patenting and how and why SMEs differ from large firms, however. This study aims to fill this gap, and more specifically intends to answer the following research questions:

RQ2: What is the importance and role of patenting in entrepreneurial SMEs?

RQ3: What are the motives for and against using patenting among entrepreneurial SMEs?

The empirical study focuses on *entrepreneurial* SMEs. The concept of entrepreneurship is neither entirely clear in the literature, nor commonly agreed upon (e.g., Schumpeter, 1934; Gartner, 1990; Covin and Slevin, 1991; Dean and Meyer, 1996), despite its long history arguably dating back to the 17th century and the economist Say (Granstrand, 1982). Nevertheless, entrepreneurial SMEs are here defined as SMEs that base their businesses on new or improved technologies and/or that are newly established or with new or improved means for commercialization and growth. This is comparable with the traditional definition of innovations, a concept that typically includes new technical and managerial developments on one hand and the commercialization of these developments on the other hand (e.g., Schumpeter, 1934; Freeman, 1982; Garcia and Calantole, 2002). The concept of entrepreneurial SMEs guides the sample selection (see Chapter 3), and new empirical data on entrepreneurial SMEs is presented in Chapter 4 in order to answer RQ2 and RQ3. These findings are discussed and concluded in Chapter 5.

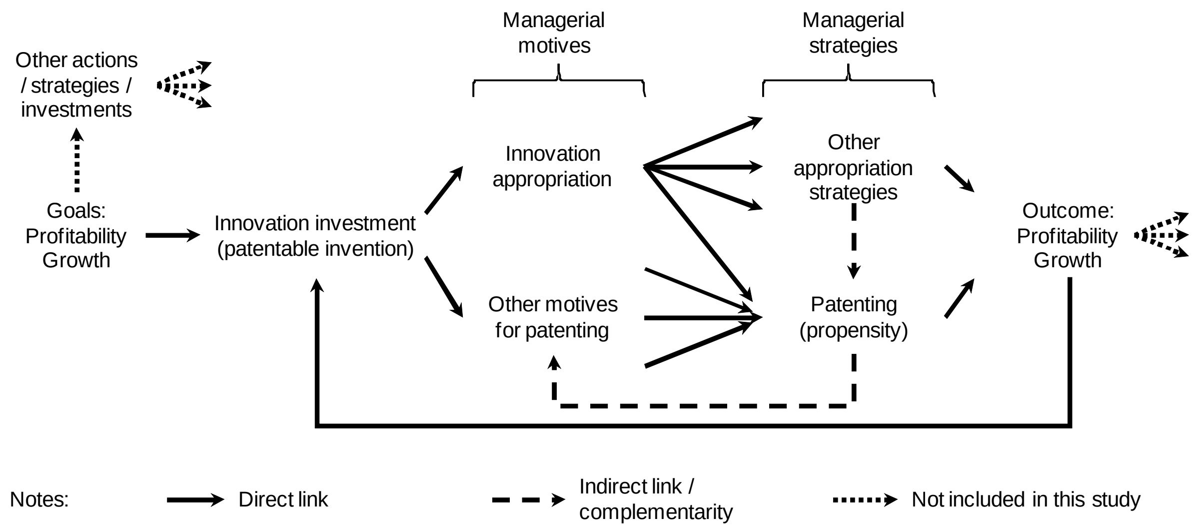



**Figure 1 The interrelated motives and strategies under study**

# 2 Previous research and literature review[1]

## 2.1 Patent propensity

The concept of patent propensity is used with slightly different meanings in the literature. Scherer (1983) focused on the patent per R&D ratio (i.e. patent intensity analogously with R&D intensity), while Mansfield (1986) defined patent propensity as the probability to patent

[1] Both ISI Web of Knowledge and Google Scholar were used for searches on topics like patent propensity, appropriation/appropriability and motives/motivations for patenting/to patent. Additional literature was then found by snowballing. Hence, the literature review had characteristics of both a systematic review and a more narrative approach (Bryman and Bell, 2007).

a patentable *invention* and Arundel and Kabla (1998) defined patent propensity as the probability to patent a patentable *innovation*. All definitions of patent propensity are however related to the underlying management decision of whether to apply for patent protection for an invention or not. Early empirical studies showed that US firms' patenting was mainly related to their R&D outlays, but with varying coefficients over industries (Scherer, 1965, 1983). The results showed that in most industries there was no significant departure from constant returns (59.7%), and that deviations from this were more commonly towards diminishing returns (25.0%) than increasing returns (15.3%) (Scherer, 1983). Constant returns have also been indicated by research showing that the R&D intensity of a firm is not affecting the propensity to patent a patentable innovation (Arundel and Kabla, 1998). Note however that there is an important difference between the patent per R&D cost ratio (as studied by Scherer) and the propensity to patent a patentable invention or innovation (as studied by subsequent scholars). Between the R&D variable and the patent variable is an intermediate variable, namely the number of patentable inventions per R&D cost (R&D yield): Number of patents = R&D × R&D yield × Patent propensity.

Differences between industries in patent output per R&D as described above can arise both due to due to differences in R&D yield and due to differences in patent propensity (for example due to differences in appropriation strategies). Mansfield (1986) investigated this by combining own data on US firms with the results of Scherer (1983). The results of Mansfield's analysis indicate that only 12% of industry variation in patent per R&D was explained by variation in propensity to patent. Instead, the main cause of differences in patent output per R&D was variation in R&D yield over industries. Nevertheless, Mansfield's results showed that not only the patent per R&D ratio varied widely over industries, but also the patent propensity. Later studies of European firms have confirmed such industry variations, and in addition showed that patent propensity is lower for process innovations than for product innovations (Arundel and Kabla, 1998; Brouwer and Kleinknecht, 1999). This goes in line with the common view that patent protection is in general more effective for product than process inventions, since the latter is more difficult to reverse engineer (Granstrand, 1999). In addition to variations over industries and innovation types, studies have indicated that patent propensity varies over time (Griliches, 1989, 1990; Kortum, 1993; Nicholas, 2011; Granstrand and Holgersson, 2012) and countries, with Japan being an extreme example in terms of high patent numbers in the 1980s and 90s (e.g., Rahn, 1983; Westney, 1993; Granstrand, 1999).

An issue of major interest among management and policy scholars alike is whether or not large firms benefit more from the patent system than small firms, which could be indicated by differences in patent propensities. A number of studies have found that large firms have higher patent propensities than small firms (Mansfield, 1986; Arundel and Kabla, 1998; Brouwer and Kleinknecht, 1999; Chabchoub and Niosi, 2005). However, other studies have found that small firms tend to have higher patent per R&D ratios than large ones (Bound et al., 1984; Granstrand, 1988). One part of the explanation could be that small firms have higher R&D yields but lower patent propensities than large firms. Another part of the explanation could be that innovation activities in large firms are underestimated when measured with patent statistics while innovation activities in small firms are underestimated when measured by R&D statistics (Pavitt, 1982).

Table 1 summarizes a selection of the studies on patent propensity. From previous studies it can be concluded that both the patent per R&D ratio and the patent propensity varies over industries, innovation types, time, countries, and firm sizes.

**Table 1 Selected studies on patent propensity**

| Study | Dataset | Main measure | Main findings |
|---|---|---|---|
| Scherer (1983) | Survey of 443 US industrial firms | Patent per R&D | Patent numbers correlate with R&D, mainly linearly<br>The patent per R&D ratio varies over industries |
| Mansfield (1986) | Survey of 100 US manufacturing firms | Propensity to patent patentable inventions | Patent propensity varies over industries (ranging from 50% in primary metals to 86% in petroleum and machinery)<br>The patentable invention per R&D ratio varies over industries<br>Patent propensity did not change significantly between late 1960s to early 80s<br>Patent propensity increases with firm size |
| Arundel and Kabla (1998) | Survey of 604 among Europe's largest industrial firms | Propensity to patent patentable innovations | Patent propensity varies over industries (for product innovations ranging from 8.1% in textiles to 79.2% in pharmaceuticals)<br>Patent propensity is higher for product innovations (avg. 35.9%) than process innovations (avg. 24.8%)<br>Patent propensity increases with firm size<br>R&D intensity does not affect patent propensity |
| Brouwer and Kleinknecht (1999) | CIS survey of about 1300 Dutch manufacturing firms | Appreciation of value of patent protection for innovations (high value is assumed to indicate high propensity) | A clear but imperfect relation between innovative sales and patenting<br>Patent propensity varies over industries<br>Small innovating firms have lower probability than large ones to apply for patents<br>Patent propensity higher among R&D collaborators |
| Chabchoub and Niosi (2005) | Financial, geographic, and patent data | Determinants of propensity to patent | Firm size, geographic clusters, and mix of products and services explain most of the patent propensity |
| Nicholas (2011) | 2777 R&D firms surveyed by NRC in the 1920s and 1930s | Propensity to file for at least one patent in R&D firms and determinants of this measure | R&D firms of the 1920s and 1930s were more likely to patent than modern R&D firms<br>Industry, firm size, and geographic location of R&D facilities are important determinants of the propensity to file for at least one patent |

## 2.2 Appropriation

Appropriability is defined as the ability, or rather possibility, to capture returns from R&D investments (Teece, 1986; Levin et al., 1987). Most empirical studies on appropriation focus on different means of protecting innovations from imitation, since returns tend to end up with others than innovators when imitation is easy (Teece, 1986). Levin et al. (1987) made an early empirical study of different appropriation methods. The results showed great variations over industries in the effectiveness of different means of appropriation, and that patents were more effective than secrecy for new products, while secrecy was more effective for new processes. However, sales or service efforts, lead time, and learning were rated more effective than both patents and secrecy. The limited effectiveness and use of patents for appropriation has been confirmed by a number of subsequent studies (Harabi, 1995; Kitching and Blackburn, 1998; Brouwer and Kleinknecht, 1999; Cohen et al., 2000; Leiponen and Byma, 2009), an exception being large Japanese firms rating patents as the most effective means (Granstrand, 1999). The latter is reflected in the high number of patent applications from Japanese firms at the time.

Worth noting is that the studies of appropriability above at least implicitly tend to view the different means of appropriation as distinct, when they in fact are not. Practitioners use various appropriation strategies in complementary ways. For example, both patents and secrecy can be strategically used to create market lead times (Hurmelinna-Laukkanen and Puumalainen, 2007). Hence, comparing for example the effectiveness of patents and lead times is problematic, to say the least. Arundel (2001) solved this by focusing only on patents and secrecy, since they to some extent are mutually exclusive means of appropriation. He showed that secrecy in general is rated more valuable than patents for all firm sizes and for both product and process innovations, but that the probability with which firms rate secrecy over patents decreases with increasing firm size in the case of product innovations. It should in this connection be noted that an innovation can be protected by both a product patent and a process trade secret, and that patents and trade secrets therefore are not mutually exclusive but rather important complements. Nevertheless, it can be argued that each single bit of knowledge cannot be protected by both a patent (which requires information disclosure) and a trade secret (which requires information non-disclosure).

A number of relative limitations and drawbacks with using patents have been identified in this stream of literature, partly explaining the limited effectiveness and use of them for appropriation. Three limitations have been indicated as especially important by empirical studies. First, competitors can legally "invent around" patents, thereby limiting the function of patents for protection (Harabi, 1995). Second, patent protection requires information disclosure through patent publications, leading to a special form of information leakage (Duquet and Kabla, 1998). Third, patent applications and patent protection is related to direct and indirect costs (Kitching and Blackburn, 1998; Cohen et al., 2000).

Table 2 summarizes the main findings from some of the studies on appropriability. It is remarkable how uniform the picture is on the low relative effectiveness of patents for protecting inventions (Japan and chemical industries being exceptions). Informal means such as sales and service efforts, lead time, learning, and secrecy are all found to be more effective means of appropriation.

**Table 2 Selected studies on appropriability**

| Study | Dataset | Main measure | Main findings |
|---|---|---|---|
| Levin et al. (1987) | Survey of 650 individuals representing 130 lines of business in the US | Effectiveness of alternative means of protecting competitive advantages of new or improved products and processes | Effectiveness of different means varies over industries<br>Patents are more effective than secrecy for new products, but secrecy is more effective for new processes<br>Sales or service efforts, lead time and learning are most effective<br>Competitors’ ability to legally “invent around” patents is the most important limitation to the effectiveness of patents |
| Harabi (1995) | Survey of 358 individuals representing 127 lines of business in Switzerland | Effectiveness of alternative means of protecting competitive advantages of new or improved products and processes | Patents are the least effective means of appropriation<br>Sales or service efforts, lead time and learning are most effective, followed by secrecy<br>Competitors’ ability to legally “invent around” patents and information disclosure are the most important limitations to the effectiveness of patents |
| Kitching and Blackburn (1998) | Telephone survey of 400 SMEs and subsequent face-to-face interviews with 101 of them | The use of informal and formal means of appropriation | Patents are the least used means of appropriation<br>Costs related to formal means of appropriation is the main reason behind the low use<br>SMEs lack resources for litigation in case of infringement |
| Brouwer and Kleinknecht (1999) | Survey of 1008 Dutch manufacturing firms | Effectiveness of various mechanisms for protection of innovations against imitators | Time lead on competitors is the most effective mechanisms, followed by keeping qualified people in the firm and secrecy before patents and other formal means<br>Only 25% of the firms rated patents as very important or crucial for protecting products, and 18% for protecting processes |
| Granstrand (1999) | Survey of 25 Japanese and 20 Swedish major industrial R&D spenders | Effectiveness of various means for protecting product technologies against imitation | The different means are rated differently in different countries and industries (in order of effectiveness):<br>Japan: Patents, cost reductions, lead times, marketing, secrecy, switching costs<br>Sweden: Marketing, cost reductions, lead times, secrecy, patents, switching costs |
| Cohen et al. (2000) | Survey of 1478 US manufacturing firms | Percentage of innovations effectively protected by various appropriation means | Patents are the least effective means of appropriation<br>Secrecy has increased in importance since the study by Levin et al. (1987) |
| Arundel (2001) | CIS survey of 2849 European R&D-performing manufacturing firms | Value of secrecy vs. patents | Secrecy is in general rated more valuable than patents for all firm sizes<br>The probability with which firms rate secrecy over patents decreases with increasing firm size in the case of product innovations |
| Leiponen and Byma (2009) | Survey of 504 Finnish SMEs | Most important mechanism for protecting innovations | Informal means of protection are more commonly than patenting rated most important<br>However, firms with university cooperation are likely to identify patents as most important |

### 2.3 Motives for patenting

The literature presented above gives an ambiguous picture of patenting in firms. On one hand, the literature on appropriation almost uniformly shows that patents have low effectiveness in protecting new products and processes. On the other hand, the literature on patent propensity shows that a large share of patentable inventions is despite this patented. Mansfield (1986) found that in industries where patents were rated unimportant, more than 60% of the patentable inventions were nevertheless patented. This peculiar circumstance is often referred to as the ‘patent paradox’. This patent paradox leads to the question: Why do firms patent? Multiple studies have tried to give answer to that question.

Empirical research has pointed at a number of important reasons to patent, including to prevent imitation, to avoid trials, to reach strong positions in negotiations (Arundel et al., 1995; Duguet and Kabla, 1998; Granstrand, 1999), and to block other firms’ R&D and patenting efforts (Cohen et al., 2000; Thumm, 2004). Studies have also indicated that enhancing the firm’s reputation is a common motive for patenting (Thumm, 2004), and more so for small firms than for large ones (Cohen et al., 2000).

Blind et al. (2006) especially pointed at the low relative importance of exchange motives for patenting as an extraordinary fact in light of increasing technology trade and open innovation. Related research on individual patent level shows that patents are most commonly used internally and for blocking competitors, while seldom licensed and cross-licensed (Giuri et al., 2007). However, in their study of the US semiconductor industry, Hall and Ziedonis (2001) found that the value of patents as “bargaining chips” in negotiations had increased after the strengthening of the US IP regime related to the pro-patent era (which was also found in Granstrand, 1999). Worth noting is moreover that standard-setting motives for patenting have been of increasing importance, especially within the telecommunications industry (Granstrand, 1999; Bekkers et al., 2002). Thus, the pro-patent era not only strengthened traditional defensive motives to patent but also generated new and more offensive motives, such as means for bargaining, standard-setting, and retaliation (Granstrand, 1999).

Regarding differences due to firm size, small firms indicate a higher importance for reputation motives (improvement of technological image and increase in company value) and a lower importance for incentive motives (motivation of staff and internal performance indicator) relative to larger firms, even though the general order of importance are not necessarily different across firm sizes (Blind et al., 2006). Small firms are also more likely to patent to license or to convince investors and banks about the value of the invention (Granstrand, 1988; Rassenfosse, 2012).

Table 3 summarizes a selection of studies on motives for patenting. It is clear that the most important motive for patenting is (the traditional motive) to prevent imitation, but there are a number of other motives that are also of large importance.

**Table 3 Selected studies on motives for patenting**

| Study | Dataset | Main measure | Main findings |
|---|---|---|---|
| Arundel et al. (1995) | Survey of European firms | Importance of various motives for patenting | The most important motives for patenting are to prevent imitation, to improve position in negotiations and to avoid litigation |
| Duguet and Kabla (1998) | Survey of 299 French manufacturing firms | Reasons to patent (yes/no) | Firms most commonly patent (in order of frequency) to prevent imitation, to avoid trials and to reach a strong position in technology negotiations with other firms |
| Granstrand (1999) | Survey of 25 Japanese and 20 Swedish major industrial R&D spenders | Importance of various advantages of patenting | The most important advantages are (in order of importance) to protect technologies, to improve bargaining positions (e.g. in licensing), and to motivate employees<br>R&D productivity measurements and improvement of image are of less importance |
| Cohen et al. (2000) | Survey of 1478 US manufacturing firms | Reasons to patent (yes/no) | The most common motives for patenting are (in order of frequency) to prevent imitation, to block, to prevent suits, to enhance reputation, and for use in negotiation |
| Thumm (2004) | Survey of 53 Swiss biotech firms | Importance of various motives for patenting | The most important motives for patenting are to prevent imitation, to block, and to improve technological image |
| Blind et al. (2006) | Survey of more than 500 German firms (active in patenting at the EPO) | Importance of various motives for patenting | The most important motives for patenting are to prevent imitation, to secure European and national markets, defensive blocking, and to improve technological image |
| Giuri et al. (2007) | Survey of 7711 EPO patents | Use of patents | Patents are most commonly used internally (50.5%) and for blocking competitors while not used internally (18.8%)<br>Patents are often unused (17.5%)<br>Patents are seldom licensed (6.2%), licensed while used internally (3.9%), or cross-licensed (3.1%) |
| Keupp et al. (2009) | Survey of Swiss SMEs | Main reasons to apply for a patent (for users of patents) | The most common main reason is protection from competition (91.9%), followed by piracy (58.4%), contract negotiations (44.1%), publicity (28.0%), and finally finance (13.7%) |
| Rassenfosse (2012) | Survey of 772 applicants at the EPO | Importance of various motives for patenting | Small firms commonly patent for monetary reasons<br>Small firms use their patents more actively than large firms<br>Small firms are more likely to license than large firms |

## 2.4 Characteristics of SMEs

Multiple differences between SMEs and large firms can be identified from previous research on the themes of this paper. A number of studies have shown that the patent propensity is lower in SMEs than in large firms (Mansfield, 1986; Arundel and Kabla, 1998; Brouwer and Kleinknecht, 1999; Iversen, 2003; Chabchoub and Niosi, 2005; Friesike et al., 2009; Keupp et al., 2009), although contrasting research indicate that SMEs actually have higher rates of patent usage than large firms if controlling for industry effects (Jensen and Webster, 2006). SMEs more often than large firms apply only for national patents, as opposed to applying for patent protection both domestically and internationally (Friesike et al., 2009). Further, SMEs more commonly than large firms prefer secrecy before patents (Arundel, 2001), and they have been argued to focus on protecting the innovative inputs (including R&D personnel) rather than innovative outputs (i.e. innovations), and then especially by using proper human resource management (HRM) (Olander et al., 2009). Research has indicated that SMEs emphasize reputation motives for patenting more than large firms (Blind et al., 2006) and that they commonly patent for monetary reasons (Rassenfosse, 2012).

A number of specific characteristics of SMEs need to be taken into account when analyzing these differences. For example, Hoffman et al. (1998) argued (based on a literature review) that the innovative activities of SMEs are more likely to involve product than process innovation, more likely to focus on niche rather than mass markets, and more likely to involve linkages to external resources. Further, Blomqvist (2002) argued that technology-based SMEs are lean, flexible, visionary, non-hierarchical with fast decision-making, but especially (for the purpose of this paper) that the resources are mainly people-embodied and that there is a lack of organizational legitimacy. Looking more specifically at new technology-based firms (NTBFs), they are characterized by a lack of financial capital, and partnerships with larger firms commonly spur (mutual) success (Storey and Tether, 1998). Thus, there are differences between large firms and SMEs of importance to patent management, aside from differences in mere size. Therefore, the remainder of this paper will focus on RQ2 and RQ3, with the purpose to increase the understanding of the importance and role of patenting and the motives for and against using patenting among entrepreneurial SMEs.

## 3 Method for empirical data collection

This study was designed and partly carried out within a larger investigation of patents and innovations' role for growth and welfare (SOU, 2006; Granstrand, forthcoming). As indicated by the literature review, quantitative methods have been dominant in previous empirical studies of patent propensity, appropriability and motives for patenting. Although these quantitative studies have been informative in many aspects, they are limited in others. A qualitative method is therefore used here to complement previous studies and to enrich the understanding of patent management in entrepreneurial SMEs. The data was collected in semi-structured interviews among three different samples (see Table 4), and non-probability sampling was used. In general, the sampling was purposive (Flick, 2009) in the sense that tail samples were chosen to generate insight in different types of entrepreneurial SMEs.

The first sample includes entrepreneurial high growth SMEs, representing SMEs with new or improved commercialization and sales growth. Top growth Swedish SMEs were sampled based on a list of the fastest (organically) growing Swedish companies (over a three year period) published by the Swedish business newspaper "Dagens Industri" (Nilses, 2004). The included firms have published at least four annual reports; have total sales greater than 10 MSEK; have at least ten employees; have during the last three years continuously increased their total sales; have during the same period at least doubled their total sales; and have a collected profit over the four years that is greater than zero. Six companies had in 2005 been on the list for all six years during which the list had been published and had sales growths from 1996 to 2003 of between 561% and 2 472%. These six were selected for the first round of telephone interviews among entrepreneurial high growth SMEs, and in addition two firms further down the list (i.e. firms that had not been on the list for all six years). The eight firms had in between 20 and 200 employees. Four of the firms were essentially service firms, while the other four were manufacturing firms active in medicine and mechanical, material, and electrical engineering. After a total of eight interviews had been performed, a decision was made not to continue with interviews among high growth SMEs, due to theoretical saturation (Glaser and Strauss, 1967).

The second sample includes entrepreneurial hi-tech SMEs, representing SMEs based on new or improved technologies. These were sampled based on a list of Swedish hi-tech firms in growth in the Swedish technology and engineering newspaper "Ny Teknik" (Alpman and Mellgren, 2005). After cleaning the list from mergers and acquisitions, inactive firms, firms without reported financials, etc., 29 firms remained. Financial data including sales and employees was collected for all firms. Twelve of the firms were then randomly selected for telephone interviews, six from the top half of sales growth between 2001 and 2004, and six from the bottom half (two of the selected firms had negative growth). These interviewed firms were all within traditional engineering industries, including mechanical, electrical, computer, and chemical (and biotech) engineering, with roughly 5 to 70 employees.

The third sample includes firms in a geographical region, the "Gnosjö region", characterized by a documented entrepreneurial spirit, the "Gnosjö spirit", of enterprising and networking (Wigren, 2003). Six firms were selected by snowball sampling (see e.g. Bryman and Bell, 2007), focusing on firms of different sizes within the SME spectra with at least some form of patenting activities. Hence, this sample consists of SMEs related to a specific geographical area with a documented entrepreneurial spirit rather than SMEs with some specific characteristics. These firms were all within mechanical (and to some extent material) engineering industries with roughly 10 to 400 employees. The firms in the entrepreneurial region were visited and interviewed face-to-face. In addition to these interviews, a hearing was held with 14 industry representatives (primarily CEOs, R&D managers and bankers) from various firms (not included in the main sample) within the region.

**Table 4 Summary of sub-studies**

| Sub-study | Dataset | Sampling | Data collection |
|---|---|---|---|
| Entrepreneurial hi-growth SMEs | Eight firms | Purposive and tail sampling | Telephone interviews (semi-structured) |
| Entrepreneurial hi-tech SMEs | Twelve firms | Purposive and tail sampling | Telephone interviews (semi-structured), questionnaire |
| Entrepreneurial region | Six firms + hearing with 14 representatives | Purposive and snowball sampling | Company visits and face-to-face interviews[2] (semi-structured), hearing |

The interviews were conducted with CEOs and/or R&D managers. 26 interviews were conducted in total and some of them were complemented with e-mail questions and/or follow-up discussions. Semi-structured interviews were used to allow for flexibility, open discussions and new ideas (Bryman and Bell, 2007). The interviews were mainly structured along four themes, including (1) importance and role of patenting for the firm, (2) competence and resources for patenting in the firm, (3) motives for patenting and reasons not to patent in the

[2] The face-to-face interview with one of the companies had to be cancelled, and a telephone interview was therefore conducted with that firm instead.

firm, and (4) potential support regarding patenting needed in the firm. This paper focuses on the first three of these themes. Within-case and cross-case analyses were performed of the collected data (Eisenhardt, 1989). These two types of analyses were performed on two different levels in this study due to multiple samples with multiple firms in each. Firstly, the results of each single firm were analyzed, followed secondly by a cross-firm analysis within each sample (the latter also corresponds to a within-sample analysis). Thirdly, a cross-sample analysis was conducted.

# 4 Empirical results

## 4.1 Entrepreneurial high growth SMEs

The interviews in the sample with entrepreneurial high growth SMEs revealed that patenting was perceived as of little or no importance for a majority of the firms. The main reason behind this, as addressed by the interviewees, was that patents were not applicable in the firms’ businesses and that technical inventions in general were of little importance. However, in one case where technical product innovations were arguably of most importance behind the growth of the firm, patents were still neglected. Despite the fact that the firm had previously experienced a former employee leaving and starting up imitating production in Germany, there were no intentions in the firm to start using patents. Comments such as “the only thing we have patented is our company name”, “the market is big enough for more actors”, and “we produce as much as we can anyway” revealed that the competence regarding patenting, how it can be used and potential benefits was low. This was true in general among the high growth SMEs, with a few exceptions.

Some interviewees addressed concerns regarding too high direct as well as indirect costs of patenting, and the weak protection patents give SMEs. Considering the technical knowledge being revealed by patents and the poor possibilities of monitoring and enforcing granted patents for SMEs, patents were often perceived to do more harm than good. The absence of a single EU patent was by one interviewee also mentioned as a major disadvantage, since the vast amount of applications (and related translations) necessary to cover the European market is difficult to handle for SMEs. Another firm addressed speed to market to be of utmost importance for appropriation, especially due to short product life cycles that limited imitation risks. However, patents were nevertheless regarded to have a significant value for the company in that they were used for customer marketing purposes, for example by the use of “patented” or “patent pending” in the marketing of the product and on the product itself (“patent markings”). Note that patent markings on products can be used both to signal inventiveness to customers and to signal proprietary characteristics to competitors. Actual patents or patent applications are necessary for enabling patent markings, since false patent markings are illegal, and in the US anyone can sue for false patent marking and share the potential penalties 50/50 with the US state. (After a legal change in the US in 2009, which significantly raised potential penalties, there has been a large increase in the number of litigation filings regarding false patent markings.)

### 4.2 Entrepreneurial hi-tech SMEs

Compared to the high growth SMEs, the hi-tech SMEs were much more active in patenting. However, despite the fact that technical inventions were of major importance for these firms and their growth, and despite the fact that patenting was frequently used, their patenting was with a few exceptions not regarded to have large impact on the firms’ competitiveness and growth.[3] One aspect of patenting differed and turned out to be of general importance. A majority of the firms addressed that patenting is crucial to attract venture capital (VC), and most of the firms in this sample were financed by VC. Since external financial capital is necessary to develop and grow for many hi-tech SMEs, patents play a central role in these firms. Patents were also found to be of importance in cases of mergers and acquisitions.

Patents’ importance in customer marketing was again addressed by numerous interviewees. Secrecy and speed were found to be more important than patents for firm competitiveness in some cases, but not all. While the internal patenting competence in the firms was perceived to be low by the interviewees (the majority relied mainly or solely on external consultancies), top management had central roles in patenting decisions.

Some of the interviewed SMEs used patent information to avoid infringements by staying away from patented technologies and/or to find blocking patents that need to be licensed. However, none of them used patent information to find available technological solutions of others that could be used directly or invented around. Despite this, disclosure of patent information was addressed as one of the major drawbacks of patenting. This is paradoxical, since at the same time as the interviewed SMEs apparently see a value of the technological information they provide to competitors through patent publications, they do not take advantage of the reverse information flow from the competitors’ patent publication. This might then be a result of a lack of resources, since this was a major problem in the entrepreneurial hi-tech SMEs, not only in the application stage but also in enforcement (and especially enforcement against large firms).

The findings from entrepreneurial hi-tech SMEs can be summarized by a comment by one of the interviewed CEOs: “A patent has three important roles in our company; 1. Facilitate financing, 2. Deter imitation, 3. Acknowledgement of unique technology”. However, the same CEO summarized the general view on patents’ limited ability to deter imitation and protect SMEs’ inventions in that “the protection is proportional to the amount of cash in your firm”.

### 4.3 Entrepreneurial region

As described above, the “Gnosjö region” is characterized by a documented entrepreneurial spirit and culture, the “Gnosjö spirit”, of enterprising and networking (Wigren, 2003). The interviews in this entrepreneurial region revealed somewhat different findings than the interviews in the other two entrepreneurial samples. Two of the firms were by sample design in the larger end of the SME spectra, and it was clear that the patent competence within these two firms was significantly higher than among the smaller ones, and both had employed

[3] Note that the sampled entrepreneurial hi-tech SMEs (which were mainly in the electronics and chemistry industries) were young, between five and twelve years of age and in general only with a short time on the market, and benefits from patents might not be immediately obvious. In addition, counterfactual analysis (of what would be the situation without a patent) is difficult to perform.

patent engineers internally which was by these firms seen as a major prerequisite to use the patent system effectively and efficiently. These firms also turned out to trust the function of patents much more than the smaller firms, and patenting was of major importance for their competitiveness. As a contrast, the patent competence among the smaller firms was low in general, and patents were less trusted and of less importance for firm competitiveness.

The general preference in the sample was patents before secrecy when protecting important product innovations, and secrecy before patents when protecting process innovations. The latter was due to impossibilities of monitoring infringements in process patents since these commonly take place within the walls of other firms, and in addition that reverse engineering is more difficult to undertake for competitors in case of process innovations than in case of product innovations. The preference for patenting product innovations had to do partly with limiting risks for reverse engineering (essentially among the larger SMEs) and partly with the use of patents in customer marketing (essentially among the smaller SMEs).

A concern among the firms was that the inventive step required for an invention to be patentable is too low, and that this is a drawback for SMEs. SMEs have fewer resources than large firms, and this limits both their patenting activities and their abilities to monitor the vast amount of patents that results from larger firms' patenting, especially when requirements for patentability are low since this leads to extensive patenting among large firms. The patent thickets of larger firms and how to navigate the internal R&D among them (patent clearance) had become a major concern.

The entrepreneurial spirit and culture in the region turned out to impact the firms' patent and appropriation strategies in an interesting direction, especially among the smaller SMEs. In light of the low inventive step requirements and the related possibilities to patent minor innovations one interviewee stated that "I would be ashamed if we patented every tiny thing we invented. We have a social responsibility". Two of the interviewees stated that their firms should not need to worry about patenting, since imitation should instead be met by outstanding inventiveness and entrepreneurial spirit: "In this region we focus on doing things, and if someone else starts doing the same things we do them even better." A related statement expressed by many interviewees was that how to produce something and the quality it results in is more important to protect (by secrecy) than the product invention (by patents), since imitators commonly cannot produce with the same level of quality. However, unauthorized imitation was still an issue for many of the firms, both imitation within the region and imitation globally (primarily in Asia). An important function of industry exhibitions/fairs/expos is then for an innovating SME to control whether any unauthorized imitation is taking place, according to the interviewees (contrasting the use of continuous patent/infringement monitoring).

## 5 Discussion and conclusion

Earlier research has been dominated by quantitative methods and commonly focused on one, or in a few cases two out of the studied themes in this paper; patent propensity, appropriation strategies, and motives for patenting. This paper contributes to the growing literature within intellectual property (IP) management by utilizing a qualitative method allowing a broader perspective including all three interrelated themes, see Figure 1. Additionally, the empirical research focuses on entrepreneurial SMEs, enabling insight into how patenting is used in the R&D management of entrepreneurial SMEs.

The empirical results, summarized in Table 5, indicate that patents were of little perceived importance when appropriating returns from R&D in the entrepreneurial SMEs. When patenting, the traditional motive to deter imitation was of limited importance (exceptions being a couple of the larger SMEs in the entrepreneurial region), contrasting previous results among SMEs as well as large firms (e.g., Arundel et al., 1995; Duguet and Kabla, 1998; Granstrand, 1999; Cohen et al., 2000; Thumm, 2004; Blind et al., 2006; Keupp et al., 2009). A major reason for the studied SMEs’ low trust on the ability of patents to deter imitation was the limited resources they have for monitoring and enforcing their patents. This contrasts the results by Cohen et al. (2000), where defense costs were found to be the least important reason not to patent. SMEs commonly lack litigation resources (Kitching and Blackburn, 1998), which in many ways are prerequisites for the ability to enforce their rights. In addition, litigation risks and threats are higher for SMEs than for large firms (Lanjouw and Schankerman, 2004), and the patent system has accordingly been argued not to function properly for SMEs (Kingston, 2004). The disclosure of patent information, an important drawback of patenting according to this and other studies (Levin et al., 1987; Harabi, 1995), has then especially severe consequences for SMEs with limited resources for monitoring and enforcing their rights after being published. (Also, a published patent application might never mature into a patent – or a patent with commercially useful claims.)

Instead of deterring imitation, two kinds of marketing motives for patenting stand out as of major importance among entrepreneurial SMEs; customer and capital marketing. These two marketing motives go well in line with some of the main struggles entrepreneurial SMEs encounter – to attract customers and meanwhile to survive financially (e.g., Storey and Tether, 1998).

Regarding customer marketing, the use of patents for improving corporate/technological image has according to previous studies been of little importance (Granstrand, 1999; Cohen et al., 2000; Thumm, 2004; Blind et al., 2006). This is contrasted by the results here, where the potential of patents to attract customers was one of the main motives for patenting, indicated in all three samples of entrepreneurial SMEs. A reason for this might be that SMEs have weaker market positions in general than large firms (Blomqvist, 2002), and the function and innovativeness of their products thus need to be proven by other means than yet not strong trademarks, for example by patent markings.

Regarding capital marketing, earlier studies have on one hand shown limited importance of VC attraction as a motive for patenting (Thumm, 2004; Keupp et al., 2009), and on the other hand shown that SMEs can use patents as a value signal to banks and investors (Lemley, 2000; Hsu and Ziedonis, 2008; Haeussler et al., 2009; Rassenfosse, 2012). This empirical study shows that patents are used to attract VC, sometimes even being prerequisites for investments, and VC attraction was the most important motive for patenting among the entrepreneurial hi-tech SMEs, contrasting earlier studies. Thus, venture capitalists seem to rely more on patents than managers of entrepreneurial SMEs. Two potential explanations to this can be highlighted. First, venture capitalists typically make long-term investments and are then well aware of the potential benefits of patents later in the SME’s life (a patent can stay valid for 20 years). Managers of SMEs, by contrast, are often unaware of the IP system (Pitkethly, 2012). Second, patents can be used as an internal governance tool, complementing for example employment contracts and mitigating the principal-agent problem by safeguarding that the knowledge and intellectual capital of the investment object, often centered among a few single individuals, is kept within the firm after the investment. This is of course of major importance to investors.

**Table 5 Summary of empirical results**

| Sub-study | Type of firms | Empirical results |
|---|---|---|
| Entrepreneurial hi-growth SMEs | Service as well as manufacturing firms of different ages | Most firms were not active in patenting<br>Patent competence was low<br>Patenting was of little or no perceived importance since a majority of the firms were not based on patentable innovations<br>When available, patents were used for customer marketing purposes<br>When used for customer marketing, the protective function of patents is not important and one patent per product is therefore enough<br>SMEs do not have enough resources for monitoring and enforcing patents<br>Costs and disclosure of information are main drawbacks with patenting<br>Patents are not prerequisites for high growth |
| Entrepreneurial hi-tech SMEs | Young (below twelve years) hi-tech firms within mechanical, electrical, computer, and chemical (and biotech) engineering | The firms were active in patenting and technical inventions were of major importance for firm growth<br>Patent competence was low<br>Patents were of little perceived importance for competitiveness and growth<br>Patents were of major importance for attracting investors/financiers<br>Patents were used for customer marketing purposes<br>SMEs do not have enough resources for monitoring and enforcing patents<br>Costs and disclosure of information are main drawbacks with patenting |
| Entrepreneurial region | Old firms (above 30 years) within mechanical and materials engineering | The firms were active in patenting<br>The larger firms had more patenting resources and competence than the smaller ones<br>The larger firms also put more trust than the smaller ones on patents' ability to deter imitation and patents were of more importance for their competitiveness<br>When internal patent resources were removed, the efficient and effective use of the patent system became limited<br>Patents were used for customer marketing purposes<br>SMEs do not have enough resources for monitoring and enforcing patents<br>Product quality and related manufacturing techniques and process technologies (protected by trade secrets) were more important for competitiveness than product patents<br>Patents were perceived unnecessary by some of the SMEs, and imitation was instead met by outstanding inventiveness and entrepreneurial spirit<br>A low inventive step requirement is a drawback for SMEs |

From a resource based perspective (e.g., Penrose, 1959) it seems like large firms with better access to complementary assets mainly patent to protect their technological resources (e.g., Arundel et al., 1995; Cohen et al., 2000), while this study indicates that entrepreneurial SMEs mainly patent to gain access to necessary complementary assets or resources, including financial capital. This is also indicated by SMEs more commonly using licensing out strategies than large firms (Rassenfosse, 2012), which connects technological innovations with complementary assets.[4] Similar to VC firms, many large firms require their small partners to patent their innovations before initializing collaboration, not the least to avoid being accused for stealing ideas from SMEs. Previous research shows that firms with R&D collaborations typically have and apply for more patents than other firms (Brouwer and Kleinknecht, 1999; Gans et al., 2002; Gans and Stern, 2003). Thus, SMEs can use patents as enablers of open innovation in order to connect their technological innovations with the complementary assets needed for commercialization (e.g., Chesbrough, 2003, 2006; Chesbrough et al., 2006; Enkel et al., 2009; Gassmann et al., 2009; Dahlander and Gann, 2010; Bogers et al., 2012).

The main constraint for entrepreneurial SMEs regarding patenting is their lack of resources, in the application stages as well as in the monitoring and enforcement stages. Internal patent competence, for example in the form of in-house patent engineers, is important for a firm’s effective and efficient use of the patent system. In fact, after the interviews were performed, an acquisition of one of the larger SMEs in the entrepreneurial region resulted in a strategic change that led to the removal of the patent engineer position. A follow-up interview with R&D personnel indicated that this severely impacted the firm’s abilities to utilize patenting in an effective and efficient way, and that sole reliance on external IP service providers is not sufficient to substitute for internal expertise. SMEs are in this connection not only suffering from lack of internal resources, previous research has also shown that SMEs are disadvantaged compared to large firms in establishing links to external expertise (Rothwell and Dodgson, 1991). This is partly due to complementarities between in-house and external expertise, which is closely related to the concept of absorptive capacity (Cohen and Levinthal, 1990). Focusing on one or a few key patents has then been suggested by Friesike et al. (2009) as a best practice for SMEs with limited resources. This can also be a good way to build some level of internal competence which could enable better use of external expertise and an ability to analyze whether additional internal and/or external resources are needed.

The study is not without limitations. For example, the small sample sizes, being sampled by non-probability sampling, limit possibilities for generalizations. At the same time, the qualitative approach has enabled a contrast to previous results by providing richer contexts. For example, the differences between the samples and individual firms give a valuable reminder of the large span of SMEs, indicating the importance for scholars to treat generalized results with care, and for practitioners to apply tailored patent and appropriation strategies that complement the general business strategies of their firms.

## Acknowledgements

The work with this paper has been conducted under the auspices of IMIT (Institute for Management of Innovation and Technology) at Chalmers University of Technology, partly within the project “Patents and Innovations for Growth and Welfare” (SOU, 2006; Granstrand, forthcoming) and partly within the project “Management, Economics and IP Law of Open Distributed Innovation Processes”. Financial support from Vinnova and comments

[4] At the same time large firms, for example in systems technologies, do indeed use patents for access to complementary resources as well, but then typically technological resources as demonstrated by cross-licensing activities (Granstrand, 1999; Hall and Ziedonis, 2001; Holgersson, 2011; Bogers et al., 2012).

by Thomas Ewing, Ove Granstrand, Clas Wahlbin, and Nicole Ziegler, as well as from the editor and two anonymous reviewers, are gratefully acknowledged.

## List of references

Alpman, M. and Mellgren, E. (2005) Lyft för nya högteknikföretag. *Ny Teknik*, 11 May 2005, 14-16.

Arrow, K.J. (1962) Economic welfare and the allocation of resources for invention. In National Bureau of Economic Research (ed.), *The Rate and Direction of Inventive Activity: Economic and Social Factors*. Princeton: Princeton University Press (for NBER), 609-625.

Arundel, A. (2001) The relative effectiveness of patents and secrecy for appropriation. *Research Policy*, **30**, 4, 611-624.

Arundel, A. and Kabla, I. (1998) What percentage of innovations are patented? Empirical estimates fo European firms. *Research Policy*, **27**, 2, 127-141.

Arundel, A., van de Paal, G. and Soete, L. (1995) *Innovation strategies of Europe's largest industrial firms. Results of th PACE survey for information sources, public research, protection of innovations and government programmes.* Maastricht: MERIT.

Bekkers, R., Duysters, G. and Verspagen, B. (2002) Intellectual property rights, strategic technology agreements and market structure - The case of GSM. *Research Policy*, **31**, 7, 1141-1161.

Blind, K., Edler, J., Frietsch, R. and Schmoch, U. (2006) Motives to patent: Empirical evidence from Germany. *Research Policy*, **35**, 5, 655-672.

Blomqvist, K. (2002) *Partnering in the Dynamic Environment: The Role of Trust in Asymmetric Technology Partnership Formation*. PhD Thesis. Lappeenranta University of Technology, Finland.

Bogers, M., Granstrand, O. and Holgersson, M. (2012) *The dynamics of multi-layered openness in innovation systems: The role of distributed knowledge and intellectual property*. Presented at the R&D Management Conference, Grenoble, May 23-25, 2012.

Bound, J., Cummins, C., Griliches, Z., Hall, B.H. and Jaffe, A.B. (1984) Who does R&D and who patents? In Z. Griliches (ed.), *R&D, Patents, and Productivity*. Chicago: University of Chicago Press. 21-54.

Brouwer, E. and Kleinknecht, A. (1999) Innovative output, and a firm's propensity to patent. An exploration of CIS micro data. *Research Policy*, **28**, 6, 615-624.

Bryman, A. and Bell, E. (2007) *Business Research Methods*. 2nd ed. Oxford: Oxford University Press.

Chabchoub, N. and Niosi, J. (2005) Explaining the propensity to patent computer software. *Technovation*, **25**, 9, 971-978.

Chesbrough, H.W. (2003) *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Boston: Harvard Business School Press.

Chesbrough, H.W. (2006) *Open Business Models: How to Thrive in the New Innovation Landscape*. Boston: Harvard Business School Press.

Chesbrough, H.W., Vanhaverbeke, W. and West, J. (eds.), (2006) *Open Innovation: Researching a New Paradigm*. Oxford: Oxford University Press.

Cohen, W. M. and Levinthal, D. A. (1990) Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, **35**, 1, 128-152.

Cohen, W.M., Nelson, R.R. and Walsh, J.P. (2000) *Protecting their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or not)*. Cambridge, MA: NBER Working Paper Series.

Covin, J.G. and Slevin, D.P. (1991) A Conceptual Model of Entrepreneurship as Firm Behavior. *Entrepreneurship: Theory and Practice*, **16**, 1, 7-25.

Dahlander, L. and Gann, D.M. (2010) How open is innovation? *Research Policy*, **39**, 6, 699-709.

Dean, T.J. and Meyer G.D. (1996) Industry environments and new venture formations in U.S. manufacturing: A conceptual and empirical analysis of demand determinants. *Journal of Business Venturing*, **11**, 2, 107-132.

Duguet, E. and Kabla, I. (1998) Appropriation strategy and the motivations to use the patent system: An econometric analysis at the firm level in French manufacturing. *Annals of Economics and Statistics*, No. 49/50, 289-327.

Eisenhardt, K. (1989) Building theories from case study research. *Academy of Management Review*, **14**, 4, 532-550.

Enkel, E., Gassmann, O. and Chesbrough, H.W. (2009) Open R&D and open innovation: exploring the phenomenon. *R&D Management*, **39**, 4, 311-316.

Flick, U. (2009) *An Introduction to Qualitative Research*. 4th ed. London: SAGE Publications Ltd.

Freeman, C. (1982) *The Economics of Industrial Innovation*. 2nd ed. Cambridge, MA: MIT Press.

Friesike, S., Hafezi, N., Jamali, N., Iorno, N., Bader, M., Schreiner, E. and Ziegler , N. (2009) *SME-IP 3rd Report: Case Studies on SMEs and Intellectual Property in Switzerland*. Publication No 6 (07.09). Bern: Swiss Federal Institute of Intellectual Property.

Gans, J.S., Hsu, D.H. and Stern, S. (2002) When does start-up innovation spur the gale of creative destruction? *The RAND Journal of Economics*, **33**, 4, 571-586.

Gans, J.S. and Stern, S. (2003) The product market and the market for "ideas": Commercialization strategies for technology entrepreneurs. *Research Policy*, **32**, 2, 333-350.

Garcia, R. and Calantole, R. (2002) A critical look at technological innovation typology and innovativeness terminology: a literature review. *Journal of Product Innovation Management*, **19**, 2, 110-132.

Gartner, W.B. (1990) What are we talking about when we talk about entrepreneurship? *Journal of Business Venturing*, **5**, 1, 15-28.

Gassmann, O., Enkel, E. and Chesbrough, H. (2009) The future of open innovation. *R&D Management*, **40**, 3, 213-221.

Giuri, P., Mariani, M., Brusoni, S., Crespi, G., Francoz, D., Gambardella, A., Garcia-Fontes, W., Geuna, A., Gonzales, R., Harhoff, D., Hoisl, K., Le Bas, C., Luzzi, A., Magazzini, L., Nesta, L., Nomaler, Ö., Palomeras, N., Patel, P., Romanelli, M. and Verspagen, B. (2007) Inventors and invention processes in Europe: Results from the PatVal-EU survey. *Research Policy*, **36**, 8, 1107-1127.

Glaser, B.G. and Strauss, A.L. (1967) *The Discovery of Grounded Theory: Strategies for Qualitative Research*. Chicago: Aldine Publishing Company.

Granstrand, O. (1982) *Technology, Management and Markets*. London: Frances Pinter.

Granstrand, O. (1988) *Patents and Innovation - A Study of Patenting Practices and Trends in Sweden with a Brief Outlook on the US*. CIM Working Paper 1988:04. Gothenburg: Department of Industrial Management and Economics, Chalmers University of Technology.

Granstrand, O. (1999) *The Economics and Management of Intellectual Property*. Cheltenham: Edward Elgar Publishing.

Granstrand, O. (forthcoming) *Patents and Innovations for Growth and Welfare*. Cheltenham: Edward Elgar Publishing.

Granstrand, O. and Holgersson, M. (2012) The anatomy of rise and fall of patenting and propensity to patent: the case of Sweden. *International Journal of Intellectual Property Management*, **5**, 2, 169-198.

Griliches, Z. (1990) Patent statistics as economic indicators: A survey. *Journal of Economic Literature*, **28**, 1661-1707.

Griliches, Z., Nordhaus, W.D. and Scherer, F.M. (1989) Patents: Recent trends and puzzles. *Brookings Papers on Economic Activity. Microeconomics*, **1989**, 291-330.

Haeussler, C., Harhoff, D. and Mueller, E. (2009) *To be Financed or not. - The Role of Patents for Venture Capital Financing*. Discussion Paper 7115. London: Center for Economic Policy Research (CEPR).

Hall, B.H. and Ziedonis, R.H. (2001) The patent paradox revisited: an empirical study of patenting in the U.S. semiconductor industry, 1979-1995. *RAND Journal of Economics*, **32**, 1, 101-128.

Harabi, N. (1995) Appropriability of technical innovations: An empirical analysis. *Research Policy*, **24**, 6, 981-992.

Hoffman, K., Parejo, M., Bessant, J. and Perren, L. (1998) Small firms, R&D, technology and innovation in the UK: A literature review. *Technovation*, **18**, 1, 39-55.

Holgersson, M. (2011) *Intellectual Property Strategies and Innovation: Causes and Consequences for Firms and Nations*. Licentiate Thesis. Chalmers University of Technology, Gothenburg, Sweden.

Hsu, D. and Ziedonis, R. (2008) Patents as quality signals for entrepreneurial ventures. In *Academy of Management Best Paper Proceedings*.

Hurmelinna-Laukkanen, P. and Puumalainen, K. (2007) Nature and dynamics of appropriability: strategies for appropriating returns on innovation. *R&D Management*, **37**, 2, 95-112.

Iversen, E. (2003) *Norwegian Small and Medium-sized Enterprises and the Intellectual Property Rights System: Exploration and Analysis*. Oslo: STEP Center for Innovation Policy.

Jensen P.H. and Webster, E. (2006) Firm Size and the Use of Intellectual Property Rights. *Economic Record*, **82**, 256, 44-55.

Keupp, M.M., Lhuillery, S., Garcia-Torres, M.A. and Raffo, J. (2009) *SME-IP 2nd Report: Economic Focus Study on SMEs and Intellectual Property in Switzerland*. Publication No 5 (06.09). Bern: Swiss Federal Institute of Intellectual Property.

Kingston, W. (2004) Making patents useful to small firms. *Intellectual Property Quarterly*, **2004**, 4, 369-378.

Kitching, J. and Blackburn, R. (1998) Intellectual property management in the small and medium enterprise (SME). *Journal of Small Business and Enterprise Development*, **5**, 4, 327-335.

Kortum, S. (1993) Equilibrium R&D and the patent-R&D ratio: U.S. evidence. *The American Economic Review*, **83**, 2, 450-457.

Lanjouw, J.O. and Schankerman, M. (2004) Protecting intellectual property rights: Are small firms handicapped? *Journal of Law and Economics*, **47**, 1, 45-74.

Leiponen, A. and Byma, J. (2009) If you cannot block, you better run: Small firms, cooperative innovation, and appropriation strategies. *Research Policy*, **38**, 9, 1478-1488.

Lemley, M.A. (2000) Reconceiving patents in the age of venture capital. *Journal of Small and Emerging Business Law*, **4**, 137-148.

Levin, R.C., Klevorick, A.K., Nelson, R.R. and Winter, S.G. (1987) Appropriating the returns from industrial research and development. *Brookings Papers on Economic Activity*, **3**, 783-820.

Mansfield, E. (1986) Patents and innovation: An empirical study. *Management Science*, **32**, 2, 173-181.

Nicholas, T. (2011) Did R&D Firms Used to Patent? Evidence from the First Innovation Surveys. *The Journal of Economic History*, **71**, 4, 1029-1056.

Nilses, A. (2004) Familjens filter rensar luften i USA. *Dagens Industri*, 17 November 2004, 22-23.

Olander, H., Hurmelinna-Laukkanen, P. and Mähönen, J. (2009) What’s small size got to do with it? Protection of intellectual assets in SMEs. *International Journal of Innovation Management*, **13**, 3, 349-370.

Pavitt, K. (1982) R&D, patenting and innovative activities: A statistical exploration. *Research Policy*, **11**, 1, 33-51.

Penrose, E. (1959) *The Theory of The Growth of the Firm*. New York: Wiley.

Pitkethly, R.H. (2012) Intellectual property awareness. *International Journal of Technology Management*, **59**, 3/4, 163-179.

Rahn, G. (1983) The role of industrial property in economic development: the Japanese experience. *International Review of Industrial Property and Copyright Law*, **14**, 4, 449-492.

Rassenfosse, G. (2012) How SMEs exploit their intellectual property assets: evidence from survey data. *Small Business Economics,* **39**, 2, 437-452.

Rothwell, R. and Dodgson, M. (1991) External linkages and innovation in small and medium-sized enterprises. *R&D Management*, **21**, 2, 125–138.

Scherer, F.M. (1965) Firm size, market structure, opportunity, and the output of patented inventions. *The American Economic Review*, **55**, 5, 1097-1125.

Scherer, F.M. (1983) The propensity to patent. *International Journal of Industrial Organization*, **1**, 1, 107-128.

Schumpeter, J.A. (1934) *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle*. Cambridge, MA: Harvard University Press.

SOU (2006) *Patent och innovationer för tillväxt och välfärd (SOU 2006:80)*. Stockholm: Statens Offentliga Utredningar.

Stiglitz, J. (1999) Knowledge as a global public good. In E. Kaul, I. Grunberg and M.A. Stern (eds.), *Global Public Goods*. Oxford: Oxford University Press. 308-325.

Storey, D.J. and Tether, B.S. (1998) New technology-based firms in the European union: an introduction. *Research Policy*, **26**, 9, 933-946.

Teece, D.J. (1986) Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. *Research Policy*, **15**, 6, 285-305.

Thumm, N. (2004) Motives for patenting biotechnological inventions: An empirical investigation in Switzerland. *International Journal of Technlogy, Policy and Management*, **4**, 3, 275-285.

Westney, E. (1993) Country patterns in R&D organization: The United States and Japan. In B. Kogut (ed.), *Country Competitiveness*. Oxford: Oxford University Press. 36-53.

Wigren, C. (2003) *The Spirit of Gnosjö*. PhD Thesis. Jönköping International Business School, Jönköping, Sweden.

# Paper III

Granstrand, O. and Holgersson, M. (forthcoming) 'Multinational technology and intellectual property management - Is there global convergence and/or specialization?', forthcoming in *International Journal of Technology Management*.

# Multinational technology and intellectual property management

# - Is there global convergence and/or specialization?

Ove Granstrand[a) b)] and Marcus Holgersson[a) c)]

Forthcoming in International Journal of Technology Management, please use the following reference:

Granstrand, O. and Holgersson, M. (forthcoming) 'Multinational technology and intellectual property management - Is there global convergence and/or specialization?', forthcoming in *International Journal of Technology Management*.

[a)] Industrial Management and Economics Research Group
Department of Technology Management and Economics
Chalmers University of Technology
SE-412 96 Gothenburg, Sweden

[b)] E-mail: ovegra@chalmers.se
Phone: +46-31-772 1209

[c)] E-mail: marhol@chalmers.se
Phone: +46-31-772 5288

## Abstract

The paper gives various indications of market and technology diversification as well as of global market and technology convergence (rather than specialization) in the context of managerial, legal and economic convergence. The results show that different countries focus on a wider but increasingly similar set of markets for R&D outputs in form of patents, which implies increasing intra-national market diversification and inter-national market convergence. The results also show that different countries focus on a wider but increasingly similar set of technologies that are patented, which implies increasing intra-national technology diversification and inter-national technology convergence. In addition, intellectual property (IP) legal convergence takes place as newly industrialized countries (NICs) have strengthened their IP regimes in compliance with TRIPS and subsequently do so in the context of their indigenous innovation policies. Asian NICs have significantly increased their international patenting and supply of patented inventions. Altogether, this puts new demands across countries on multinational technology and innovation management skills, and in particular multinational IP management skills.

**Keywords:** Technology convergence; market convergence; revealed technological advantage; revealed market advantage; technological specialization; market specialization; diversification; patent statistics; technology management; intellectual property management; intellectual property regime; internationalization; catch-up

# 1 Background and purpose

Looking at the countries in the world it is clear that most of them do not influence globalization very much. At the same time globalization substantially influences almost all countries, e.g. regarding their consumption, trade, and investment decisions, including innovation and technology management decisions. In the context of globalization as a phenomenon at aggregate level, it is then natural to ask whether there are any indications of international convergence and/or specialization in some sense. On the one hand globalization might lead to large-scale conformity, standardization and homogenization, or in biological systems terms to competitive exclusion and loss of diversity. On the other hand technological opportunities and possible diversity increases over time. In addition, the rates of adoption and diffusion of new technologies and innovations may be country-specific so that essential differences across countries will persist.

The general purpose of this paper is to explore developments along a number of dimensions of convergence and their interrelations in a global context, and the ensuing implications of any signs of convergence for technology management. This purpose will be pursued by characterizing convergence in economic, legal, management, market, and technology terms. Quantitative empirical results have been collected for various indicators of market convergence and technology convergence through patent statistics, and qualitative information related to especially legal convergence of intellectual property (IP) legal systems has been collected through field studies in Asia, Europe, and US.[1]

The paper is structured along the various types of convergence with sections for frame of reference with key concepts and literature (where specific research questions are derived), methodology, empirical data analysis, discussion and managerial implications, and finally conclusions.

# 2 Frame of reference and literature

## 2.1 Key concepts

The concept of convergence in general refers to the increasing similarities (or equivalently decreasing differences or dissimilarities) across two or more entities over time. Here we will distinguish between the following dimensions or types of convergence across national entities (countries):

1. **Economic convergence**, i.e. decreasing economic differences between different countries, e.g. differences in gross domestic product (GDP) per capita, differences in rates of economic growth, differences in international trade patterns, and differences in

[1] The paper will not deal with military R&D and technology, however, which is obviously an important factor in geopolitical developments including economic developments. Although military technologies are increasingly being patented and licensed internationally, patent statistics offer limited possibilities for drawing conclusions regarding internationalization of military R&D and technology.

quality and longevity of life. Economic convergence is an overarching type of convergence for contextualizing other types of convergence.

2. **Legal convergence**, i.e. decreasing differences between legal systems in different countries, e.g. the intellectual property rights (IPR) systems.
3. **Management convergence**, i.e. decreasing differences between different countries in terms of national management styles, strategies, skills, and methods. This focus then includes strategic management decisions in companies with different nationalities and whether these decisions become increasingly similar. Decisions regarding which technologies to develop and patent, and where in the world to patent them then constitute two types of decisions that we will focus especially on, as further described below.
4. **Market convergence**, i.e. companies with different nationalities increasingly prioritizing similar sets of national markets in their international patenting.
5. **Technology convergence**, i.e. companies with different nationalities increasingly investing in, developing, and patenting similar sets of prioritized technologies.[2]

New quantitative empirical data analysis is presented for market and technology convergence, while qualitative information on the other dimensions of convergence is used to frame and contextualize the quantitative results. Market and technology convergence are both closely related to management convergence, and can actually be regarded as subsets or sub-dimensions of the latter since they are related to convergence of management decisions (see below). Management convergence is moreover closely related to the institutional economic and legal environment that firms operate in, since differences in local institutional environments might result in local and differentiated management strategies and decision patterns. The IP legal system in a country is finally guiding decisions of organizations and individuals in a way that supposedly leads to increased welfare and economic growth for the country, since most IP legal systems are by and large formed on a utilitarian rather than on a moral rights basis.

A concept closely related to convergence is specialization. Here we distinguish between two main types of specialization related to market and technology convergence, respectively. First, a country (or company or other entity) can be or become more narrowly focused on few(er) markets or technologies. This is thus a country-specific state or process of specialization, *independent of the specialization of other countries*. We therefore call this type of specialization **intra-national specialization**, with its opposite (i.e. a focus on a wider range of markets or technologies) being **intra-national diversification**. Second, a given country can be more focused (in some sense) on a specific market or technology, *relative to other countries* on average. This is then a state of that country's inter-national specialization in that

[2] This concept has to be distinguished from the concept of technological convergence, as pioneered by Rosenberg (1963), and the related concepts of technological confluence by Jantsch (1967) and technology fusion by Kodama (1992), meaning that two or more technologies increasingly become combined or jointly developed in various new products.

specific market or technology. One can then study the process of increasing or decreasing **inter-national specialization** (or inter-national divergence), either in a separate market or separate technology or on a more aggregate level of separate sets of markets or technologies. The opposite to inter-national specialization is **inter-national convergence**, i.e. when countries become increasingly similar in their focus on various markets or technologies relative to other markets or technologies.[3] This will be further described in the methodology section.[4]

### 2.2 Previous literature and research

#### *2.2.1 Economic convergence*

Economic convergence is addressed here as an overarching dimension of convergence, closely related to all the other dimensions of convergence. As industrialization and technological developments were set in motion historically at different paces and places, interrelated economic and technological gaps increased across countries, resulting in increased divergence. As globalization proceeds one could expect a subsequent transition to convergence to the extent that countries and companies are able to catch-up technologically and economically, which in turn is influenced by managerial and political skills, endowments, institutional structures and other factors. Economic convergence does not necessarily imply other dimensions of convergence, however, since similar economic results may in principle be produced by dissimilar means. In fact, division of labor, investments in R&D and education, free international trade and dynamic comparative advantages, e.g. through learning and technological specialization, have long been advocated as conducive for economic catch-up, see e.g. Abramovitz (1986), Cantwell (1999), Freeman et al. (1982), Patel and Pavitt (1994) Santangelo (2005), Scherer (1999) and Schumpeter (1942). At the same time it is not clear that economic and/or technological catch-up is at all possible under certain conditions. As in most development processes initial conditions, early mover advantages, and history (path-dependence) matter. Technological leaders may be able to maintain their leads through sustaining superior R&D investments, "evergreening" through IP protection, and limiting technological spill-overs.[5] Such a strategy may be successful for large advanced countries vis-à-vis small ones but less so, if at all, vis-à-vis large ones such as China and India because of

[3] All combinations of intra-national specialization/diversification and inter-national specialization/convergence processes are possible. Imagine e.g. that we study the use of dining tools in China and Europe. Let us now assume that one half of the Chinese people eats with forks while the other half eats with chopsticks, and that all Europeans eat with forks. If now the Chinese people eating with chopsticks would start switching over to forks we would get a process of intra-national specialization (due to an increased focus on forks only in China) and inter-national convergence (due to increasing similarities between China and Europe), while a reversed process would lead to intra-national diversification and inter-national specialization. A process where the Chinese people eating with forks would start switching over to chopsticks would lead to both intra-national specialization (due to an increased focus on chopsticks only in China) and inter-national specialization (due to increasing differences between China and Europe), while the reversed process would lead to intra-national diversification and inter-national convergence.

[4] Note that these conceptualizations do not only apply to markets and technologies, but also to products, resources, etc. Neither do these conceptualizations apply only to nations, but also to companies and other entities.

[5] As to the concept of evergreening, see Granstrand (2003, Ch. 10).

the attractiveness of their large domestic markets to foreign entrants from advanced countries. At the same time many countries have been able to technologically catch-up and there are few, if any, cases in history of sustained exclusivity of technological leadership, just as there are few if any cases of a country catching up technologically in the presence of a strong IP regime from the outset. Patent statistics provide early or precursory indicators in this context.

As to some empirical results about economic convergence across countries Baumol (1986) found clear signs of converging income per capita measures for 16 industrialized countries in the period 1870-1979. These signs of convergence are substantially weakened by sample selection bias and measurement errors, as shown by De Long (1988). Moreover, Summers and Heston (1991) found little evidence of economic convergence in a study of most of the non-communist world in the period 1960-1985. Thus, poor countries do not so far seem to have grown faster than rich ones on average over long periods of time. Despite a growing set of economic growth studies and studies in comparative economics it is therefore still an open question if there is economic convergence and if globalization will lead to more comprehensive rather than partial economic global convergence. It is also an open question how the economic and legal institutional environment constituting national innovation systems of various types impact innovativeness and economic performance and if the national innovation systems with all their differences after all converge.[6]

#### *2.2.2 Legal convergence*

It is a long standing issue in comparative law whether different legal systems will converge and if so to what, especially since there are no strong inherent universal concepts of justice and right according to legal anthropologists. More specifically in a Western context any convergence of the continental European civil law and the Anglo-Saxon common law legal systems is of interest and there are signs that some convergence is taking place, albeit far from any true harmonization. Still, an open question is which type of legal system is most conducive to innovation and economic growth and development. It might be argued that a common law system (being relatively more based on legal cases) is more flexible and reactive to new technologies and industrial developments than a civil law system (being relatively more based on certain theoretic principles), but adaptability in itself does not necessarily imply innovativeness. As to the patent system in the world, which is of special interest in this paper, international diffusion and harmonization of the various national patent systems has progressed steadily throughout centuries, although there is still a long way to go in international harmonization, see Granstrand (1999b, 2003). As to harmonization, which concerns not only codified laws but also law enforcement, law adherence and court practices (e.g. regarding IP damage calculations), between developed and developing countries, a long-standing concern is the differences in strength in some sense of patent and IP systems across different countries, or the appropriability regimes more generally. The variations in national IP legal systems clearly impact both technological choices and marketing decisions. In certain countries, some technologies are not patentable, and in certain countries it is not worthwhile

[6] For descriptions of various national innovation systems, see e.g. Edqvist (1997), Lundvall (1992), and Nelson (1993).

to patent in general, due to e.g. weak enforcement or low patent infringement damages and rare injunctions. Moreover, differences in IP legal systems around the world increase multinational technology management costs and uncertainties. On the other hand, different IP legal systems also have different impacts on economic growth and development for countries in different development stages (see e.g. Kim, 2011, and Park and Ginarte, 1997, for related studies).

#### *2.2.3 Management convergence*

Comparative management studies in general are growing and many national differences have been identified and analyzed, see e.g. Edfelt (2009). Whether these national differences decrease on average over time, i.e. that there is management convergence, is by and large an open question as well. Still, there is some evidence (often anecdotal) that suggests that such convergence takes place after all. The expansion of multinational corporations (MNCs), the role of multinational management consultancy firms (mostly US) and managerial service firms (like accounting and financial service firms), the internationalization of financial markets, harmonization of international accounting standards, the international mobility of managers, international competition on input/output markets and so on are all factors that tend to lead to increasing management convergence in the longer run.

As to technology management more specifically, comparative management studies are few. Studies of chief technology officers (CTOs) identify certain similar features among them (see Adler and Ferdows, 1990, and Herstatt et al., 2007). Some evidence from studies of technology management practices in US, European and Japanese MNCs also suggest a certain convergence of technology management practices as these MNCs increasingly internationalize and compete on international markets, not only output markets but also input markets, e.g. markets for talent. An example of such convergence practices is the increasing use of external technology acquisition strategies and open innovation. At the same time there are many distinctive national features and practices, e.g. the degree of centralization of R&D (see Granstrand, 2000b). Regarding use of open innovation or external technology acquisition strategies, these depend on the developmental stage of a company and a country. Needless to say a company or a country trying to catch-up is more dependent upon external technology than a technological leader, everything else equal (see e.g. Abramovitz, 1986, and Mansfield, 1988).[7] A country will then benefit from a resource base congruent with technological opportunities (Abramovitz, 1990) and an R&D production structure apt to absorb technological spill-overs (Abramovitz, 1991, Beelen and Verspagen, 1994).

Further case study evidence indicates a certain convergence in multinational R&D and multinational technology management as to location (e.g. in Bangalore and/or Silicon Valley) and role of foreign R&D labs in MNCs. Early industrialized countries like Holland and Sweden with small domestic markets became early internationalizers of their sales, production and R&D (Granstrand et al., 1992b). Companies like Philips and SKF already in

[7] If technological diversity or complexity is also taken into account, technological leaders are also dependent upon open innovation and more so the more diverse and expensive the technology base of the leader is.

the 1970s had a substantial amount of R&D located abroad.[8] They reorganized their worldwide R&D and product development from local-for-local to local-for-global development and distinguished between demand and supply led R&D labs. These management practices then became increasingly adopted by companies in large countries like US and Japan.

Studies of the international adoption and diffusion of managerial inventions also suggest that management convergence takes place. As to new managerial inventions (techniques, methods, models, etc.) one can see how old ones like the multidivisional form (M-form) of corporate organizations, technological forecasting techniques, capital budgeting techniques, and later on venture capital organizations diffused around the world among advanced MNCs. Especially Japan then developed a number of additional ones in production and technology management, like Kanban, total quality management (TQM), just-in-time (JIT), Kaizen, and patent mapping in intellectual property management (IPM) (see e.g. Granstrand, 1999b). In this context a study by Lillrank (1995) indicates that organizational innovations are typically more difficult to transfer across cultural, national, and industrial borders than are innovative management principles and tools, suggesting different rates of convergence.[9]

In this process of cross-national learning and knowledge transfer, management principles and strategies could possibly converge to some international best practices, especially if globalization leads to decreasing importance of local (national) factors, which would otherwise require differentiated management strategies. This leads us to study two types of management strategies, and the corresponding dimensions of convergence: Market convergence (related to the relative importance of various output markets) and technology convergence (related to the relative importance of various technological areas).

#### *2.2.4 Market convergence*

The concept of market convergence can relate to different aspects of markets, including market integration (see e.g. Goldberg and Verboven, 2005), price convergence (see e.g. Rogers, 2007), and product market convergence.

In this paper we define market convergence more specifically as the convergence of geographical output markets' relative importance for different countries of origin of products. It can thus be seen as a special form of management convergence, related to the output market decisions of managers. We especially focus on new product markets, and use patent statistics on aggregate national level as a proxy of this. Thus, this convergence is related to the

[8] SKF was probably one of the world's most globalized companies in the 1970s, not the least regarding R&D and production. A 'global forecasting and supply system' was introduced with global coordination of local for global R&D and production in response to Japanese competition. A multinationally manned central R&D lab with foreign location was created as a hub for world-wide R&D. (See Granstrand, 1982, and Granstrand and Fernlund, 1978.) In 2011 SKF was still an essentially Swedish European company but with a non-Swedish CEO as well as a non-Swedish CTO.

[9] Based on cases like these Vernon's international product life-cycle (PLC) theory could be seen to apply also to management developments. The model may continue to apply in this area (despite all criticisms voiced over it in general, see Cantwell, 1995). If so, Western companies could expect to learn in the future from Chinese and Indian management, not least in the area of technology management (e.g. in large scale R&D and production, software development, and bio-tech).

management strategy decision “where to patent”. With a patent in a specific country, the patent holder can exclude others from commercializing (through both manufacturing and selling) the patented invention in that country. Therefore, one can assume that patentable inventions are patented in the countries/markets where the inventor/inventing firm has or will have some form of technology-based business (including both product and technology sales) during the estimated length of the effective patent protection and where the inventor/inventing firm finds it likely that the benefits from patent protection are greater than the patent costs (applications costs, renewal fees, and costs of the information disclosure related to the patent application), taking into account the risk of being subjected to competing imitations and the protection provided by the IP legal system and its strength of patent legislation and enforcement in the country in question (see e.g. Granstrand, 1999b). Now, the related research question that will be probed empirically in this paper is: *Do the sets of country markets selected by inventive firms/individuals for patenting become increasingly similar, i.e. is there a market convergence globally?* This question has to our knowledge not previously been studied.[10]

### *2.2.5 Technology convergence*

The number of worldwide patent applications has steadily grown during recent decades. According to World Intellectual Property Organization (WIPO) estimates the number of applications has increased from 926 000 in 1985 to 1 908 000 in 2008, corresponding to a compounded annual growth rate (CAGR) equal to 3.2%. Moreover, the number of priority filings, which excludes double counting of patent applications for the same invention to many different patent offices, has increased from 579 000 in 1990 to 881 000 in 2007, corresponding to a CAGR equal to 2.5% (using the WIPO statistics on patent families as a measure).

Looking more deeply into the technological areas in which various countries file patents, different countries’ technological specializations have been investigated in a range of studies, including the ones by Archibugi and Pianta (1994), Cantwell (1989, 1991), Cantwell and Vertova (2004), Dosi et al. (1990), Gambardella and Torrisi (1998), Pavitt (1982) and Soete (1981). The results of these studies have in general showed that inter-national technological specializations increase, and that the areas of specialization are cumulative, in turn giving rise to path dependencies. These increasing national technological specializations can be interpreted as technology divergence between countries, since high levels of specialization in various countries relative to other countries imply differences between them in terms of areas of specialty.

As to technological diversification, Archibugi and Pianta (1992) found a positive relationship between size of national technology bases and technological diversification and Cantwell and Vertova (2004) investigated this relationship further and concluded that countries have

[10] Some work has been published on related issues, see e.g. Bosworth’s (1984) and Caviggioli’s (2011) works on determinants of foreign patent applications to certain countries (from other countries) and foreign patent applications from certain countries (to other countries). These studies have however not had a global focus, but a focus on single countries or subsets of countries. Neither have they focused on convergence across different countries.

become less diversified (or more narrowly specialized) over the past 40 years. One explanation addressed in that paper is that international technology sourcing activities lead to different geographic locations focusing on what they do best. This goes in line with the model by Krugman (1987) in which specialization is predicted to be stable due to economies of scale and lock-in effects.

Besides showing increasing levels of inter-national technological specialization (i.e. technology divergence), Archibugi and Pianta (1994) showed convergences between OECD countries in a number of other economic and science and technology indicators, including GDP per capita, R&D intensity and external patents per unit of exports. They conclude that countries converge in these other indicators by becoming more technologically specialized and different in that aspect.

In contrast with the aforementioned studies on technological specialization, a study by Dalum et al. (1998) on trade specialization, which in that paper is assumed to be closely linked to technological specialization, shows that the development between 1965 and 1992 can be characterized by de-specialization (technology convergence). High revealed symmetric comparative advantages (RSCA) are shown to decrease while low ones are shown to increase over time.

Now, the related research question that will be probed empirically in this paper is: *Do the sets of technological areas developed and patented by inventive firms/individuals become increasingly similar, i.e. is there a technology convergence globally?*

## 3 Methodology

As described above, five different dimensions of convergence and their interrelations are elaborated in this paper, although the empirical evidence is focused on market and technology convergence, and to some extent legal convergence. The units of observation and analysis in general are the world's countries as recognized by agencies like WIPO and the United States Patent and Trademark Office (USPTO), and companies and inventions of various nationalities. The population frame of countries varies a little over decades (and of course quite a bit over centuries) but roughly consists of 170 countries in this study.

Quantitative data in form of patent statistics is used for market and technology convergence and specialization. A patent right is granted in a country for a specific invention and the set of patent rights in different countries for the same invention is called a patent family. The set of countries in a patent family indicates the selection of prioritized markets by the inventing individual, company or other agent. It is possible to assign a nationality to each patented invention based on the nationality of the applicant, or in case of several applicants the nationality of the first applicant named in the patent application as a proxy for national origin of the invention.[11]

[11] See e.g. Holgersson (2011) for a discussion of careful interpretation of patent statistics.

The selection of national markets for each patented invention of a certain nationality could then be compared across countries of origin, calculating an index of market difference (dissimilarity) as described in more detail below. This paper is based on data on aggregate national level, and therefore the selection of national markets can not be studied on individual invention level. Instead, we use the number of patent applications from a specific country of origin to different receiving offices as a measure of the market selection. The differences in choices of markets between different countries of origin are measured by three difference indices, as described below. Multiple indices are used to decrease the risk of misrepresentation due to index construction. In addition, the Herfindahl-Hirschman index is used as a measure of the market concentration and intra-national specialization from the point of view of a specific country of origin.

Each patented invention is classified into one main and often also into a few additional patent classes, corresponding to technological areas, assigned to it by the patent examiner. This gives an opportunity to construct an index of technology difference (dissimilarity) as described in more detail below. Here we have used US as a country of reference for patenting with the assumption that US is a highly prioritized market on average for inventors around the world. Using US as a reference country in patent information analysis is also common in previous research, see e.g. Patel and Pavitt (1994) and Granstrand et al. (1997). A set of difference indices, designed analogously with the ones above, are used for measuring technological differences as defined below.

Finally, qualitative information, mainly regarding IP legal convergence, underlying the discussion in the paper and the interpretation of data has been collected through documents, conference discussions and interviews (about 50) at country and company level in China, Europe, India, Japan, Korea, and US in connection with field visits during 2010 and 2011.

### 3.1 Quantitative datasets

We use two datasets on aggregate national level to study market and technology convergence, respectively. The first dataset consists of input/output matrices with receiving offices and countries of origins for all patent applications reported to WIPO from 1995 through 2008. These matrices were constructed from the patent statistics available from WIPO and they are primarily used to study inter-national market convergence or reversely inter-national market specialization. The second dataset consists of matrices with countries of origin and patent classes for all patent applications to the USPTO from 2005 through 2009. These matrices were constructed from the patent statistics available from the USPTO and they are primarily used to study inter-national technology convergence or reversely inter-national technology specialization.

### 3.2 Market difference indices

We introduce three different measures of differences (dissimilarities) between countries for each dimension of inter-national convergence (or reversely inter-national specialization), i.e. market and technology convergence. The concept of convergence in general refers to a process in which the difference or dissimilarity between two variables (or one variable and a constant) decreases as one or another variable (usually time) increases.[12]

The first measure of market differences is a market share difference index. When comparing two countries' ($a$ and $b$) foreign patent strategies, the total numbers of applications from $a$ and $b$, respectively, to foreign patent offices are calculated, excluding $a$'s and $b$'s applications to $a$ and $b$ to decrease bias. Then, the shares of these applications going to the different foreign patent offices are calculated (totaling 100%). (Domestic patent applications – i.e. applications from country $a$ to country $a$ – are excluded, since these bias the share size of different countries heavily due to large differences in domestic patenting strategies.) The shares of foreign applications are then compared between countries to see the overlap of foreign patenting strategies. Our first market difference index, the **market share difference index**, between two countries, $a$ and $b$, is then constructed by the following formula, (giving a difference or dissimilarity metric since $d_{ac} \leq d_{ab} + d_{bc}$):

$$d_{ab}^{MS} = d_{ba}^{MS} = \frac{\sum_{i=1}^{N} |s_{ai} - s_{bi}|}{2}$$

Here $s_{ai}$ is the number of foreign patent applications from country $a$ that is filed in country $i$ divided by the number of all foreign applications from country $a$, excluding applications to country $b$ to reduce bias. Hence, $s_{ai}$ is the share of country $a$'s total number of foreign applications (excluding those to country $b$) that goes to country $i$. $N$ is the total number of countries, excluding country $a$ and country $b$. This gives a difference index $d^{MS}$, which is 1 when there is a complete difference and 0 when there is no difference at all.

The second market difference index used here is based on a modified version of the revealed comparative advantage (RCA), as introduced by Balassa (1965). Based on the RCA, Soete (see e.g. Soete, 1981, 1987) and others developed the concept of revealed technological advantage (RTA). Here we introduce the revealed market advantage (RMA) analogously to the revealed technological advantage. RMA of country $a$ in market $i$ is then defined as:

$$RMA_{ai} = \frac{p_{ai} / \sum_{i=1}^{N} p_{ai}}{\sum_{j=1}^{N} p_{ji} / \sum_{j=1}^{N} \sum_{i=1}^{N} p_{ji}}$$

Here $p_{ai}$ is the number of foreign applications from country $a$ to receiving office $i$, and $N$ is the total number of countries.[13] This measure is larger than 1 for a country if the share of its foreign patent applications to a specific receiving office (country) is larger than the share of total foreign applications from various countries that is received by that specific receiving

[12] In index construction in general it is desirable that a difference or dissimilarity index is a metric distance measure, i.e. it has the triangle inequality property. E.g. the concept of technological distance between entities could then be operationalized as done in Granstrand (1994).

[13] Note that since $p_{ai}$ is the number of foreign applications from country $a$ to receiving office $i$, the following holds since a domestic patent application is not a foreign application: $p_{ai} = 0 \; if \; a = i$. Also note that this measure gives a small error due to the fact that one of the receiving offices differs in the comparison between each pair of nations of origin since patenting from one nation to its own patent office is excluded. However, no good way of excluding this error has been found.

office (country), and smaller than 1 if the opposite applies. Analogously with above, the **RMA difference index** between two countries, $a$ and $b$, is defined as[14]:

$$d_{ab}^{RMA} = d_{ba}^{RMA} = \frac{\sum_{i=1}^{N} |RMA_{ai} - RMA_{bi}|}{2}$$

There are some problems related to this measure, since RMA can take on values between 0 and $\infty$ and thus is not bounded. Therefore we also introduce a third difference index, based on a symmetric RMA, a normalization giving a symmetric index as suggested by Dalum et al. (1998) in the case of revealed comparative advantage.[15] We thus define the revealed symmetric market advantage, RSMA, as:

$$RSMA_{ai} = \frac{RMA_{ai} - 1}{RMA_{ai} + 1}$$

The **RSMA difference index** is constructed as previously:

$$d_{ab}^{RSMA} = d_{ba}^{RSMA} = \frac{\sum_{i=1}^{N} |RSMA_{ai} - RSMA_{bi}|}{2}$$

The reason why three different indices are used is that the results from the statistical analysis are sensitive to the index construction. The market share difference index is e.g. in many cases mainly impacted by the largest markets, since they downplay the shares for the smaller ones. A large increase in importance of a specific output market in general for all countries leads to a convergence in this measure, by downplaying the differences in smaller markets. The RMA difference index on the other hand puts more weight on the smaller markets, since these are impacting the index as much as the larger ones. This might create an overweight in importance for otherwise rather unimportant output markets. Therefore, using more than one index in a sensitivity analysis reduces the risk of misrepresentation and misinterpretation.

In addition to the difference indices, the Herfindahl-Hirschman index is calculated and used as a measure of the foreign market concentration from a specific country of origin. Thus, this is defined in the usual way as:

$$H_a^M = \sum_{i=1}^{N} \left( \frac{p_{ai}}{\sum_{j=1}^{N} p_{aj}} \right)^2$$

Here $p_{ai}$ is the number of foreign applications from country $a$ to receiving office $i$, and $N$ is the total number of countries. This is used as a measure of the intra-national market specialization (or reversely market diversification, defined as in previous studies as $1 - H_a^M$).

[14] Note that the division by two is kept for consistency, although it does not limit the index measure to a number between 0 and 1 in this case.

[15] Other forms of normalizations have also been used, e.g. logarithmic transformation as in Soete and Verspagen (1994).

### 3.3 Technology difference indices

Three technology difference indices are introduced analogously with the ones above in order to measure the technology convergence (or inter-national specialization). Our first technology difference index, the **technology share difference index**, is a technology distance measure between two countries, $a$ and $b$, constructed by the following formula:

$$d_{ab}^{TS} = d_{ba}^{TS} = \frac{\sum_{i=1}^{M} |s_{ai} - s_{bi}|}{2}$$

Here $s_{ai}$ is the share of all US patent applications from country $a$ that belong to US patent class $i$ and $M$ is the total number of US patent classes. Hence, $s_{ai} = p_{ai}/\sum_{i=1}^{M} p_{ai}$ where $p_{ai}$ is the number patent applications from country $a$ in patent class $i$. This again gives a metric difference index $d^{TS}$, which is 1 when there is a complete difference and 0 when there is no difference at all (i.e. there is no technological distance between country $a$ and $b$).

The second measure of technology difference is based on the revealed technological advantage, RTA of country $a$ in technology $i$, as traditionally defined:

$$RTA_{ai} = \frac{p_{ai}/\sum_{i=1}^{M} p_{ai}}{\sum_{j=1}^{N} p_{ji}/\sum_{j=1}^{N}\sum_{i=1}^{M} p_{ji}}$$

Here $p_{ai}$ is again the number patent applications from country $a$ in patent class $i$, $M$ is the total number of patent classes, and $N$ is the total number of countries. Thus, RTA indicates whether or not a technology's patent share in a country is larger than the technology's share of all patents (across countries).[16] Note that the denominator in RTA may get arbitrarily small, e.g. for a new technology $i$. Thus, RTA is an unbounded measure. Based on RTA, we introduce the **RTA difference index** between two countries, $a$ and $b$:

$$d_{ab}^{RTA} = d_{ba}^{RTA} = \frac{\sum_{i=1}^{M} |RTA_{ai} - RTA_{bi}|}{2}$$

The revealed symmetric technological advantage, RSTA, is defined as:

$$RSTA_{ai} = \frac{RTA_{ai} - 1}{RTA_{ai} + 1}$$

The **RSTA difference index** is introduced as previously:

$$d_{ab}^{RSTA} = d_{ba}^{RSTA} = \frac{\sum_{i=1}^{M} |RSTA_{ai} - RSTA_{bi}|}{2}$$

[16] Careful use of concepts and terminology is called for in this context. Note e.g. that:

$$RTA_{ai} = \frac{p_{ai}/\sum_{i=1}^{M} p_{ai}}{\sum_{j=1}^{N} p_{ji}/\sum_{j=1}^{N}\sum_{i=1}^{M} p_{ji}} = \frac{p_{ai}/\sum_{j=1}^{N} p_{ji}}{\sum_{i=1}^{M} p_{ai}/\sum_{j=1}^{N}\sum_{i=1}^{M} p_{ji}}$$

Thus, a simple algebraic rearrangement shows that the RTA-measure also indicates if a country's patent share in a technology is larger than the country's share of all patents (across technologies). Therefore, the traditional interpretation in terms of a country's relative technology specialization just as well could be phrased in terms of a technology's relative country specialization.

Finally, the Herfindahl-Hirschman index is again calculated and used as a measure of the technology concentration from the point of view of a specific country of origin. This is defined as:

$$H_a^T = \sum_{i=1}^{M} \left( \frac{p_{ai}}{\sum_{j=1}^{M} p_{aj}} \right)^2$$

Here $p_{ai}$ is the number of US patent applications from country $a$ in patent class $i$, and $M$ is the total number patent classes. This is used as a measure of the intra-national technology specialization (or reversely technology diversification, defined as in previous studies as $1 - H_a^T$).

### 3.4 A note on the statistical tests

All difference indices are calculated for all comparison pairs of countries of origin, resulting in $\frac{N^2-N}{2}$ unique difference indices for each year and each type of index, with $N$ number of countries (170+, but slightly varying in the different datasets). However, in many cases data is missing, resulting in a significantly lower number of unique difference indices, as presented in the empirical results.

The Student's paired t-test is used to test the change in differences between two years. For changes in market differences, the years 1995 and 2004 are compared. The reason why 2004 was chosen as the latest year is that the WIPO statistics lag somewhat, and data from some major countries' patent offices, including India's, is still not included for later years.[17] However, for some of the descriptive statistics later years are also included. For changes in technology differences, the years 2005 and 2009 are compared as they are the earliest and latest years with data freely available and accessible on the USPTO website.

Even though the distributions studied in this paper in general are symmetric and unimodal, they are not normally distributed, especially not the unbounded RTA-based difference indices. Therefore, the Wilcoxon signed-rank test is used to complement the Student's t-test.

## 4 Empirical evidence

### 4.1 Market convergence

Changes in three market difference indices, as described above, are used to measure inter-national market convergence and/or specialization. The market difference indices are created in the comparison of two countries of origins of the patent, and all comparison pairs of countries are included in the analysis. Hence, each country of origin is compared with all other countries of origin regarding their foreign patent applications. Since we are interested in investigating signs of convergence, we focus on the unique country comparisons with available numbers for both 1995 and 2004, all in all 2080 ones. We measure convergence as

[17] Missing data in WIPO's statistics is a source of potential error in this study.

the change in the market difference indices from 1995 through 2004. A positive change indicates inter-national market specialization and a negative change indicates inter-national market convergence in patenting patterns.

Based on the full set of market difference indices for 1995 and 2004, respectively, an analysis of the change is performed and the results are presented in Table 1. Our statistical analysis shows significant decreases in all three market difference indices between 1995 and 2004.

**Table 1 Summary of statistical results of market convergence and concentration**

| | n | 1995 Mean | 2004 Mean | Mean change | % Change | Estimated median of change |
|---|---|---|---|---|---|---|
| $d^{MS}$ | 2080 | 0.65578 | 0.51853 | -0.13724*** | -20.93% | -0.1647### |
| $d^{RMA}$ | 2080 | 288.7 | 142.0 | -146.61*** | -50.81% | -58.77### |
| $d^{RSMA}$ | 2080 | 22.825 | 18.787 | -4.038*** | -17.69% | -4.047### |
| $H^{M}$ | 65 | 0.4817 | 0.2996 | -0.1821*** | -37.80% | -0.1548### |

Notes:
* Mean change different from zero with 0.05 significance (paired t-test)
** Mean change different from zero with 0.01 significance (paired t-test)
*** Mean change different from zero with 0.001 significance (paired t-test)
# Median change different from zero with 0.05 significance (Wilcoxon signed-rank test)
## Median change different from zero with 0.01 significance (Wilcoxon signed-rank test)
### Median change different from zero with 0.001 significance (Wilcoxon signed-rank test)

The decreases in market difference indices indicate that there has been an inter-national market convergence between 1995 and 2004 (i.e. that the inter-national market specialization has decreased). Table 1 also includes results regarding the Herfindahl-Hirschman index, which is here used as a measure of the intra-national market specialization (or reversely market diversification) of a specific country of origin, or more specifically a measure of the market concentration of its foreign patent applications. The results show a decline in market concentration. These two results together indicate that countries have widened their markets for patenting, becoming more intra-nationally diversified in terms of output markets, at the same time as the differences between various countries of origin have decreased in terms of their output markets, indicating inter-national market convergence.

The market concentration is further illustrated in Figure 1 where the worldwide average of the market concentration is presented for the years 1995 through 2008 together with the concentrations of a number of reference countries. An issue that impacts the results of the worldwide average is the fact that new countries of origin are added and included in the average each year. These countries commonly have little foreign patenting and therefore also quite high concentrations of foreign patenting (and thereby inflate the average). Therefore our main emphasis should be put on the adjusted worldwide average, since that average is constructed as an index based on the average in the first year, and where the changes between each year are only based on the countries with available data for both years of comparison (similar to what is done when using for example the paired t-test).[18]

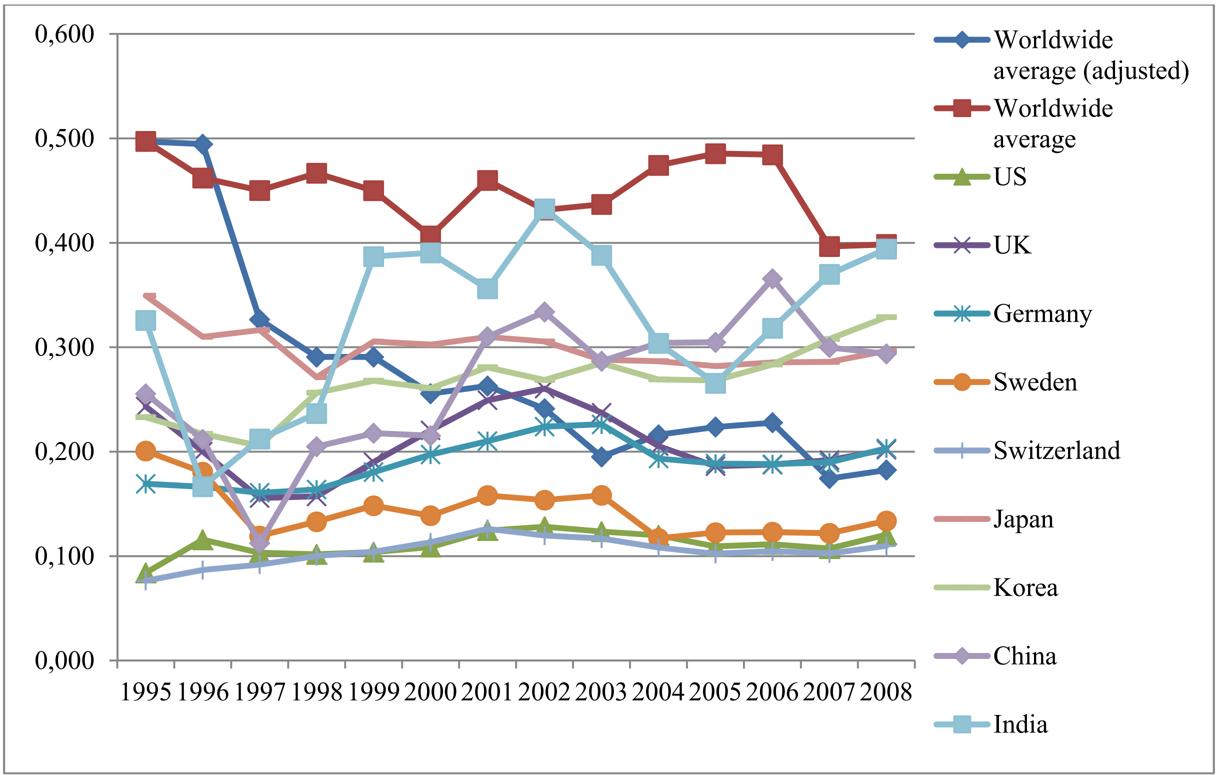



**Figure 1 Concentration of markets for foreign patent applications**

The difference between the adjusted and the unadjusted worldwide averages of concentration indicates that the major decline in concentration is found among countries where the foreign patenting is a recent phenomenon (or even introduced during the period of observation). This is indicated also by Table 2, since the countries with the largest decreases in market concentration from 1995 to 2008 have the same size of their absolute and relative decreases meaning that they had a Herfindahl-Hirschman index equal to 1 in 1995 (which is true only when the foreign patenting is performed on one market only). Hence, such major decreases in market concentration are phenomena existent among countries with limited foreign patenting in 1995.

[18] Note that missing data from various patent offices for different years might also impact the results for different years, but since this is only true for some small patent offices (except possibly India) this impact is expected to be small.

**Table 2 Growth (or decrease) in market concentration from 1995 to 2008**

| Country of origin | Abs Growth (% Growth) | Country of origin | Abs Growth (% Growth) |
|---|---|---|---|
| Panama | -0.92 (-92%) | Slovakia | -0.03 (-19%) |
| Cuba | -0.91 (-91%) | Israel | -0.03 (-8%) |
| Monaco | -0.88 (-88%) | Portugal | -0.02 (-15%) |
| Chile | -0.84 (-84%) | Ireland | -0.01 (-9%) |
| Iceland | -0.83 (-83%) | Norway | -0.01 (-8%) |
| Croatia | -0.82 (-82%) | Greece | -0.01 (-7%) |
| Tunisia | -0.80 (-80%) | South Africa | -0.01 (-6%) |
| Brunei Darussalam | -0.79 (-79%) | Cook Islands | 0.00 (0%) |
| Saudi Arabia | -0.78 (-78%) | Côte d'Ivoire | 0.00 (0%) |
| Singapore | -0.76 (-76%) | France | 0.00 (1%) |
| Barbados | -0.76 (-76%) | Turkey | 0.00 (1%) |
| Thailand | -0.70 (-70%) | Finland | 0.01 (9%) |
| Uruguay | -0.67 (-67%) | Czech Republic | 0.02 (12%) |
| Belarus | -0.63 (-63%) | Italy | 0.02 (11%) |
| Indonesia | -0.62 (-62%) | Netherlands | 0.02 (16%) |
| Malaysia | -0.62 (-62%) | Luxembourg | 0.03 (35%) |
| Vanuatu | -0.61 (-61%) | Switzerland | 0.03 (44%) |
| Bermuda | -0.60 (-60%) | Germany | 0.03 (20%) |
| Sri Lanka | -0.46 (-46%) | United States of America | 0.04 (43%) |
| Hong Kong (SAR). China | -0.44 (-44%) | China | 0.04 (15%) |
| Cyprus | -0.39 (-79%) | Hungary | 0.04 (36%) |
| Slovenia | -0.37 (-67%) | Australia | 0.05 (26%) |
| Netherlands Antilles | -0.18 (-21%) | Liechtenstein | 0.06 (48%) |
| Poland | -0.15 (-34%) | Austria | 0.06 (49%) |
| Canada | -0.12 (-22%) | Brazil | 0.06 (48%) |
| European Patent Office | -0.11 (-11%) | India | 0.07 (21%) |
| Sweden | -0.07 (-33%) | Spain | 0.08 (89%) |
| Denmark | -0.07 (-30%) | Romania | 0.09 (53%) |
| New Zealand | -0.06 (-25%) | Republic of Korea | 0.10 (41%) |
| Japan | -0.05 (-15%) | Ukraine | 0.12 (24%) |
| Mexico | -0.05 (-15%) | Unknown | 0.13 (104%) |
| Belgium | -0.05 (-24%) | Argentina | 0.14 (93%) |
| United Kingdom | -0.04 (-17%) | Bulgaria | 0.27 (180%) |
| Russian Federation | -0.04 (-17%) | | |

### 4.2 Technology convergence

Few, if any, studies on technology convergence (or reversely inter-national specialization) have previously been performed including data on all countries active in (US) patenting. Moreover, previous studies have commonly used either the RTA-index or other indicators giving equal weight to small and large technological areas. In this study we use three different indices to control for biases due to index constructions. We use the US market as a reference market, as it is probably the world's most important market for patenting currently, and include data on all available countries. The use of US as a reference market might slightly bias the measures depending on closeness to the US, and this needs to be taken into consideration. However, in this case the changes over time are of most interest, and therefore this bias is expected to have little impact. We use the statistics on various countries' patenting in the 404 different US patent classes, and calculate three technology difference indices analogously with the market difference indices above and as described in the methodology section above. Changes in these indices are used to indicate inter-national technology convergence (when differences decrease) or inter-national technology specialization (when differences increase). We base the statistical analysis on the unique country comparisons with available numbers for both 2005 and 2009, which amount to 3570 ones. The results are presented in Table 3.

**Table 3 Summary of statistical results of technology convergence and concentration**

| | n | 2005 Mean | 2009 Mean | Mean change | % Change | Estimated median of change |
|---|---|---|---|---|---|---|
| $d^{TS}$ | 3570 | 0.91999 | 0.89610 | -0.02389*** | -2.60% | -0.01728### |
| $d^{RTA}$ | 3570 | 609.0 | 681.3 | 72.3*** | 11.87% | -37.30### |
| $d^{RSTA}$ | 3570 | 65.628 | 65.768 | 0.140 | 0.21% | 0.2758# |
| $H^{T}$ | 85 | 0.2631 | 0.2021 | -0.0610* | -23.19% | -0.01658# |

Notes:
* Mean change different from zero with 0.05 significance (paired t-test)
** Mean change different from zero with 0.01 significance (paired t-test)
*** Mean change different from zero with 0.001 significance (paired t-test)
# Median change different from zero with 0.05 significance (Wilcoxon signed-rank test)
## Median change different from zero with 0.01 significance (Wilcoxon signed-rank test)
### Median change different from zero with 0.001 significance (Wilcoxon signed-rank test)

Our results show that there is a decrease in the technology share difference index ($d^{TS}$), indicating technology convergence. The change in the RTA difference index ($d^{RTA}$) has a mean above zero, but a median below zero. This indicates a skewness in the distribution, which has been confirmed also by graphical analysis. Hence, the statistical results from the analysis of the RTA difference index does neither indicate convergence, nor specialization. The RSTA difference index ($d^{RSTA}$, which is a symmetric version of $d^{RTA}$) shows an (insignificant) increase.[19] To summarize, the results mainly indicate inter-national technology convergence, although with some signs of inter-national technology specialization according to certain measures.[20] Finally, the intra-national technology specialization, measured by the

[19] Interesting to note is how the normalization of the RTA-index ($d^{RTA}$) into the RSTA-index ($d^{RSTA}$), severely reduces the significance of the statistical results, showing the sensitivity of RTA-based results to a transformation of the unbounded RTA-measure into a bounded RSTA-measure.

[20] To explain this we need to consider the index constructions. The technology share difference index ($d^{TS}$) is a measure of the differences in the shares of two countries' patent applications in different patent classes, meaning that the largest patent classes have most impact on the measure. The RTA and RSTA difference indices ($d^{RTA}$ and $d^{RSTA}$) are normalized in this regard and give equal weight to differences in all patent classes (giving larger weight to many small classes). Therefore, we can conclude that while the differences measured with RTA and RSTA could possibly be increasing (inter-national technology specialization), the same main technological areas (patent classes) tend to grow larger or smaller in importance for all countries (inter-national technology convergence).

Herfindahl-Hirschman index, is decreasing, meaning that there is intra-national technology diversification.

Continuing to the more descriptive statistics, some interesting developments in terms of US patents can be seen in Table 4. Many newly industrialized countries, including Korea, China and India, have impressive GDP growths. The compounded annual growth rates (CAGR) in constant prices between 1996 and 2009 are 4.1% for Korea, 9.8% for China, and 6.8% for India[21]. However, their growths in US patenting and patent productivity measured as granted patents per capita are even steeper than their GDP growths (although from very low levels), see Table 4. The CAGRs of the number of patents granted in the US over the same time period are 14.6% for Korea, 31.7% for China, and 25.6% for India. Brazil and Russia on the other hand do not show similar increases in patent rankings or patent productivity, although they had fairly high levels initially in the studied time period compared to some of the other NICs.

The climbing of China and India on the rankings of foreign US patentees is even more noteworthy due to their still comparatively low patent productivity. Hence, there is still room for a continued growth. If China would have had the same productivity as e.g. Sweden in 2009, China would have been granted approximately 150 000 US patents. Another interesting fact is that if the growth of granted patents between 1996 and 2009 continues with the same pace[22], China will pass Japan as the top foreign country in terms of the number of US patents per year within approximately 12 years, i.e. around 2020, which is a year targeted in China's long term science and technology (S&T) development plans for the transition into an innovation-oriented economy. China will then not only be an economic superpower (as is already the case as proved by China passing Japan as the world's second largest economy after the US in 2010), but also an innovative superpower. The legal changes in China in terms of IPRs as discussed below will here play an important role, and one can actually talk about future IP superpowers, as IP is likely to become even more important in the future world economy.

The recent developments in China and India leads to a related question: Which are the technological areas in which China and India increase their patenting the most? This question is addressed in Table 5 and Table 6 where the patent classes in which absolute patenting has increased the most from these countries are listed. Note that the majority of the patent classes are related to electronics and information and communication technologies (ICTs). Part of the explanation for this might be a relatively high propensity to patent in hi-tech industries, see e.g. Brouwer and Kleinknecht (1999). Also note that eleven out of the top 20 patent classes in these countries are on both lists. This gives an illustration to the conclusion above, namely that the same patent classes tend to grow large throughout the world.

[21] Calculations are based on UN statistics.
[22] Japan: 3.4% per year, China: 32% per year.

**Table 4 Top twenty foreign countries regarding number of patents granted in the USA in the period 1996-2009, including patents per million capita**

| Rank | Country | 1996 | Per M capita | Country | 2003 | Per M capita | Country | 2009 | Per M capita |
|---|---|---|---|---|---|---|---|---|---|
| 1. | Japan | 23053 | 183 | Japan | 35515 | 279 | Japan | 35501 | 279 |
| 2. | Germany | 6818 | 83.3 | Germany | 11444 | 139 | Germany | 9000 | 109 |
| 3. | France | 2788 | 46.6 | Taiwan | 5298 | - | Korea | 8762 | 181 |
| 4. | UK | 2454 | 42.2 | Korea | 3944 | 83.6 | Taiwan | 6642 | 288 |
| 5. | Canada | 2232 | 75.4 | France | 3868 | 62.4 | Canada | 3655 | 108 |
| 6. | Taiwan | 1897 | - | UK | 3631 | 60.9 | UK | 3175 | 51.6 |
| 7. | Korea[1)] | 1493 | 33.2 | Canada | 3427 | 108 | France | 3140 | 48.9 |
| 8. | Italy | 1200 | 21.0 | Italy | 1722 | 29.7 | China | 1655 | 1.25 |
| 9. | Switzerland | 1112 | 157 | Sweden | 1521 | 170 | Israel | 1404 | 196 |
| 10. | Sweden | 854 | 96.5 | Netherlands | 1325 | 82.0 | Italy | 1346 | 22.5 |
| 11. | Netherlands | 797 | 51.3 | Switzerland | 1308 | 178 | Netherlands | 1288 | 77.6 |
| 12. | Belgium | 488 | 48.3 | Israel | 1193 | 185 | Australia | 1221 | 57.3 |
| 13. | Israel | 484 | 87.5 | Australia | 902 | 45.3 | Switzerland | 1208 | 160 |
| 14. | Australia | 471 | 25.7 | Finland | 865 | 166 | Sweden | 1014 | 110 |
| 15. | Finland | 444 | 86.6 | Belgium | 622 | 60.3 | Finland | 864 | 162 |
| 16. | Austria | 362 | 45.5 | Austria | 592 | 72.8 | India | 679 | 0.567 |
| 17. | Denmark | 241 | 45.9 | Denmark | 529 | 98.2 | Belgium | 594 | 55.8 |
| 18. | Spain | 157 | 3.98 | Singapore | 427 | 103 | Austria | 503 | 60.1 |
| 19. | Norway | 139 | 31.7 | India | 342 | 0.312 | Singapore | 436 | 92.0 |
| 20. | Russia[2)] | 116 | 0.782 | Spain | 309 | 7.38 | Denmark | 390 | 71.3 |
| | 22. Singapore | 88 | 24.5 | 21. China | 297 | 0.233 | 24. Russia | 196 | 1.39 |
| | 25. Brazil | 63 | 0.384 | 24. Russia | 203 | 1.40 | 28. Brazil | 103 | 0.532 |
| | 27. China[3)] | 46 | 0.0383 | 27. Brazil | 130 | 0.716 | | | |
| | 30. India | 35 | 0.0360 | | | | | | |

*Notes:*

1) Korea = Republic of Korea (South Korea)

2) Russia = Russian Federation

3) China, mainland excl. Hong Kong

*Sources:* USPTO statistics on patents, UN statistics on populations

Besides the absolute increase of patent numbers in these classes, an important observation is that at least China's patent shares increased steeply over the short time between 2005 and 2009. In e.g. the heat exchange patent class, China's patent share has grown from 0.5% to 9.6%. China's average increase in patent shares between 2005 and 2009, averaged over all 404 patent classes, is 0.56%-units, while China's share of foreign patent applications in the

US during the same time has increased more than threefold from 0.58% to 1.95% (with a similar increase in the share of foreign granted patents in the US).

India's patenting does not grow as fast as China's. India's average patent share over all different classes has even decreased with 0.10%-units. However, India's share of foreign patent applications in the US has in this short time period increased from 0.56% to 0.80% (again with a similar increase in the share of granted patents).

**Table 5 Top 20 US patent classes where China has increased its patenting the most between 2005 and 2009**

| | | Absolute numbers | | | Patent shares | | |
|---|---|---|---|---|---|---|---|
| Patent class | Ranked after increase in absolute numbers | 2005 | 2009 | Growth | 2005 | 2009 | Growth (%-units) |
| 361 | Electricity: Electrical Systems and Devices | 8 | 128 | 120 | 0.55% | 6.05% | 5.49% |
| 439 | Electrical Connectors | 54 | 145 | 91 | 2.99% | 7.02% | 4.03% |
| 370 | Multiplex Communications | 6 | 85 | 79 | 0.22% | 1.61% | 1.39% |
| 382 | Image Analysis | 5 | 55 | 50 | 0.37% | 2.10% | 1.74% |
| 707 | DP: Database and File Management or Data Structures (Data Processing) | 6 | 47 | 41 | 0.49% | 1.64% | 1.15% |
| 324 | Electricity: Measuring and Testing | 2 | 30 | 28 | 0.12% | 1.73% | 1.61% |
| 345 | Computer Graphics Processing and Selective Visual Display Systems | 5 | 32 | 27 | 0.25% | 1.24% | 0.99% |
| 709 | Multicomputer Data Transferring (Electrical Computers and Digital Processing Systems) | 3 | 29 | 26 | 0.19% | 0.88% | 0.69% |
| 362 | Illumination | 6 | 31 | 25 | 0.63% | 2.31% | 1.68% |
| 438 | Semiconductor Device Manufacturing: Process | 9 | 34 | 25 | 0.20% | 0.69% | 0.49% |
| 713 | Support (Electrical Computers and Digital Processing Systems) | 1 | 26 | 25 | 0.10% | 1.39% | 1.29% |
| 165 | Heat Exchange | 2 | 24 | 22 | 0.47% | 9.56% | 9.09% |
| 378 | X-Ray or Gamma Ray Systems or Devices | 3 | 25 | 22 | 0.65% | 3.58% | 2.93% |
| 327 | Miscellaneous Active Electrical Nonlinear Devices, Circuits, and Systems | 1 | 21 | 20 | 0.09% | 1.70% | 1.61% |
| 455 | Telecommunications | 6 | 26 | 20 | 0.26% | 0.77% | 0.51% |
| 340 | Communications: Electrical | 1 | 20 | 19 | 0.07% | 1.07% | 1.00% |
| 375 | Pulse or Digital Communications | 9 | 28 | 19 | 0.57% | 1.23% | 0.66% |
| 714 | Error Detection/Correction and Fault Detection/Recovery | 1 | 20 | 19 | 0.09% | 0.96% | 0.87% |
| 379 | Telephonic Communications | 1 | 19 | 18 | 0.11% | 2.44% | 2.33% |
| 532 | Organic Compounds (includes Classes 532-570) | 5 | 23 | 18 | 0.24% | 0.83% | 0.60% |
| | | | | | | **Avg. for all classes:** | **0.56%** |

*Source:* USPTO statistics

**Table 6 Top 20 US patent classes where India has increased its patenting the most between 2005 and 2009**

| Patent class | Ranked after increase in absolute numbers | Absolute numbers 2005 | Absolute numbers 2009 | Absolute numbers Growth | Patent shares 2005 | Patent shares 2009 | Patent shares Growth (%-units) |
|---|---|---|---|---|---|---|---|
| 714 | Error Detection/Correction and Fault Detection/Recovery | 2 | 43 | 41 | 0.17% | 2.06% | 1.89% |
| 707 | DP: Database and File Management or Data Structures (Data Processing) | 6 | 43 | 37 | 0.49% | 1.50% | 1.01% |
| 370 | Multiplex Communications | 7 | 37 | 30 | 0.26% | 0.70% | 0.45% |
| 375 | Pulse or Digital Communications | 2 | 23 | 21 | 0.13% | 1.01% | 0.89% |
| 532 | Organic Compounds (includes Classes 532-570) | 61 | 78 | 17 | 2.88% | 2.82% | -0.05% |
| 711 | Memory (Electrical Computers and Digital Processing Systems) | 9 | 23 | 14 | 0.70% | 1.44% | 0.74% |
| 709 | Multicomputer Data Transferring (Electrical Computers and Digital Processing Systems) | 12 | 24 | 12 | 0.76% | 0.73% | -0.03% |
| 713 | Support (Electrical Computers and Digital Processing Systems) | 2 | 13 | 11 | 0.20% | 0.70% | 0.49% |
| 710 | Input/Output (Electrical Computers and Digital Processing Systems) | 0 | 10 | 10 | 0.00% | 0.92% | 0.92% |
| 717 | DP: Software Development, Installation, and Management (Data Processing) | 7 | 17 | 10 | 1.50% | 2.05% | 0.55% |
| 382 | Image Analysis | 6 | 15 | 9 | 0.44% | 0.57% | 0.13% |
| 715 | DP: Presentation Processing of Document, Operator Interface Processing, and Screen Saver Display Processing (Data Processing) | 4 | 12 | 8 | 0.55% | 0.89% | 0.35% |
| 365 | Static Information Storage and Retrieval | 3 | 10 | 7 | 0.15% | 0.42% | 0.27% |
| 455 | Telecommunications | 3 | 10 | 7 | 0.13% | 0.30% | 0.17% |
| 327 | Miscellaneous Active Electrical Nonlinear Devices, Circuits, and Systems | 9 | 14 | 5 | 0.85% | 1.13% | 0.29% |
| 705 | DP: Financial, Business Practice, Management, or Cost/Price Determination (Data Processing) | 4 | 9 | 5 | 0.52% | 0.46% | -0.06% |
| 708 | Arithmetic Processing and Calculating (Electrical Computers) | 1 | 6 | 5 | 0.43% | 2.14% | 1.71% |
| 718 | Virtual Machine Task or Process Management or Task Management/Control (Electrical Computers and Digital Processing Systems) | 1 | 6 | 5 | 0.56% | 2.30% | 1.74% |
| 726 | Information Security | 0 | 5 | 5 | 0.00% | 0.51% | 0.51% |
| 340 | Communications: Electrical | 0 | 4 | 4 | 0.00% | 0.21% | 0.21% |
| | | | | | | **Avg. for all classes:** | **-0.10%** |

*Source:* USPTO statistics

# 5 Discussion and managerial implications

In summary, our empirical results indicate:

1. Continuous growth of international patenting.
2. Inter-national market convergence of patenting according to all our indicator tests.
3. Inter-national technology convergence according to some of our indicator tests.
4. Decreases in both market and technology concentrations of patenting, i.e. increasing market diversification as well as technology diversification.

For detailed interpretations of these results, the importance of definitions and operationalizations of intra-national diversification/specialization, and inter-national convergence/specialization must be kept in mind. Inter-national technology specialization defined and measured by RTA and RSTA indicators is by and large prevalent according to many previous studies. However, since the RTA and RSTA types of operationalizations mainly used in previous studies of inter-national technology specialization are normalized in a way that gives equal weight to all technological areas, large as well as small, the trends in the most important technological areas are possibly given too limited emphasis in those studies. Thus RTA and RSTA indices could lead to overemphasis on technology specialization, especially if technology concentration is high with a long thin tail. One ought therefore to be cautious when interpreting results and drawing managerial implications based on only the RTA and RSTA difference indices. Depending on how technological areas are defined (e.g. depending on which level the patent classes are defined in a hierarchical patent classification system) there can be more or less biased effects. The more narrow the classification, the more emphasis is likely put on small technological areas. In this study 404 classes of US patents are used, which must be considered a narrow classification, and therefore our technology share difference index does more adequately express the trends in the largest (in terms of patenting) technological areas, then showing increasing similarities between countries in such terms.[23]

Further, it should be noted that inter-national market convergence and inter-national technology convergence could conceivably be negatively correlated. If consumption patterns converge throughout the world at the same time as different countries become increasingly technologically specialized relative to each other, the relative importance of various output markets for different countries of origin will likely converge (inter-national market convergence). On the other hand, if industries across countries increasingly work in similar technological areas, i.e. in case of inter-national technology convergence, this could conceivably promote market specialization across countries rather than market convergence.

As the results indicate, intra-national market diversification as well as technology diversification increases. This in turn indicates an expansion of both the market base (set of output market areas) and the technology base (set of areas of technological inputs) for various countries. Contrary to what one could expect from a competition point of view, this expansionary process is in turn co-evolving with both market convergence and (based on our index) technology convergence. Management in major industries in various countries then seems to adopt the strategy to compete in similar major market areas and in similar major technological areas. This in turn likely leads to more competitive encounters between companies of different nationalities and to the extent that these companies in turn are multinational to more competitive encounters between the same leading MNCs from various countries across markets and technologies. The resulting impact of these encounters upon marketing management and technology management is then conceivably leading to even more increased management convergence, at least in certain management aspects, everything else equal. If managerial strategies and skills are decisive for survival in competitive games, competitive exclusion would then likely eliminate inferior management and less than best practices in case of sustained market and/or technological convergence. As for developing

[23] One could possibly then counter-argue that the technology share difference index used here gives too much weight to patent intensive technological areas and too little weight to other areas. This leads us to emphasize the need for further research with a more axiomatic approach to index construction to reduce bias.

countries catching up, some scholars argue that technology management skills for imitative catch-up are different from innovation management skills. However, in the case of Japan, there have been few signs of substantial differences of that kind, and few signs of any economic importance of such differences in a transition to a more innovative stage (Granstrand, 1999). The trend toward more open innovation, which is an inherent feature of catching up, is likely reinforcing such a development pattern.

One management area linked to technology management in particular, but also to marketing management, is IP management. In light of the significant growth of patenting in general and international patenting in particular, the strong growth of international technology licensing, and on top of that the international dispersion of patentees, IP management becomes increasingly important and then as a corollary multinational IP management, including management of licensing and international technology trade (see e.g. Arora et al., 2001, and Granstrand, 2004). Moreover, internationalization of R&D and technology sourcing and exploitation likely increases internationalization of IP operations. As the multinational competitive encounters increases internationally, and the patents to support technology-based businesses not only increase in volume and importance but also become increasingly dispersed across more players, the so called IP assembly problem becomes more complex and costly to manage.[24] This in turn requires technology management skills in responding to patent blockage by various technology acquisition strategies, like licensing, cross-licensing, patent pooling, invent around R&D, etc. together with various IP legal strategies.

Technology and market diversification and convergence with more localized technology specialization moreover likely lead to more open innovation and collaborative encounters, and collaborative encounters also increases the need for skills in IP management, including skills in coping with the IP assembly problem and the IP sharing problem. Finally, previous studies show a strong positive correlation between technology diversification and economic growth at company level in various countries.[25] If now there is technology and market convergence in addition to technology diversification, a prediction is that economic convergence will increase. This is a testable hypothesis that falls outside the empirical scope of this paper to probe, and is thus suggested for further research.

As to technology, market and management convergence in relation to IP legal convergence, multinational IP management has to deal with differences in IP legal systems across countries, which increases management costs. If these systems converge, there will be substantial cost-savings and a likely increase in IP management convergence as well.

There are in fact indications of convergence of IP legal systems, albeit at a slow pace. The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) and its World Trade Organization (WTO) enforcement has on average strengthened the often weak IP

[24] The IP assembly problem refers to the problem to assemble the necessary IPRs in order to do business, see Granstrand (1999).

[25] See e.g. Cantwell et al. (2004) and Granstrand et al. (1992, 1997) for studies of the links between increasing technological diversification, increasing in-house R&D together with increasing external technology acquisition, i.e. increasingly open innovation, and economic growth.

regimes in developing countries, inducing an upward convergence to levels in developed countries who exercise external pressure on developing countries to switch to a strong IP regime. Internal conditions within developing countries may however induce them to try to choose a suitable transition time period for switching from a weak to a strong patent system and appropriation regime. Since the patent system is not very industry specific (i.e. it is a "one size fits all" type of system, criticized among others by Thurow, 1997) and development stages of industries may differ widely in developing countries, the optimal timing of such a switch or transition is hard to find and is in addition likely to be subjected to industry lobbying. Nevertheless, as countries, industries and companies climb the development ladder(s), i.e. move ahead from a more imitative catch-up stage to a more innovative forging ahead stage, it is likely that from a national economic point of view the aggregate benefits from a strong IP regime (e.g. in attracting inward foreign direct investments in R&D and hi-tech production, incentivizing domestic R&D investments and technology trade, as well as reducing imitation from countries trailing behind technologically) at some point on average outweigh the benefits from a weak IP regime (e.g. incentives for imitative entrepreneurship, piracy, counterfeiting and domestic diffusion of new technologies).[26] [27]

This strengthening of IP regimes for domestic economic purposes has taken place in Japan and Korea and is clearly taking place in China and India. All these countries have with varying time lags recognized the importance of indigenous innovation for economic development and have subsequently introduced various innovation inducing policy measures, including the strengthening of the IP regime and the IP legal system. One may even venture to say that IP policies and IP issues at large have gradually become more closely linked to innovation issues than to traditional trade issues in these countries.[28] Russia is a bit of a special case with a recently developed patent system, much patterned on Western ones, but still with very little patenting by domestic industry and very little IP litigation. It is also noteworthy in this context that few if any countries with an open economy have historically been able to effectively catch-up technologically in the presence of a strong IP regime domestically and abroad. Neither has any country (in an open economy) been trying, let alone been able to, forge ahead with a weak IP regime domestically, after once having caught-up.

The case of China is of special interest for various reasons. China introduced new patent laws in the 2000s, just as Brazil and India (see e.g. Li, 2010 and Mukherjee, 2006). These laws essentially strengthen the patent system, needless to say for national economic purposes.[29]

[26] The role of strong IP regimes for attracting inward FDIs has been studied empirically by e.g. Mansfield (1994, 1995) and the role of strong IP regimes for economic growth by e.g. Park and Ginarte (1997).

[27] Some form of co-existence of strong and weak parts in different industries or regions is feasible, at least temporarily.

[28] Traditionally trade related issues mostly concern trade on product markets (e.g. piracy, counterfeiting, parallel imports, and access to medicines) rather than trade on technology markets.

[29] Throughout the whole history of patent system developments, changes have frequently been enacted with protectionist purposes. A major example is the US switch to a much stronger pro-patent era in the early 1980s as a response to Asian competition, a switch that subsequently led to substantial strengthening of the IP systems worldwide. The patent system in fact opens up many possibilities to opportunistic protectionist behavior. E.g. at the detailed level of inventive step requirements for patentability of an invention in a country, a high step requirement may be used by a developing country to be able to more freely reject patent applications from

China is then in a mixed mode of actual IP enforcement, being weak in some areas and regions and strong in others. Foreign companies and countries have prepared a certain set of strategies for appropriating invention benefits in a weak IP regime in China (see e.g. Keupp et al., 2010), while being less prepared for a new strong IP regime. In general, Western technology and marketing management then tend to be more concerned about appropriation strategies in weak IP regimes than the long-term competitive implications of increasing IP portfolios and IP management skills in countries that switch from weak to strong IP regimes.

Finally, as to economic convergence as an overarching issue at macro level, it is hard to conceive of a world with sustained absence of economic convergence in the presence of convergence in other essential dimensions, including technology, market, management, and legal convergence. Economic convergence could on the other hand conceivably be present in a world with absence of some or all of technology, market, management, and legal convergence. One may e.g. conceive of a world with countries with planned or market economies, common or civil law systems, East or West management styles, specialized technologies and specialized markets. To the extent that competitive forces, including competition between economic systems, can play out such a world is not likely sustainable, again with an, admittedly general, reference to competitive exclusion. Openness of economies – enabling economies of scale, larger returns on R&D, more R&D spill-overs, and more efficiency-inducing effects from cross-border mobility of resources – is sufficient for competitive exclusion to play out on a global level. However, openness of an economy is not a necessary condition as demonstrated by the breakdown of the Soviet empire under pressure from military competition, inferior technological innovativeness and economic ineffectiveness. Theoretically seen, equilibria with multiple optima along a development path is not likely to be stable, and practically seen, history has no clear illustration of that.

# 6 Conclusions

This paper addresses various dimensions of convergence in a global context – market, technology, management, legal, and economic convergence. An empirical analysis of market and technology convergence based on worldwide patent statistics has employed both new and old measures of convergence, specialization, and diversification of markets and technological areas among the world's countries. In addition field studies in Asia, Europe, and US with a focus on innovation and IP policies and management have been conducted. We may conclude that there are indications of global convergence in form of inter-national market convergence and to a certain extent inter-national technology convergence and IP legal convergence, together with intra-national market and technology diversification. This is in contrast to some previous research indicating increasing technology specialization. Market, technology, and IP legal convergences in turn likely imply increased convergence of multinational technology management, and then IP management, as an increasingly important part thereof. Whether

abroad, and a low step requirement may be used by a developed country to allow for patent strategies such as flooding (blanketing or thicketing) and evergreening by domestic large firms with numerous minor product and process improvements (see Granstrand 1999b, 2003).

these developments will lead to increased economic convergence is difficult to say on the basis of our current knowledge, but a testable hypothesis suggested for further research is that so is the case.

As to managerial implications, global developments of the sort discussed in this paper calls for increasing skills in multinational intellectual property management (IPM), increasingly becoming a core skill in multinational technology management (e.g. in licensing and litigation). This managerial implication is valid for both developed and developing countries. Increasing technology- and innovation-based competition from ANICs should then be of more concern for technology management in industrialized countries (ICs) than short-term concern over piracy, free-riding, counterfeiting, parallel imports, and other related issues. A companion policy implication, briefly put, is that countries around the world should worry more about innovation related IP issues than about traditional trade related IP issues in the years to come.

## Acknowledgements

The work with this paper has been conducted under the auspices of IMIT (Institute for Management of Innovation and Technology) at Chalmers University of Technology within the project “Management, Economics and IP Law of Open Distributed Innovation Processes”, financed by the Swedish research and innovation funding agency Vinnova. Comments from John Cantwell and two anonymous reviewers are gratefully acknowledged.

## Literature references

Abramovitz, M. (1986) ‘Catching up, forging ahead and falling behind’, *Journal of Economic History*, Vol. 46, No. 2, pp. 385-406.

Abramovitz, M. (1990) ‘The catch-up factor in postwar economic growth’, *Economic Inquiry*, Vol. 28, January, pp. 1-18.

Abramovitz, M. (1991) *Thinking about Growth and Other Essays on Economic Growth and Welfare*, Cambridge: Cambridge University Press.

Adler, P. S. and Ferdows, K. (1990) ‘The Chief Technology Officer’, *California Management Review*, Vol. 32, No 3, pp. 55-62.

Archibugi, D. and Pianta, M. (1992) ‘Specialization and size of technological activities in industrial countries: The analysis of patent data’, *Research Policy*, Vol. 21, pp. 79-93.

Archibugi, D. and Pianta, M. (1994) ‘Aggregate convergence and sectoral specialization in innovation’, *Journal of Evolutionary Economics*, Vol. 4, pp. 17-33.

Arora, A., Fosfuri, A. and Gambardella, A. (2001) *Markets for Technology: The Economics of Innovation and Corporate Strategy*, The MIT Press.

Balassa, B. (1965) 'Trade liberalization and "revealed" comparative advantage', *The Manchester School o Economic and Social Studies*, Vol. 33, No. June.

Baumol, W.J. (1986) 'Productivity Growth, Convergence, and Welfare: What the Long-run Data Show', *American Economic Review*, Vol. 76, No. 5, pp. 1072-1085.

Baumol, W.J. (2002) *The Free-Market Innovation Machine: Analyzing the Growth Miracle of Capitalism*, Princeton, NJ: Princeton University Press.

Beelen, E. and Verspagen, B. (1994) 'The Role of Convergence in Trade and Sectoral Growth', in Fagerberg, J., Berspage, B. and von Tunzelmann, N. (Eds) *The Dynamics of Technology, Trade and Growth*, London: Edward Elgar.

Bosworth, D.L. (1984) 'Foreign patent flows to and from the United Kingdom', *Research Policy*, Vol. 13, pp. 115-124.

Brouwer, E. and Kleinknecht, A. (1999) 'Innovative output, and a firm's propensity to patent. An exploration of CIS micro data', *Research Policy*, Vol. 28, pp. 615-624.

Cantwell, J. (1989) *Technological Innovation and Multinational Corporations*, Oxford: Blackwell.

Cantwell, J. (1991) 'Historical trends in international patterns of technological innovation', in: *New perspectives on the late Victorian Economy*, Cambridge: Cambridge University Press.

Cantwell, J. (1995) 'The Globalisation of Technology: What Remains of the Product Cycle Model?', *Cambridge Journal of Economics*, Vol. 19, No. 1, pp. 155-174.

Cantwell, J. (Ed.) (1999) *Foreign Direct Investments and Technological Change*, Cheltenham: Elgar Publishing.

Cantwell, J. (2000) 'Technological lock-in of large firms since the interwar period', *European Review of Economic History*, Vol. 4, pp. 147-174.

Cantwell, J., Gambardella, A. and Granstrand, O. (Eds) (2004) *The Economics and Management of Technological Diversification*, Routledge.

Cantwell, J. and Vertova, G. (2004) 'Historical evolution of technological diversification', *Research Policy*, Vol. 33, pp. 511-529.

Carr, C. and Pudelko, M. (2006) 'Convergence of Management Practices in Strategy, Finance and HRM between the USA, Japan and Germany', *International Journal of Cross Cultural Management*, Vol. 6, No. 1, pp. 75-100.

Cavvigioli, F. (2011) *Understanding Patent System Through the Analyses of Patent Flows Across Countries and of Patent Quality*, PhD Thesis, Università degli Studi di Bergamo.

Dalum, B., Laursen, K. and Villumsen, G., (1998) 'Structural Change in OECD Export Specialisation Patterns: de-specialisation and 'stickiness'', *International Review of Applied Economics*, Vol. 12, No. 3, pp. 423-443.

De Long, J.B. (1988) 'Productivity Growth, Convergence, and Welfare: Comment', *American Economic Review*, Vol. 78, No. 5, pp. 1138-1154.

Dosi, G., Pavitt, K.L.R. and Soete, L.L.G (1990) *The Economics of Technical Change and International Trade*, New York: Harvester Wheatsheaf.

Edfelt, R.B. (2009) *Global Comparative Management: A Functional Approach*, SAGE Publications.

Edquist, C. (1997) *Systems of innovation: technologies, institutions, and organizations*, London: Pinter.

Freeman, C., Clark, J. and Soete, L. (1982) *Unemployment and Technical Innovation*, London: Pinter.

Gambardella, A. and Torrisi, S. (1998) 'Does Technological Convergence Imply Convergence in Markets? Evidence from the Electronics Industry', *Research Policy*, Vol. 27, No. 5, pp. 447-465.

Goldberg, P.K. and Verboven, F. (2005) 'Market integration and convergence to the Law of One Price: evidence from the European car market', *Journal of International Economics*, Vol. 65, No. 1, pp. 49-73.

Granstrand, O. (1982) *Technology, Management, and Markets*, London: Pinter Publ.

Granstrand, O. (Ed.) (1994) *Economics of Technology*, Amsterdam: Elsevier.

Granstrand, O. (1999) 'Internationalization of corporate R&D: a study of Japanese and Swedish corporations', *Research Policy*, Vol. 28, pp. 275-302.

Granstrand, O. (1999b) *The Economics and Management of Intellectual Property – Towards Intellectual Capitalism*, Cheltenham: Edward Elgar Publishing Ltd.

Granstrand, O. (2000) 'The shift towards intellectual capitalism – the role of infocom technologies', *Research Policy*, Vol. 29, pp. 1061-1080.

Granstrand, O. (2000b) 'Corporate Innovation Systems. A Comparative Study of Multi-Technology Corporations in Japan, Sweden and the USA', report submitted to the EU Dynacom project, CIM report 2000:01, Dept. of Industrial Management and Economics, Chalmers University of Technology.

Granstrand, O. (Ed.) (2003) *Economics, Law and Intellectual Property*, Dordrecht: Kluwer Academic Publishers.

Granstrand, O. (2004) 'The Economics and Management of Technology Trade – towards a pro-licensing era?', *International Journal of Technology Management*, Vol. 27, No. 2, pp. 209-240.

Granstrand, O, Bohlin, E., Oskarsson, C. and Sjöberg, N. (1992) ‘External technology acquisition in large multi-technology corporations’, *R&D Management*, Vol. 22, No. 2, pp. 111–134.

Granstrand, O. and Fernlund, I. (1978) ‘Coordination of multinational R&D’, *R&D Management*, Vol. 9, No. 1, pp. 1-7.

Granstrand, O., Håkansson, L. and Sjölander, S. (Eds.) (1992b) *Technology Management and International Business - Internationalization of R&D and Technology*, London: Wiley.

Granstrand, O., Patel, P. and Pavitt, K. (1997) ‘Multi-Technology Corporations: Why They Have “Distributed” Rather Than “Distinctive Core” Competencies’, *California Management Review*, Vol. 39, No. 4, pp. 8-25.

Granstrand, O. and Sigurdsson. J. (Eds.) (1981) *Technological and Industrial Policy in China and Europe*, Lund: Research Policy Institute.

Herstatt, C., Tietze, F., Nagahira, A. and Probert, D. (2007). ‘The Chief Technology Officer (CTO) in Literature and Practice: A Review and Results from Field Research in Japan’, *International Journal of Innovation and Technology Management*, Vol. 4, No. 3, pp. 323-350.

Holgersson, M. (2011) *Intellectual Property Strategies and Innovation: Causes and Consequences for Firms and Nations*, Licentiate Thesis, Gothenburg: Chalmers University of Technology.

Jantsch, E. (1967) *Technological Forecasting in Perspective*, Paris: OECD.

Keupp, M.M., Beckenbauer, A. and Gassmann, O. (2010) ‘Enforcing Intellectual Property Rights in Weak Appropriability Regimes: The Case of de Facto Protection Strategies in China’, *Management International Review*, Vol. 50, No. 1, pp. 109-130.

Kim, Y.K., Lee, K., Park, W.G. and Choo, K. (2011) ‘Appropriate intellectual property protection and economic growth in countries at different levels of development’, *Research Policy*, doi:10.1016/j.respol.2011.09.003.

Kodama, F. (1992) ‘Technology fusion and the new R&D’, *Harvard Business Review*, Vol. 10, No. 4, pp. 70-78.

Krugman, P. (1987) ‘The narrow moving band, the dutch disease, and the competitive consequences of Mrs. Thatcher: notes on trade in the presence of dynamic scale economies’, *Journal of Development Economics*, Vol. 27, pp. 41-55.

Lillrank, P. (1995) ‘The Transfer of Management Innovations from Japan’, *Organization Studies*, Vol. 16, No. 6, pp. 971-989.

Lundvall, B-Å. (Ed.) (1992) *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*, London: Pinter Publishers.

Mansfield, E. (1988) ‘The speed and cost of industrial innovation in Japan and the United States: External vs. Internal Technology’, *Management Science*, Vol. 34, No. 10, pp. 1157-68.

Mansfield, E. (1994) *Intellectual Property Protection, Foreign Direct Investment, and Technology Transfer*, Discussion Paper 19, Washington, DC: International Finance Corporation (IFC).

Mansfield, E. (1995) *Intellectual Property Protection, Direct Investment, and Technology Transfer: Germany, Japan, and the United States*, Discussion Paper 27, Washington DC: International Finance Corporation (IFC).

Mukherjee, S. (2006) 'The new Indian patent law: a challenge for India', *International Journal of Intellectual Property Management*, Vol. 1, Nos. 1/2, pp. 131-149.

Nelson, R.R. (Ed.) (1993) *National innovation systems: a comparative analysis*, New York: Oxford University Press, Inc.

Park, W.G. and Ginarte, J.C. (1997) 'Intellectual property rights and economic growth', *Contemporary Economic Policy*, Vol. 15, July, pp. 51-61.

Patel, P. and Pavitt, K. (1994) 'Uneven (and Divergent) Technological Accumulation among Advanced Countries: Evidence and a Framework of Explanation', *Industrial and Corporate Change*, Vol. 3, No. 3, pp. 759-787.

Pavitt, K.L.R. (1982) 'R&D, patenting and innovative activities. A statistical exploration', *Research Policy*, Vol 11, pp. 33-51.

Rogers, J.H. (2007) 'Monetary union, price level convergence, and inflation: How close is Europe to the USA?' *Journal of Monetary Economics*, Vol. 54, No.3, pp. 785-796.

Rosenberg, N. (1963) 'Technological Change in the Machine Tool Industry, 1840–1910', *The Journal of Economic History*, Vol. 23, pp. 414-443.

Santangelo, G. (2005) *Technological Change and Economic Catch-up*, Cheltenham: Edward Elgar Publishing.

Scherer, F.M. (1999) *New Perspectives on Economic Growth and Technological Innovation*, Washington DC: Brookings Institution Press.

Schumpeter, J.A. (1942) *Capitalism, Socialism and Democracy*, London: George Allen & Unwin.

Soete, L.L.G. (1981) 'Technical Change, Catching Up and the Productivity Slowdown', published in Granstrand, O. and Sigurdson, J. (Eds) *Technological and Industrial Policy in China and Europe*, Lund: Research Policy Institute.

Soete, L.L.G. (1987) 'The impact of technological innovation on international trade patterns: The evidence reconsidered' *Research Policy*, Vol. 16, pp. 101-130.

Soete, L.L.G. and Verspagen, B. (1994) 'Competing for growth: the dynamics of technology gaps', in: L. Pasinetti and R. Solow (Eds) *Economic Growth and the Structure of Long-Term Development*, London: Macmillan.

Summers, R. and Heston, A. (1991) 'The Penn World Table (Mark 5): An Expanded Set of International Comparisons, 1950-1988', *Quarterly Journal of Economics*, Vol. 106, No. 2, pp. 327-368.

Thurow, L.C. (1997) 'Needed: a new system of intellectual property rights', *Harvard Business Review*, Vol. 75, No. 5, pp. 94-103.

Paper IV

# Conceptualizing Innovation Openness: A Framework and Illustrative Case

Marcel Bogers[a)], Ove Granstrand[b)] and Marcus Holgersson*[b)]

[a)] SPIRE Center
Mads Clausen Institute for Product Innovation
University of Southern Denmark
Alsion 2, 6400 Sonderborg, Denmark

[b)] Industrial Management and Economics
Department of Technology Management and Economics
Chalmers University of Technology
SE-412 96 Gothenburg, Sweden

* Corresponding author: marhol@chalmers.se

## Abstract

Open innovation has become an increasingly recognized source of innovativeness and competitive advantage. However, various perspectives on innovation openness co-exist and a complete comprehension of the underlying mechanisms and dimensions is still lacking. This paper therefore develops a conceptual framework that helps to better describe and analyze innovation openness. We draw on resource-/capability-based, transaction-/contract-based and (intellectual) property rights-based perspectives to conceptualize innovation openness as consisting of three main dimensions, namely resource distribution, technology governance and technology accessibility. We also present an illustrative case of four generations of mobile communication systems to exemplify the value of the framework and to further illustrate the multi-layered and dynamic nature of innovation openness, as well as the important role of intellectual property rights. As such, we conclude that any notion of a stable optimum and one-dimensional view on innovation openness is overly simplistic and likely to mislead managerial and policy decisions.

## Keywords

Governance; Intellectual property rights; Open innovation; Resources

## Acknowledgements

The work on this paper has been undertaken within the project *Management, Economics and IP Law of Open Distributed Innovation* at Chalmers University of Technology, administered by IMIT. The financial support from Vinnova and STINT is gratefully acknowledged. We also thank Dr. Robert Myers at Fairfield Resources International for his assistance with data collection. Finally, we are grateful for the feedback we received from participants of the Open and User Innovation Workshop in Vienna (2011), the R&D Management Conference in Grenoble (2012), and seminars at the University of Manchester, University of Amsterdam and Aalborg University, where earlier versions of this paper were presented.

# 1 Background

Innovation openness typically refers to innovation activities or processes that cross an organizational boundary, and it may involve more or less collaborative elements and more or less transfer of resources, property rights and control. In innovation practice and research, a more open approach to innovation has increasingly been argued to be a key mechanism for firms to benefit from various sources of knowledge and profit from technology (Chesbrough et al., 2006; Dahlander and Gann, 2010; van de Vrande et al., 2009). This interest is especially fueled by Chesbrough (2003) who coined the term “open innovation” as the new imperative for creating and profiting from technology. At the same time, innovation openness more generally also has roots in earlier work, such as the research on the role of external sources of innovation (Burns and Stalker, 1961; Cohen and Levinthal, 1990; von Hippel, 1988) or that on markets for technology and related exploration and exploitation (Arora et al., 2001; Granstrand and Sjölander, 1990). Given the recent emergence and some ambiguity in definitions and conceptualizations, open innovation can still be seen as a relatively recent phenomenon that requires more theorizing and synthesis before it can fully mature as a research field (Huizingh, 2011; von Krogh et al., 2012).

In the literature, innovation openness relates to a broad range of innovation activities and processes. On a general level, research has recognized that firms can benefit from an open approach to innovation by relying on inflows of external knowledge in order to cheapen and accelerate internal innovation processes (Laursen and Salter, 2006), exploit internal knowledge through external paths to market (Tranekjer and Knudsen, 2012), and/or co-create with complementary partners (Enkel et al., 2009). More specifically, research has identified various ways in which firms can achieve more and better innovation openness, as for example reflected in the work on innovation toolkits and communities (Jeppesen and Frederiksen, 2006; von Hippel and Katz, 2002; von Hippel and von Krogh, 2003), crowdsourcing and broadcast search (Afuah and Tucci, 2012; Frey et al., 2011; Jeppesen and Lakhani, 2010), and innovation alliances, networks or ecosystems (Adner and Kapoor, 2010; Cassiman et al., 2009; Dittrich and Duysters, 2007).

The growing interest in innovation openness has led to a variety of conceptualizations and terminologies. And although multiple conceptual dimensions have been identified, a coherent theory and conceptual framework is still lacking (Dahlander and Gann, 2010; Huizingh, 2011). Moreover, the exact meaning and related operationalization of innovation openness remain ambiguous, even though there is an increasing recognition of the complementary nature of internal and external innovation sources (Cassiman and Veugelers, 2006; Faems et al., 2010; West and Gallagher, 2006) and a continuous dimension of openness ranging from closed to open innovation (Laursen and Salter, 2006; von Hippel and von Krogh, 2003; West, 2003). West et al. (2006) moreover call for a better consideration of multiple levels of openness, indicating the need for a more complete framework.

This growing diversity and ambiguity calls for an elaboration of a set of common defining and/or distinctive characteristics among the various definitions and practices of innovation openness. The purpose of this paper is therefore to develop a general conceptual framework for innovation openness. Given the importance of resource distribution, ownership and governance, we will particularly draw on theoretical perspective related to resources and capabilities (Penrose, 1959; Richardson, 1972), transactions and contracts (Coase, 1960; Ostrom, 1990), and (intellectual) property rights (Demsetz, 1967; Foss and Foss, 2005; Granstrand, 1999), in order to develop the conceptual logic that will connect the relevant concepts in our framework.

Our main contributions are threefold. First, we provide a general conceptual framework of innovation openness, enabling increased understanding of innovation processes across organizational boundaries by establishing three key dimensions for describing innovation processes, namely resource distribution, governance, and accessibility. Second, we illustrate the applicability of this framework by presenting a longitudinal case of a sequence of four generations of mobile communication systems, namely NMT (1G), GSM (2G), UMTS (3G) and LTE (4G). Third, based on a discussion of the framework and case, we propose a number of important implications for the research and practice of innovation openness.

## 2 Framework of innovation openness

Here we discuss the various definitions of innovation in general and innovation openness in particular, and we present our theory and conceptual framework.

### 2.1 Definitions of innovation (openness)

While innovation can be defined as the development of an invention and the commercialization of that invention through adoption, diffusion and use (Freeman, 1982; Rogers, 1995; Schumpeter, 1934), innovation openness entails a disconnection of some sort between inventing, which entails the creation of new knowledge, and commercializing this knowledge. Such knowledge creation activities are then rendered from organizational resources (Penrose, 1959) or capabilities (Richardson, 1972). These resources may include background knowledge (i.e. existing knowledge prior to the innovation process/activity) but also other types of resources, including human and physical resources. These resources may in turn be distributed over various resource holders (owners, possessors, controllers). Such resources may then be involved in many types of resource processes, but the main focus in this paper is on technological innovations, and Figure 1 illustrates the innovation process related to the development and commercialization of a specific new technology, $\tau$.

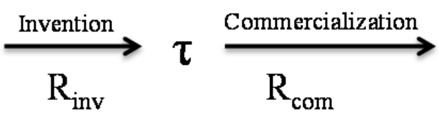



**Figure 1: Conceptualizing the innovation process**

A wide range of literature has emphasized openness in innovations, innovation processes, and innovation systems. Baldwin and von Hippel (2011, p. 1400) define an innovation as open when “all information related to the innovation is a public good—nonrivalrous and nonexcludable", with similarities to open source software and open science (Partha and David, 1994; von Hippel and von Krogh, 2003). This is, as they also point out, different from openness from Chesbrough's (2003, p. xxiv) definition of open innovation as "a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as firms look to advance their technology", which neither implies nor excludes nonrivalry or nonexcludability.

Thus, one stream of literature emphasizes openness in terms of external acquisition and/or exploitation activities of technologies (Arora et al., 2001; Chesbrough, 2003; Tranekjer and Knudsen, 2012), which implies a certain permeability of organizational boundaries and a quasi-integrated organizational form (Granstrand, 1982; Williamson, 1985). Another stream of literature emphasizes openness in terms of innovations' characteristics of nonrivalry and nonexcludability, which relates more to the public good nature of innovation (Baldwin and von Hippel, 2011; Grand et al., 2004; O'Mahony, 2003). As we will show, these different conceptualizations do not necessarily contradict each other but rather emphasize different dimensions of innovation openness. These dimensions will then form the basis for our framework. While the first dimension below relates to characteristics of the involved resources in general, $R$, the subsequent two dimensions relate to characteristics of the invented technology, $\tau$, which is a specific resource created in the innovation process.

## 2.2 Resource distribution

As described above, the innovation process consists of both invention activities and commercialization activities, rendered by resources/capabilities (Penrose, 1959; Richardson, 1972), including human resources, technological resources, and physical resources (e.g. research and test labs), which are possibly distributed across different actors (Hayek, 1945; Schumpeter, 1934). The set of resources, $R$, involved in the invention and commercialization activities can be distributed over various actors, for example through ownership across multiple actors (including different forms of co-ownership, such as communal ownership among a group of agents) or through no ownership at all. The distribution of resources over few or many holders is then an important characteristic of innovation openness (cf. Granstrand et al., 1997; Jeppesen and Lakhani, 2010; von Hippel, 2007), and we include this as the first dimension in our framework of innovation openness. Note that when resources are distributed over many resource holders, multiple boundaries can be involved, ranging from within to between firms, networks, industries and nations. Resource distribution is thus a multi-layered characteristic, with different level of resource holders.

The set of resources involved in the innovation process can be illustrated by a matrix, $R$, where each row represents the set of resources belonging to a certain agent and each column represents how a certain resource type is distributed over a set of agents:

$$R = \begin{bmatrix} r_{11} & \cdots & r_{m1} \\ \vdots & \ddots & \vdots \\ r_{1n} & \cdots & r_{mn} \end{bmatrix} \quad , \quad r_{ij} = amount\ of\ resource\ of\ type\ i\ held\ by\ agent\ j$$

Thus, the vector $\boldsymbol{r}_{\cdot j} = [r_{1j} \quad \cdots \quad r_{mj}]$ represents the resource base of agent $j$, while $\boldsymbol{r}_{i\cdot} = \begin{bmatrix} r_{i1} \\ \vdots \\ r_{in} \end{bmatrix}$ represents the actor base of resource $i$. Note that $r_{ij}$, $n$, and $m$ typically vary over time as a new technology could represent a new type of resource and resource exchanges take place over time. Assuming that the resources are distributed over multiple resource holders, we can now distinguish between a *specialized distribution* of resources, in which various actors focus on different resources (i.e. the resource bases do not overlap significantly), and a *collective distribution*, in which various actors focus on similar resources.[1] Typically, some degree of overlap is necessary to enable absorptive capacity (Cohen and Levinthal, 1990).

We can also separate between invention related resources, $R_{inv}$, and commercialization related resources, $R_{com}$, out of the total set of resources involved in the innovation process, $R = R_{inv} + R_{com}$. If the invention related resources are distributed over a different set of actors than the commercialization related resources, we talk about a *technology trade related distribution* of the total resource set (which is then a special case of a specialized resource distribution, with one set of actors specializing in invention activities and related resources and another set of actors specializing in commercialization activities and related resources). Previous conceptualizations of innovation openness have commonly focused on technology trade related openness in terms of inbound and/or outbound innovation (Chesbrough, 2003; Dahlander and Gann, 2010), which makes sense from a (single) firm-centric input/output perspective. However, our framework goes beyond a pure inbound/outbound perspective as it can also refer to innovation systems rather than just single firms. As such, from a systems perspective, each trade-related acquisition of knowledge is simultaneously exploitation of knowledge. Our framework thus also covers collaborations within invention activities and/or within commercialization activities (e.g. Dittrich and Duysters, 2007; von Hippel, 2007). The framework moreover entail a dynamic element as the developed technology becomes part of the resource-set related to its commercialization and possibly related to the subsequent invention activities. Thus $m$ above can be expanding (while contracting in case of a technology or resource in general is fully substituted, i.e. obsoleted).

### 2.3 Governance, contracting, and control of technological innovations

While our dimension of resource distribution relates to the resources related to inventing and commercializing new technologies, we also consider the characteristics of the new technological resources/innovations, $\tau$. Here we consider properties as constituting resources with some form of (*de jure* or *de facto*) assigned ownership, which contrasts to resources

[1] We can operationalize the distinction between specialized and collective distributions for example by using the number of holders of each type of resource combined with the number of resource types belonging to a certain resource holder. If both numbers are small, we talk about a specialized (core) distribution, while if both numbers are large, we talk about a collective distribution. Another option for operationalization is to calculate horizontal and vertical concentrations for each actor and resource type, respectively, e.g. using the Herfindahl index. If both horizontal concentrations and vertical concentrations are large, we talk about a specialized distribution, while if both horizontal and vertical concentrations are small, we talk about a collective distribution.

without ownership.[2] Property rights are typically divided into the right to use and transform a resource, the right to earn income form a resource, and the right to transfer ownership of the resource (Eggertsson, 1990), and property rights can thus be used to govern the use and commercialization of a resource (property).[3]

Now focusing on the technological resources being developed in the innovation process, the type and "strength" of the intellectual property rights (IPRs) related to a technological resource impact the opportunities for appropriation of value from that resource (e.g. Foss and Foss, 2005; Levin et al., 1987; Teece, 1986), and property rights are also necessary for trading the resource. IPRs essentially constitute the contractual control over the technological resource, which can take various forms and strengths. The property right then impacts both the value of the resource and the transaction cost of trading the resource. For example, a patent requires different actions when being traded than the actions necessary when trading a trade secret right or a physical property right, and it is fundamentally different from transferring technological resources that are not controlled by property rights at all.

Although private property rights could be used to internalize externalities (Coase, 1960), they do not internalize all externalities, and might even create new ones (Demsetz, 1967). The type of implicit or explicit contracting (i.e. formal or informal governance), related to the technological resources being developed are therefore not only impacting the holder of that particular resource, but also other agents. The type of contracting and governance related to technological resources is thus an important characteristic of an innovation system, not the least since propertization impacts transaction costs (see e.g. Coase, 1937, 1960) and governance costs more generally. We therefore make a distinction between formal governance/explicit contracting and informal governance/implicit contracting related to the technological resources being developed in an innovation process/system.

This distinction also relates to different streams of literature innovation openness. While scholars as Chesbrough (2003) and Arora et al. (2001) generally focus on trading and licensing intellectual property (IP) via formal contracting, user innovation and open source scholars have emphasized openness of the technology itself, in terms of its characteristics of nonrivalry and nonexcludability (Baldwin and von Hippel, 2011; O'Mahony, 2003; von Hippel, 2005). This latter group emphasizes benefits from freely revealing information about innovations (Harhoff et al., 2003), meaning that "exclusive intellectual property rights to that information are voluntarily given up by the innovator" (Baldwin and von Hippel, 2011, p. 1401). Von Hippel and von Krogh (2003) treat open source as a hybrid case of "private-collective" innovation, which combines the "private investment" model that builds on the inventors' ability to appropriate returns due to exclusive rights and the "collective action" model of innovation that builds on innovators relinquishing control of their technologies and

[2] Resources without ownership could however be defined as properties with communal ownership distributed among all agents (Demsetz, 1967). If so, resources can also be viewed as bundles of property rights (see e.g. Coase, 1960; Foss and Foss, 2005). Such a definition of the property concept leaves little difference between resources and properties, however.

[3] Note the difference between properties and property rights. Property rights are legal tools to turn resources in general into properties.

providing them to a common pool. Accordingly, there is also a difference between explicit contracting enforceable by law, implicit contracting enforceable by markets (Klein et al., 1978) or social norms (Ostrom, 1999; Ostrom et al., 1999), and possibly no contracting at all.

## 2.4 Accessibility

The third and final dimension in our innovation openness framework relates to the accessibility of the invented technology, $\tau$. Although explicit contracting/formal governance (e.g. by patents) is typically used for limiting accessibility to technologies by innovators to collect monopolistic rents (e.g. Arrow, 1962; Scotchmer, 2004; Teece, 1986), it can also be used to ensure a high accessibility to technologies. An example is the use of copyrights and different types of licenses in open source software, such as the General Public License (GPL), which is a formal type of contract aimed to protect the rights of users to view, modify, and distribute the technology/code (O'Mahony, 2003), i.e. to enable high accessibility. The same is true for implicit contracting and informal governance, and O'Mahony (2003) emphasizes the importance of social norms in the enforcement of GPL, enabling accessibility. Alternatives to formal contracting have been studied more generally by Ostrom (1990) and Ostrom et al. (1999), and these can also be designed for high or low/limited accessibility.

Accessibility is a third dimension in our framework of innovation openness, which relates to Dahlander and Gann’s (2010) distinction between revealing and selling in outbound innovation processes. The latter distinguishes between pecuniary and non-pecuniary technology transactions. Here we see the accessibility of a technology as a characteristic describing how easy or cheaply it can be accessed and used by agents who have not invented it. Determinants of the accessibility include characteristics at the technology holder, including IPR strategies and pricing as well as external knowledge exploitation capabilities, and characteristics at the technology accessing agents, including the absorptive capacities, and also other internal and external factors such as communication technologies, language differences, geographical distances, etc. The accessibility can be differentiated among a set of potential accessing agents by the technology holder, thereby differentiating the accessibility between different (types or levels of) boundaries, indicating the multi-layered nature of innovation openness. A patent holder might for example offer a cheap license to non-competitors while not offering a license at all to competitors. Moreover, Henkel (2006) showed that firms selectively revealed certain source code while protecting other code by various means, indicating a differentiated accessibility of various technologies.

## 2.5 Summary of the framework

To summarize, our framework of innovation openness consists of three dimensions, as shown in Figure 2, with different innovation setups in the various cells in order to illustrate the various combinations. Cell 5 and 7 illustrate what would typically be called fairly closed innovation, with few actors being involved and limited accessibility to the innovations for others than the innovator(s). While cell 5 illustrates a setup in which accessibility is limited by informal means, the accessibility is in cell 7 limited by formal governance, such as patents or copyrights. The setups in cell 5 and 7 enable direct value appropriation from the innovations, e.g. by selling innovative products or licenses to innovations that are difficult to imitate. Cell 1 and 3, in contrast, illustrate innovation systems in which innovation processes are carried out within closed alliances, groups, or clubs of actors, limiting accessibility for outsiders with either informal or formal means providing some form of boundary. Firms can then both collaborate and compete within the alliance (co-opetition), while the alliance can compete with outside firms and other alliances. If the boundary is inexistent, or relatively permeable, outsiders can freely or cheaply access technologies and provide additional invention or commercialization resources, leading to either uncontrolled or controlled sharing, depending on how the accessibility is governed, see cell 2 and 4. In such a system, networks or eco-systems can jointly develop innovations, while profits typically need to be collected by other means than direct control of the technological resources, e.g. by instead controlling complementary resources (Teece, 1986). Setups in which accessibility to innovations is high for outsiders, but in which the number of involved actors are still relatively low, are then open for either uncontrolled or controlled sharing, see cell 6 and 8. This means that the innovation setup is open for additional actors to utilize, benefit from, and add to the focal innovation.

| | | | | |
|---|---|---|---|---|
| **Many resource holders** | 1) Informal innovation alliance/network | 2) Uncontrolled sharing | 3) Formal innovation alliance/network | 4) Controlled sharing |
| **Few resource holders** | 5) Closed (informal) innovation | 6) Open for uncontrolled sharing | 7) Closed (proprietary) innovation | 8) Open for controlled sharing |
| | **Low accessibility** | **High accessibility** | **Low accessibility** | **High accessibility** |
| | **Implicit contracting/informal governance** | | **Explicit contracting/formal governance** | |

**Figure 2: Innovation openness framework**

## 3 Illustrative case: Four generations of mobile telecommunications

We now illustrate the applicability of our conceptual framework by presenting an empirical case. As our framework describes the complex nature of innovation openness, we present a longitudinal case since it enables a rich picture of the complex phenomenon and interdependencies. As noted by Hargadon and Douglas (2001, p. 480) “historical case studies

[…] provide a perspective that covers the decades often necessary to observe an innovation's emergence and stabilization". In particular, we use the case of several generations of mobile telecommunication systems, which is an empirically well researched field, in open innovation in particular (e.g. Dittrich and Duysters, 2007; West, 2006) and in technology and innovation management in general (e.g. Bekkers et al., 2002a; Bekkers et al., 2002b; Bekkers and West, 2009; Bohlin and Granstrand, 1991; Di Minin and Bianchi, 2011; Fuentelsaz et al., 2008; Gandal et al., 2003; Granstrand, 1999). The case describes the development of four overlapping generations of mobile telecommunication systems, namely NMT (1G), GSM (2G), UMTS/WCDMA (3G), and LTE Advanced (4G) in which we will take a European (and Nordic) perspective since the "European" generations of mobile telecommunication standards have come to dominate the world market from GSM and onwards. Figure 3 gives an overview of the historical development. See Appendix for a note on methodology.

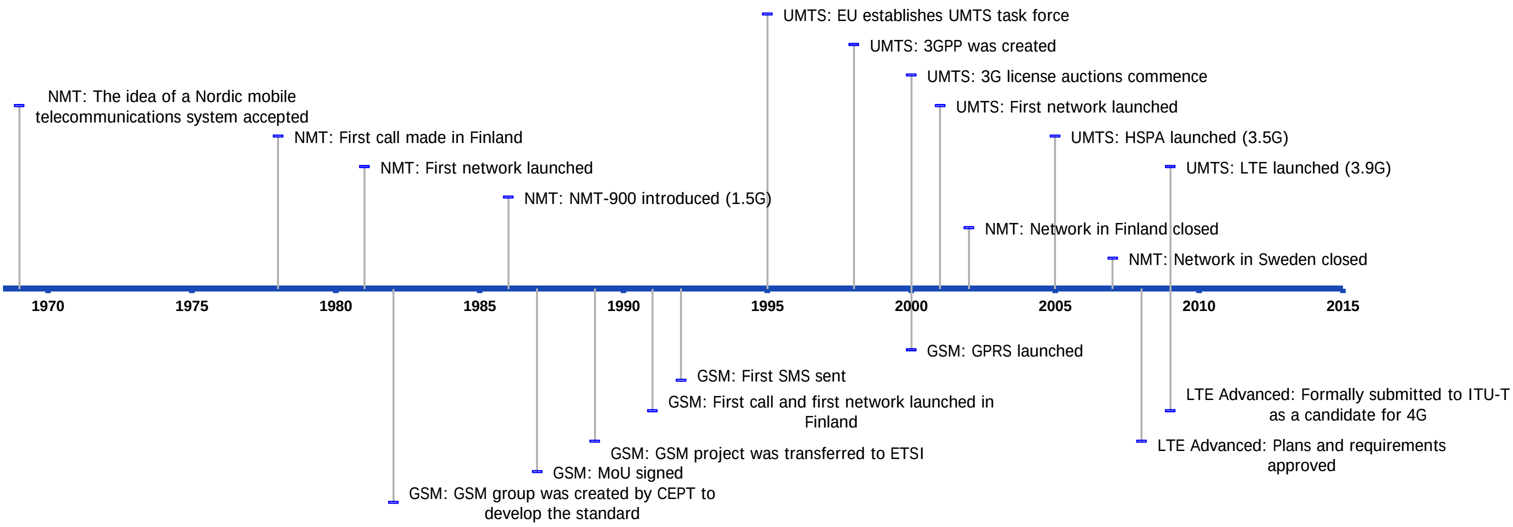



**Figure 3: Timeline of four generations of mobile telecommunications**

## 3.1 1st generation: NMT

The development of analog mobile communication technologies in the Nordic countries in the 1960s through the 1980s is a successful case of international collaboration among national telecom operators and a family of related companies. This quasi-integrated corporate innovation system consisted of system operators (incumbent service distributors), suppliers of terminals and base stations, distributors/retail dealers (of terminals), and users (such as public authorities and private users). The development was neither administered within a large, integrated firm, nor did it emerge as a result of pure, competitive market forces. More precisely, innovation was open within the innovation system or "club"—i.e. among the Nordic operators and their affiliates—but not with outsiders. This "semi-open" innovation process combined open and closed innovation activities relative to boundaries at lower and higher inter-organizational levels.

The actors together had sufficient capabilities within development and technology transfer across several key technologies, especially radio technology and switching technology. The geographical and cultural proximity between the Nordic operators and suppliers facilitated such technology transfer. In order to govern the required knowledge sharing among relevant actors, a special “working group” was established as a center or hub for idea formation, implementation and coordination in the network of actors. It was a deliberate policy to promote supplier cooperation and operator adoption of the NMT system through wide and open communication as well as avoidance of patenting, to keep obstacles for diffusion low, at the same time as the domestic markets were protected by monopolies. The NMT group thus promoted high resource distribution (within the group), a low level of formal governance, and high accessibility of technologies. The idea was that widespread adoption would lead to increased demand for systems equipment, which through economies of scale in turn would lead to lower costs, benefiting everyone. One result was that very little in NMT became covered by patents, despite the fact that much specification and R&D work was patentable, also because the established telephone industry structure of the 1970s and 1980s favored national suppliers with protected output markets.

Thus, in order to promote technology transfer in NMT, which was characterized by a moderate degree of resource distribution, the relevant actors implemented informal governance and high accessibility of technological resources. In addition, there were features of a multi-layered actor network, with the NMT working group in the center. However, as described above, the working group did not utilize formal governance in order to appropriate returns from the technological developments, but rather relied upon benefits from low resource control and high accessibility for outsiders through a combination of high diffusion rates, economies of scale, and market protection. This was about to change, however, due to market liberalization as well as strategies of new entrants.

### 3.2 2nd generation: GSM

The analog 1G market in Europe grew rapidly in the 1980s, but with different systems throughout the European countries there were limited possibilities for roaming (the Nordic countries being an exception with the joint NMT standard). As a next step, the European Conference of Postal and Telecommunications Administrations (CEPT) decided to create a pan-European digital 2G mobile phone standard, which enabled a joint standard and increased economies of scale in equipment production (Besen, 1990; Gandal et al., 2003). Later, the uniform de jure standard in Europe also implied a significantly faster diffusion for 2G than in the US (Fuentelsaz et al., 2008). In 1987, the national operators in CEPT agreed upon using the Global System for Mobile Communications (GSM) in a memorandum of understanding (MoU). The creation of the European Telecommunications Standards Institute (ETSI) by the European Commission in 1988 was followed by a transfer of the GSM standard efforts from CEPT to ETSI in 1989 (Bohlin, 1995; Gandal et al., 2003; Lindmark, 2002).

This development implied an increased number of resource holders (increased resource distribution) as more actors and technologies became involved. However, a lax IPR mentality—inherited from 1G—initially remained among the European national service providers and equipment suppliers. A kind of club mentality had developed in the telecom community in Europe, with a gentleman's agreement to be generous to each other when it came to patents (Granstrand, 1999), relying upon informal governance and implicit contracting. The situation changed drastically in the late 1980s when Motorola—a newcomer on the European scene—started to use formal governance (in the form of patents) aggressively against the GSM group. Reasons for Motorola's IPR strategy include the generally higher awareness of IPRs among US firms compared to European ones (Hall and Ziedonis, 2001), especially in the early development of GSM (Bekkers et al., 2002b). Motorola also had a larger focus on license revenues than its European competitors, both since domestic suppliers were preferred on the European market and since Motorola had no digital switching systems from which continuous sales could be generated (Iversen, 1999).

Eventually, Motorola entered into cross-licensing agreements with a limited number of selected parties, including Alcatel, Ericsson, Nokia, and Siemens (Bekkers et al., 2002b). For companies with no essential or other patents to trade, licensing costs became a high barrier to entry (Bekkers and West, 2009; West, 2006)—Bekkers et al. (2002a) report royalty fees of 29% of the costs of a GSM handset—indicating a very low accessibility of essential technologies for outsiders. A consequence was more IPR awareness and activity in (European) telecommunications, leading to a much more formal governance. Thus, despite an increase in technological resource distribution, in terms of number of resource holders (as illustrated by the number of firms with essential patents in Table 1), this development in some sense led to the closing of a previously open IP regime through more explicit contracting and formal governance. This is exemplified by the increasing focus on (essential) patenting, while the licensing agreements and royalty rates implied a more limited access for external actors to relevant technological resources in the innovation system. In the early 1990s, the GSM system involved over 2,000 patents, of which about 30 were standard blocking patents (Granstrand, 1999), which rose to 140 by 2000 (Bekkers et al., 2002b), see also Table 1.

### 3.3 3rd generation: UMTS

The GSM standard became a major success with widespread diffusion worldwide. Not surprisingly, the European strategy for the third generation (3G) of mobile communication systems—which was to support a wider range of applications—followed a similar path as for 2G, including a uniform standard and the same frequency band throughout the Euro-area (Fuentelsaz et al., 2008). ETSI selected UMTS, a combination of W-CDMA and TD/CDMA, for 3G, after essentially compromising between Nokia and Ericsson's W-CDMA and Alcatel and Siemens's TD/CDMA (Bekkers and West, 2009).

Some learning how to handle IP issues in modern standardization work had taken place among standardization bodies, and companies had also learnt how to use IPR more strategically in standardization, and the number of patents continued to increase (see Table 1). An IPR policy had been established in the European telecom standardization body ETSI, requiring that in order to be included in standards, the patents should be licensable on fair, reasonable and non-discriminatory (FRAND) terms, a policy first proposed in 1994. This is an example of how institutions (such as ETSI and FRAND) can be explicitly or implicitly formed to mitigate transaction costs (North, 1990) and thereby promote some form of openness. However, the FRAND terms set no cap on royalty rates, thus leaving important residual rights (Hart, 1995) controlled by the patent holders. The actual access to the distributed technological resources therefore remained limited and highly dependent on individual patent holders.

**Table 1: Essential patents in mobile telecommunications standards [a)]**

| | NMT | GSM late [b)] | WCDMA early [c)] | WCDMA middle [d)] | WCDMA late [e)] | LTE early [f)] |
|---|---|---|---|---|---|---|
| Reported essential patent families [g)] | None/Few | 561 | 732 | 1425 | 1884 | 211 |
| Evaluated essential patent families [g)] | None/Few | 158 | 157 | 358 | 526 | 105 |
| Over-reporting | N/A | 255% | 366% | 298% | 258% | 101% |
| Number of firms with reported essential patents | None/Few | 45 [h)] | 47 [h)] | 50 | 58 | 14 |
| Number of firms with evaluated essential patents | None/Few | 19 | 18 | 18 | 36 | 13 |
| Herfindahl index of reported essential patents, H | N/A | 0,181 | 0,200 | 0,161 | 0,127 | 0,276 |
| Normalized Herfindahl index, H* | N/A | 0,163 | 0,182 | 0,144 | 0,111 | 0,220 |
| Herfindahl index of evaluated essential patents, H | N/A | 0,240 | 0,161 | 0,161 | 0,132 | 0,330 |
| Normalized Herfindahl index, H* | N/A | 0,198 | 0,097 | 0,112 | 0,108 | 0,274 |

Notes:
a) Based on data available in reports from Fairfield Resources International.
b) Study based on patents reported to ETSI as of June 6, 2007.
c) Study based on patents reported to ETSI as of beginning of 2004.
d) Study based on patents reported to ETSI as of January 1, 2006.
e) Study based on patents reported to ETSI as of December 31, 2008.
f) Study based on patents reported to ETSI as of June 30, 2009.
g) Note the difference between a patent family, which includes multiple patents in various countries for the same invention, and a single patent.
h) Assumptions based on available data. The Herfindahl indices are not sensitive to these assumptions.

As ETSI decided to opt for the UMTS standard throughout Europe, the Qualcomm and CDMA2000 camp (with a competing 3G standard following their cdmaOne 2G standard) realized that there was a great risk that UMTS—designed to be backward-compatible with GSM—would become the dominant worldwide 3G standard. Qualcomm then tried to influence ETSI to modify UMTS to make it backward-compatible with its cdmaOne 2G standard, also simplifying the development of components supporting both UMTS and CDMA2000 (Bekkers and West, 2009). Relying on their essential patents (see Table 2), it essentially threatened to otherwise block UMTS with their CDMA patents and asked for roughly 5% of sales in royalty fees from all UMTS equipment manufacturers.

**Table 2: Top five evaluated essential patent family holders (patent shares within parentheses)**

| GSM late | WCDMA early | WCDMA middle | WCDMA late | LTE early |
|---|---|---|---|---|
| Nokia: 67 (42.4%) | Nokia: 40 (25.5%) | Nokia: 103 (28.8%) | Nokia: 138 (26.2%) | Nokia: 57 (54.3%) |
| Ericsson: 31 (19.6%) | Ericsson: 34 (21.7%) | Ericsson: 83 (23.2%) | Ericsson: 99 (18.8%) | Ericsson: 14 (13.3%) |
| Motorola: 19 (12.0%) | Qualcomm: 30 (19.1%) | Qualcomm: 44 (12.3%) | Qualcomm: 53 (10.1%) | Qualcomm: 8 (7.6%) |
| Siemens: 9 (5.7%) | Motorola: 11 (7.0%) | Siemens: 18 (5.0%) | Huawei: 51 (9.7%) | Sony: 8 (7.6%) |
| BT: 5 (3.2%) | Siemens: 8 (5.1%) | Interdigital: 15 (4.2%) | Siemens: 26 (4.9%) | Nortel: 7 (6.7%) |

Then, the main European companies (notably Ericsson) essentially threatened to block CDMA2000 in the US, unless there was reciprocity in licensing, and Ericsson started to plan US litigations. Thus, Ericsson's stake of patents related to CDMA2000 was central here as a means for a defensive retaliation strategy (see e.g. Somaya, 2012). The industry seemed to be deadlocked by a conflict that could not be resolved until Ericsson and Qualcomm negotiated a solution behind the scenes. On March 25, 1999, the two companies announced an agreement that included Ericsson acquiring Qualcomm's systems division and associated R&D operations. By doing so, Ericsson gained access to Qualcomm's cdmaOne competence and—perhaps more importantly—its IPR portfolio. This arguably also led to Qualcomm becoming more proactively involved in the UMTS group of standardization.

As in the case of GSM, a few companies with aggressive IP strategies and licensing policies jeopardized the IP-vulnerable UMTS standardization process, exemplifying the tragedy of the anti-commons (Heller, 1998) and the patent/IP assembly problem (Granstrand, 1999). However, in the case of UMTS, the established group was not as vulnerable to outside impact as in GSM, due to their relatively well-controlled technological resources in terms of formal governance through patents. It is also noteworthy that the solution to the patent deadlock was a form of open innovation, namely Ericsson's acquisition of Qualcomm's systems business and technology, a form of integration that would also be suggested by property rights theory as a solution to hold-up problems (Demsetz, 1967; Hart, 1995).

### 3.4 4th generation: LTE Advanced

Long Term Evolution (LTE) was suggested in 2004 by NTT DoCoMo to succeed GSM and UMTS as a fourth generation standard. Although LTE is commonly called 3.9G, e.g. due to too low download rates, it is closely related to its successor LTE Advanced, which is a true 4G standard.[4] At this point, the standardization work was well established, and patents had become the natural mechanism of governance in the innovation system.

[4] Thus, LTE could be viewed as a so-called gap filler technology, temporarily filling a time gap on the market in a shift between two major generations. Previous generations also had gap filler technologies, e.g. GSM Edge and NMT-900.

With increasing focus on multimedia and data transfer, and decreasing focus on pure voice transfer, the telecom industry was since long converging with the computer industry, from which an alternative standard, WiMAX, was being developed by Intel, Cisco and others. Once again new players, this time from the computer industry, seemed to impact the established group of firms working with GSM/UMTS/LTE, albeit in a different way than previously. Several WiMAX companies agreed to create a patent pool—the Open Patent Alliance—to give access to WiMAX-related patent licenses at limited and predictable cost. However, Ericsson and other firms in the GSM/UMTS/LTE group raised concerns about the fact that the WiMAX group wanted to create a communication standard from which little revenues were generated to innovators in the telecommunications field while at the same time enabling income in other areas due to dominant positions in for example processor technologies (Brismark and Alfalahi, 2008). Hence, the strategy of the new competitors was this time not related to blocking power, but rather consisted of high accessibility to their communication technologies on the one hand, and strict control of important complementary assets in order to generate revenues on the other hand. However, Ericsson clearly stated that it would not give away its WiMAX-related patents and licenses for free to the WiMAX group (Brismark and Alfalahi, 2008).

At the same time, the LTE group tried to increase the accessibility of its technologies, by suggesting caps to total royalty rates, as for example expressed by Ericsson, Nokia, and Alcatel-Lucent agreeing upon a single-digit maximum aggregate royalty rate for LTE. However, statements of royalty rates required from individual firms, as summarized by Stasik (2010), aggregated to far more than 10%, again indicating the difficulties with setting cap royalties in standards with multiple patent holders, inhibiting accessibility for outsiders. The accessibility problems for outsiders are exemplified by Research In Motion's (RIM) acquisition of at least 66 patents from Ericsson in 2008 for an estimated price of $172M (Stasik, 2010). Stasik argues that this is the price RIM had to pay for being able to compete in the wireless industry, since the patents would enable improved possibilities for cross-licensing—without affecting Ericsson's bargaining position that much (due to its vast amount of patents in the field). Nevertheless, the LTE group aimed to improve accessibility in the fourth generation, while at the same time keeping a strict formal governance of resources, and the major vehicle among the major LTE players was (as of 2012) bilateral agreements rather than (common) patent pooling.

# 4 Discussion

The illustration presents a longitudinal case of the applicability of the conceptual framework and the distinct dimensions of innovation openness, namely resource distribution, technology governance, and technology accessibility (see Figure 4). The case also illustrates dynamics in all three dimensions of the innovation openness framework (cf. Baldwin et al., 2006; Christensen et al., 2005). The set of holders of relevant resources for the innovation processes, or at least the invention activities, shifted over different generations. If essential patents are taken as a proxy for invention process resources, Tables 1 and 2 give some quantitative indication of the resource distribution and its dynamics. Most notably, the number of invention resource holders increased from NMT to GSM and subsequently to

UMTS (WCDMA). Then, from UMTS to LTE, it decreased, at least initially (Table 1). Similarly, the concentration decreased in the shift from GSM to UMTS, after which it increased in the shift to LTE.

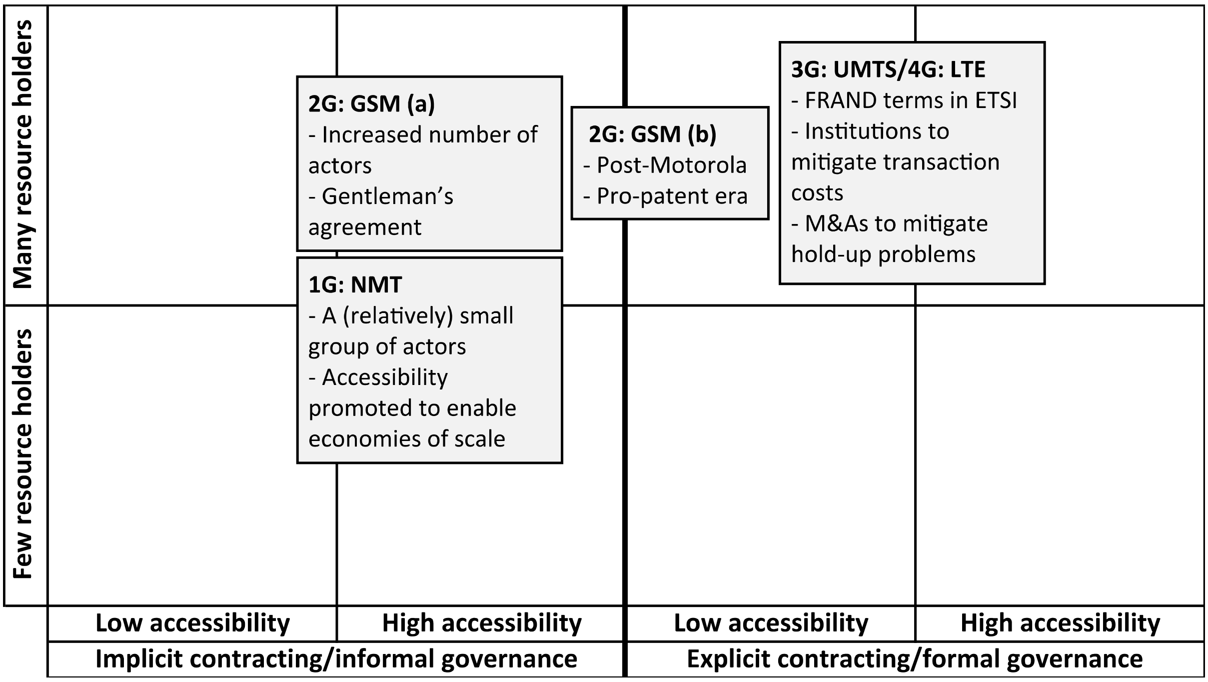



**Figure 4: Innovation openness in the case of mobile telecommunications**

The case also illustrates a shift from informal to formal governance of the innovation system—cf. Ostrom's (1990) robust, fragile and failed institutions. The NMT and early GSM innovation system, informally governed by a gentlemen's agreement among involved actors, can then be described as a fragile institution. Although informal governance might have been a Pareto optimal solution (in a strategy game with formal/informal governance as the strategy variable), possibly due to lower costs, all players adopting formal governance by patenting may be a (perhaps non-Pareto optimal) move to a Nash equilibrium, thus resulting in an irreversible strategy shift as soon as one actor starts using patents aggressively. Aggressive IPR strategies of others are typically difficult to fight back with anything else than own IPRs to enable retaliatory power. Especially innovation systems that are developing cumulative innovations while relying upon no or informal governance of technologies and innovations are therefore vulnerable to strategy shifts or entrants of new players, as illustrated by the case.

Over the years, changes also occurred regarding the accessibility of the technologies invented in the innovation system. For NMT, accessibility was intentionally high, in order to promote diffusion and economies of scale, while for GSM accessibility was limited in connection with the shift in governance strategies. As described above, however, there were continuous efforts to increase accessibility by capping total royalty rates.

## 4.1 Implications for research

We believe our framework has a number of important implications for future research. First, a static and one-dimensional perspective of innovation openness is overly simplistic. Openness corresponds to a degree of organizational disintegration or quasi-integration, which could change over time, as illustrated by the case. Our conceptual framework also illustrates that there are multiple dimensions of innovation openness and outlines three of the most important dimensions for researchers to consider in their studies. Various perspectives of innovation openness as described in this paper are then complements rather than substitutes. Our framework is then useful for guiding future conceptual and empirical work, both qualitative and quantitative and gives a reference point and definition to enable cross-fertilization across currently separate concepualizations. A particularly promising area for future research is the co-evolution of multiple dimensions (cf. Jacobides and Winter, 2005).

Second, there are multiple aspects of each dimension. For example, resource distribution can be characterized by few or many involved actors and by a specialized or collective distribution. Similarly, technology governance can relate to the extent to which innovations are patented (patent propensity) (Arundel and Kabla, 1998; Mansfield, 1986; Scherer, 1965, 1983), while it can also relate to the use of copyrights and the use of formal agreements and contracts (e.g. licenses) in between different parties in the innovation system.

Third, the concept of innovation openness is largely dependent on the level of analysis in terms of boundaries (cf. West et al., 2006). Boundaries are central to the concept of innovation openness. Resource distribution relates to the distribution over different actors separated by boundaries, technology accessibility relates to the permeability of the boundaries in terms of how easily or cheaply outsiders can access the innovations, and technology governance relates to how one or multiple agents control an innovation within or across boundaries, basically setting the rules for the boundaries. Such boundaries then exist on different levels, such as individual, team, business unit, firm, partnership, industry, region, nation, etc., implying some type of innovation system (e.g. corporate, regional, sectorial, national) (cf. Breschi and Lissoni, 2001; Nelson, 1993; Pavitt, 1984). Additionally, boundaries on one level can be open in some sense, while more peripheral boundaries can be closed, as exemplified by the post-Motorola situation in GSM, with a core of actors adopting cross-licensing of technologies, while outsiders had limited access. More general examples of this are closed technological consortia or closed patent pools—not uncommon in standardization processes of technological systems (Bekkers et al., 2002a; Bekkers and West, 2009). Thus, while a core group of innovation collaborators might apply a high degree of inter-core openness, the boundary between the core and outsiders might be closed.

Fourth, the concept of openness, and especially the dimension of resource distribution, not only depends on the boundary level but also on the level of the innovation. Looking for example at the smallest inventive step in an innovation process, this step is the result of the thought process of one or possibly a few human individuals, supported by other resources (e.g. research labs). Such small inventive steps can then be combined with other inventions, possibly invented by others, to create “larger” innovations, technologies, or technological systems in a predominantly cumulative way (cf. Murray and O'Mahony, 2007), although also involving technological substitutions (or “invent-arounds”). Thus, the resource distribution depends on the innovation level under study. For one specific patented invention, the resource distribution could be operationalized by the number of inventors (in different organizations), while for a larger technological system, it can be operationalized by the ownership distribution of the involved patents. In the latter case, each individual patented invention could be characterized as closed (in terms of resource distribution) if it is invented by one single individual using resources within one single firm, while at the same time the technological system at large could be characterized as open if multiple individuals in multiple firms all contribute with different inventions to the larger technological system.

### 4.2 Implications for practice

The framework of innovation openness challenges strategic thinking related to innovation openness in a number of ways. Innovation-based firms must position themselves in terms of openness as part of the business model, taking into consideration how external forces such as competitors and technological shifts might impact this position. Our framework then acts as guidance for what dimensions to consider when designing the innovation setup.

First, managers need to consider which invention and commercialization resources to keep in-house or acquire and which resources to access from outside (and possibly which resources to divest). If a firm benefits from economies of scale (e.g. due to large investments in R&D labs and equipment), a specialized distribution could be conducive to success. The resource distribution can then be limited either vertically, e.g. by focusing solely on invention or commercialization processes, or horizontally, e.g. by focusing on a narrow area of technologies and related products/services. In contrast, integrated invention processes do entail in-house learning in R&D, production and marketing, while these may also facilitate external learning through absorptive capacity (Bogers and Lhuillery, 2011; Cohen and Levinthal, 1990). As such, behaviors and policies related to “not invented here” or “not sold here” should be considered (cf. Katz and Allen, 1982; Tranekjer and Knudsen, 2012). In terms of horizontal integration, firms moreover benefit from cross-fertilization of technologies and economies of scope (Granstrand et al., 1997). Depending on the resource distribution, firms may thus need to adopt various technology acquisition and/or exploitation strategies (Arora et al., 2001; Chesbrough et al., 2006; Granstrand and Sjölander, 1990).

Second, managers need to consider how accessible the innovative output should be for non-innovators. For example, if the business model emphasizes direct appropriation of innovative product sales and out-licensing, accessibility should typically be low in order to enable higher prices and margins (cf. Chesbrough, 2010; Teece, 2010). Instead, if it emphasizes the development of systems of cumulative innovations, accessibility could be kept high in order to improve the attractiveness of the innovation system for an increasing amount of technology contributors. It is then important to consider strategy combinations, for example by promoting high accessibility to one technological area, while keeping a proprietary position in necessary supplies—a strategy that Ericsson “accused” the WiMAX group of adopting, as described in the case.

Third, managers need to consider how to control the innovation output. It is likely that, especially if differentiating the accessibility over different layers of boundaries, the use of formal governance through IPRs is more stable than informal governance when the agents are heterogeneous in terms of cultural norms, beliefs, resources, and strategies (as the case illustrates). Furthermore, accessibility is intertwined with the governance of technologies, as for example the FRAND licensing terms, which partly govern the innovative output, are designed to enable accessibility and avoid hold-up problems. Similarly, in open source software, formal governance through the GPL was created by Richard Stallman in order to ensure accessibility to source code (DiBona et al., 1999; Lerner and Tirole, 2002; O'Mahony, 2003). Thus, the use of different IPRs is by no means exclusively feasible for those aiming to limit accessibility to directly appropriate returns from out-licensing and product sales. Proper use of IPRs can be just as important in order to enable and ensure accessibility. Thus, IPRs play an important role in innovation openness, as one out of several vehicles for governance (cf. Arora et al., 2001; Chesbrough, 2003; von Hippel and von Krogh, 2003).

Fourth, managers need to consider how outside actor can impact the open innovation setup. Let us assume that one inventor applies informal governance and high accessibility of its inventions (cell 6 in Figure 2). If requirements of complementary resources are low in order to appropriate returns from the inventions, this would lead to other actors joining in order to commercialize the invention (moving to cell 2). An informally governed innovation system with resources distributed across many actors and high accessibility of technologies (cell 2) is however likely fragile (unstable) and vulnerable to strategy shifts among inside as well as outside actors, as described above. An actor who sees the (short term) opportunity to appropriate returns through the aggressive use of IPRs and hold-ups is then likely forcing the other actors to also move over to formal governance (to cell 3 or 4) in order to create retaliatory power (Granstrand, 1999, 2006; Hall and Ziedonis, 2001), at least in cases of cumulative and complex systems technologies. It is then probable that a shift to formal governance and low accessibility (cell 3) would lead to further hold-up problems and transaction costs, in turn leading to some level of integration and consolidation (leading to fewer resource holders) to mitigate these according to property rights theory (Demsetz, 1967)—as also exemplified by our case with Ericsson's acquisition of Qualcomm's systems division. If the shift would instead be made to formal governance and high accessibility (cell 4), this is likely to be more stable than the initial position (cell 6), at least if the high accessibility feature is included in the explicit contracts, as in the case of many open source licenses.

To summarize, a prescription for firms to strive towards "open innovation" is not relevant. Managers need to evaluate in what sense their firm can benefit from innovation openness and actively align innovation setups accordingly. IP management is then crucial in open innovation, if not due to the need for formal governance in the focal innovation system, then due to potential impact from outside. As exemplified by the case, strategies of external actors can and do impact the successfulness of the focal innovation setup. It is also important to remember that most firms are probably already "open" in some sense, be it consciously or not, and some might therefore realize that they need to decrease openness. Nevertheless, conscious management of innovation openness, be it directed towards openness or closeness, should be an integral part of the strategy of any innovation-based business.

# 5 Conclusions

The practice and research in the area of innovation has increasingly emphasized the importance of more openness in innovation processes and activities. Extant literature has identified a variety of such mechanisms, such as the sourcing of external knowledge, the use of external commercialization paths, and co-creation through alliances, networks or ecosystems (cf. Adner and Kapoor, 2010; Baldwin and von Hippel, 2011; Dittrich and Duysters, 2007; Enkel et al., 2009). Despite, or possibly due to, an increasing amount of research related to innovation openness, the available definitions, conceptualizations and operationalizations are typically compatible only with a particular part of available theory and practice of innovation openness. The purpose of this paper was therefore to develop a general conceptual framework for describing and analyzing innovation openness, based on theoretical perspective related to resources and capabilities (Penrose, 1959; Richardson, 1972), transactions and contracts (Coase, 1960; Ostrom, 1990), and (intellectual) property rights (Demsetz, 1967; Foss and Foss, 2005; Granstrand, 1999). These perspectives offer the conceptual logic to connect the three main dimensions that comprise our framework: (1) *Resource distribution* refers to the distribution among resource holders of resources rendering innovation activities; (2) *Technology governance* refers to whether the focal innovation system relies upon explicit or implicit contracting (formal or informal governance); (3) Accessibility refers to the access to the invented technology for different agents, and their possibilities to access, use, and gain from it.

We moreover presented an illustrative empirical case, which describes four generations of mobile telecommunication technologies/standards, to highlight the applicability of the framework. Besides showing the relevance of the dimensions in the framework per se, the case particularly illustrates the dynamics and multi-layered nature of innovation openness. Innovation openness can thus be characterized by different types and layers of boundaries. Such boundaries exist between both competing and non-competing agents, and such agents can refer to individuals, firms, groups of firms, or other actors. Therefore, depending on one’s focus, most innovation processes can probably be characterized as both open and closed in some sense. Thus, a general prescription to strive towards becoming “more open” is hardly relevant. Instead, firms should try to evaluate what type of openness—in terms of resource distribution, governance and accessibility—is most conducive to reaching its objectives.

These results imply that firms adjust their open innovation activities dynamically according to the value they can create and appropriate, both individually and as a group of co-opetitors (Afuah, 2000; Cassiman et al., 2009; Teece, 2010). This holds important implications for the strategic management of innovation, given that the ultimate performance will depend on the complex interaction of who owns relevant resources, how they are governed, and what access opportunities exists, all within a modular architecture of resource rights and ownership (Chesbrough and Prencipe, 2008; Langlois and Robertson, 1992). In managing innovation openness, there may therefore not be a single best strategy, and firms may need to experiment with different ownership structure and governance modes, especially within the context of their IPR strategy (Chesbrough, 2010; Granstrand, 1999).

## References

Adner, R., Kapoor, R. 2010. Value creation in innovation ecosystems: How the structure of technological interdependence affects firm performance in new technology generations. Strategic Management Journal 31(3), 306-333.

Afuah, A. 2000. How much do your 'co-opetitors" capabilities matter in the face of technological change? Strategic Management Journal 21(3), 387-404.

Afuah, A., Tucci, C.L. 2012. Crowdsourcing as a solution to distant search. Academy of Management Review 37(3), 355-375.

Arora, A., Fosfuri, A., Gambardella, A. 2001. Markets for Technology: The Economics of Innovation and Corporate Strategy. MIT Press, Cambridge, MA.

Arrow, K.J. 1962. Economic welfare and the allocation of resources for invention. in: National Bureau of Economic Research (Ed), The Rate and Direction of Inventive Activity: Economic and Social Factors. Princeton University Press, Princeton, NJ, pp. 609-625.

Arundel, A., Kabla, I. 1998. What percentage of innovations are patented? Empirical estimates for European firms. Research Policy 27(2), 127-141.

Baldwin, C.Y., Hienerth, C., von Hippel, E. 2006. How user innovations become commercial products: A theoretical investigation and case study. Research Policy 35(9), 1291-1313.

Baldwin, C.Y., von Hippel, E. 2011. Modeling a paradigm shift: From producer innovation to user and open collaborative innovation. Organization Science 22(6), 1399-1417.

Bekkers, R., Duysters, G., Verspagen, B. 2002a. Intellectual property rights, strategic technology agreements and market structure: The case of GSM. Research Policy 31(7), 1141-1161.

Bekkers, R., Verspagen, B., Smits, J. 2002b. Intellectual property rights and standardization: The case of GSM. Telecommunications Policy 26(3-4), 171-188.

Bekkers, R., West, J. 2009. The limits to IPR standardization policies as evidenced by strategic patenting in UMTS. Telecommunications Policy 33(1-2), 80-97.

Besen, S.M. 1990. The European Telecommunications Standards Institute: A preliminary analysis. Telecommunications Policy 14(6), 521-530.

Bogers, M., Lhuillery, S. 2011. A functional perspective on learning and innovation: Investigating the organization of absorptive capacity. Industry and Innovation 18(6), 581-610.

Bohlin, E. 1995. Economics and Management of Investments: An International Investigation of New Technology Decision-Making in Telecommunications. Unpublished doctoral thesis. Gothenburg: Chalmers University of Technology.

Bohlin, E., Granstrand, O. 1991. Strategic options for national monopolies in transition: The case of Swedish telecom. Telecommunications Policy 15(5), 453-476.

Breschi, S., Lissoni, F. 2001. Knowledge spillovers and local innovation systems: A critical survey. Industrial and Corporate Change 10(4), 975-1005.

Brismark, G., Alfalahi, K. 2008. Patent strategies: A fork in the road toward 4G. Ericsson Business Review, 62-65.

Burns, T., Stalker, G.M. 1961. The Management of Innovation. Tavistock, London.

Cassiman, B., Di Guardo, M.C., Valentini, G. 2009. Organising R&D projects to profit from innovation: Insights from co-opetition. Long Range Planning 42(2), 216-233.

Cassiman, B., Veugelers, R. 2006. In search of complementarity in innovation strategy: Internal R&D and external knowledge acquisition. Management Science 52(1), 68-82.

Chesbrough, H.W. 2003. Open Innovation: The New Imperative for Creating and Profiting from Technology. Harvard Business School Press, Boston, MA.

Chesbrough, H.W. 2010. Business model innovation: Opportunities and barriers. Long Range Planning 43(2-3), 354-363.

Chesbrough, H.W., Prencipe, A. 2008. Networks of innovation and modularity: A dynamic perspective. International Journal of Technology Management 42(4), 414-425.

Chesbrough, H.W., Vanhaverbeke, W., West, J. (Eds), 2006. Open Innovation: Researching a New Paradigm, Oxford: Oxford University Press.

Christensen, J.F., Olesen, M.H., Kjær, J.S. 2005. The industrial dynamics of open innovation: Evidence from the transformation of consumer electronics. Research Policy 34(10), 1533-1549.

Coase, R.H. 1937. The nature of the firm. Economica 4(16), 386-405.

Coase, R.H. 1960. The problem of social cost. Journal of Law and Economics 3, 1-44.

Cohen, W.M., Levinthal, D.A. 1990. Absorptive capacity: A new perspective on learning and innovation. Administrative Science Quarterly 35(1), 128-152.

Dahlander, L., Gann, D.M. 2010. How open is innovation? Research Policy 39(6), 699-709.

Demsetz, H. 1967. Toward a theory of property rights. American Economic Review 57(2), 347-359.

Di Minin, A., Bianchi, M. 2011. Safe nests in global nets: Internationalization and appropriability of R&D in wireless telecom. Journal of International Business Studies 42(7), 910-934.

DiBona, C., Ockman, S., Stone, M. (Eds), 1999. Open Sources: Voices from the Open Source Revolution, Sebastopol, CA: O'Reilly Media.

Dittrich, K., Duysters, G. 2007. Networking as a means to strategy change: The case of open innovation in mobile telephony. Journal of Product Innovation Management 24(6), 510-521.

Eggertsson, T. 1990. Economic Behavior and Institutions: Principles of Neoinstitutional Economics. Cambridge University Press.

Enkel, E., Gassmann, O., Chesbrough, H.W. 2009. Open R&D and open innovation: Exploring the phenomenon. R&D Management 39(4), 311-316.

Faems, D., de Visser, M., Andries, P., van Looy, B. 2010. Technology alliance portfolios and financial performance: Value-enhancing and cost-increasing effects of open innovation. Journal of Product Innovation Management 27(6), 785-796.

Fairfield Resources International 2007. Analysis of patents declared as essential to GSM as of June 6, 2007. Published December 31, 2007. Available at http://www.frlicense.com/GSM_FINAL.pdf.

Fairfield Resources International 2009. Review of patents declared as essential to WCDMA through December, 2008. Published January 6, 2009. Available at http://www.frlicense.com/wcdma1.pdf.

Fairfield Resources International 2010. Review of patents declared as essential to LTE and SAE (4G Wireless Standards) through June 30, 2009. Published January 6, 2010. Available at http://www.frlicense.com/LTE Final Report.pdf.

Foss, K., Foss, N.J. 2005. Resources and transaction costs: How property rights economics furthers the resource-based view. Strategic Management Journal 26(6), 541-553.

Freeman, C. 1982. The Economics of Industrial Innovation (2nd ed.). MIT Press, Cambridge, MA.

Frey, K., Lüthje, C., Haag, S. 2011. Whom should firms attract to open innovation platforms? The role of knowledge diversity and motivation. Long Range Planning 44(5–6), 397-420.

Fuentelsaz, L., Maícas, J.P., Polo, Y. 2008. The evolution of mobile communications in Europe: The transition from the second to the third generation. Telecommunications Policy 32(6), 436-449.

Gandal, N., Salant, D., Waverman, L. 2003. Standards in wireless telephone networks. Telecommunications Policy 27(5–6), 325-332.

Goldstein, L.M., Kearsey, B.N. 2004. Technology Patent Licensing: An International Reference on 21st Century Patent Licensing, Patent Pools and Patent Platforms. Aspatore Books, Boston, MA.

Goodman, D.J., Myers, R.A. 2005. 3G cellular standards and patents. IEEE WirelessCom 2005.

Grand, S., von Krogh, G., Leonard, D., Swap, W. 2004. Resource allocation beyond firm boundaries: A multi-level model for open source innovation. Long Range Planning 37(6), 591-610.

Granstrand, O. 1982. Technology, Management and Markets: An Investigation of R&D and Innovation in Industrial Organizations. London.

Granstrand, O. 1999. The Economics and Management of Intellectual Property: Towards Intellectual Capitalism. Edward Elgar Publishing, Cheltenham.

Granstrand, O. 2006. Intellectual property rights for governance in and of innovation systems. in: Andersen, B. (Ed), Intellectual Property Rights: Innovation, Governance and the Institutional Environment. Edward Elgar Publishing, Cheltenham, pp. 311-343.

Granstrand, O., Patel, P., Pavitt, K. 1997. Multi-technology corporations: Why they have 'distributed' rather than 'distinctive core' competences. California Management Review 39(4), 8-25.

Granstrand, O., Sjölander, S. 1990. Managing innovation in multi-technology corporations. Research Policy 19(1), 35-60.

Hall, B.H., Ziedonis, R.H. 2001. The patent paradox revisited: An empirical study of patenting in the U.S. semiconductor industry, 1979-1995. RAND Journal of Economics 32(1), 101-128.

Hargadon, A.B., Douglas, Y. 2001. When innovations meet institutions: Edison and the design of the electric light. Administrative Science Quarterly 46(3), 476-501.

Harhoff, D., Henkel, J., von Hippel, E. 2003. Profiting from voluntary information spillovers: How users benefit by freely revealing their innovations. Research Policy 32(10), 1753-1769.

Hart, O.D. 1995. Firms, Contracts, and Financial Structure. Clarendon Press, Oxford, UK.

Hayek, F.A. 1945. The use of knowledge in society. American Economic Review 35(4), 519-530.

Heller, M.A. 1998. The tragedy of the anticommons: Property in the transition from Marx to markets. Harvard Law Review 111(3), 621-688.

Henkel, J. 2006. Selective revealing in open innovation processes: The case of embedded Linux. Research Policy 35(7), 953-969.

Huizingh, E.K.R.E. 2011. Open innovation: State of the art and future perspectives. Technovation 31(1), 2-9.

Iversen, E.J. 1999. Standardisation and intellectual property rights: Conflicts between innovation and diffusion in new telecommunications systems. in: Jakobs, K. (Ed), Information Technology Standards and Standardization: A Global Perspective. Idea Group Publishing, Hershey, PA, pp. 80-101.

Jacobides, M.G., Winter, S.G. 2005. The co-evolution of capabilities and transaction costs: Explaining the institutional structure of production. Strategic Management Journal 26(5), 395-413.

Jeppesen, L.B., Frederiksen, L. 2006. Why do users contribute to firm-hosted user communities? The case of computer-controlled music instruments. Organization Science 17(1), 45-63.

Jeppesen, L.B., Lakhani, K.M. 2010. Marginality and problem solving effectiveness in broadcast search. Organization Science 21(4), 1016-1033.

Jick, T.D. 1979. Mixing qualitative and quantitative methods: Triangulation in action. Administrative Science Quarterly 24(4), 602-611.

Katz, R., Allen, T.J. 1982. Investigating the not invented here (NIH) syndrome: A look at the performance, tenure, and communication patterns of 50 R&D project groups. R&D Management 12(1), 7-19.

Klein, B., Crawford, R.G., Alchian, A.A. 1978. Vertical integration, appropriable rents, and the competitive contracting process. Journal of Law and Economics 21(2), 297-326.

Langley, A. 1999. Strategies for theorizing from process data. Academy of Management Review 24(4), 691-710.

Langlois, R.N., Robertson, P.L. 1992. Networks and innovation in a modular system: Lessons from the microcomputer and stereo component industries. Research Policy 21(4), 297-313.

Laursen, K., Salter, A. 2006. Open for innovation: The role of openness in explaining innovation performance among U.K. manufacturing firms. Strategic Management Journal 27(2), 131-150.

Lerner, J., Tirole, J. 2002. Some simple economics of open source. Journal of Industrial Economics 50(2), 197-234.

Levin, R.C., Klevorick, A.K., Nelson, R.R., Winter, S.G. 1987. Appropriating the returns from industrial research and development. Brookings Papers on Economic Activity 14(3), 783-831.

Lindmark, S. 2002. Evolution of Techno-Economic Systems: An Investigation of the History of Mobile Communications. Unpublished doctoral thesis. Gothenburg: Chalmers University of Technology.

Mansfield, E. 1986. Patents and innovation: An empirical study. Management Science 32(2), 173-181.

Murray, F., O'Mahony, S. 2007. Exploring the foundations of cumulative innovation: Implications for organization science. Organization Science 18(6), 1006-1021.

Nelson, R.R. (Ed), 1993. National Innovation Systems: A Comparative Study, Oxford: Oxford University Press.

North, D.C. 1990. Institutions, Institutional Change and Economic Performance. Cambridge University Press, Cambridge, UK.

O'Mahony, S. 2003. Guarding the commons: How community managed software projects protect their work. Research Policy 32(7), 1179-1198.

Ostrom, E. 1990. Governing the Commons: The Evolution of Institutions for Collective Action. Cambridge University Press, Cambridge, UK.

Ostrom, E. 1999. Coping with the tragedy of the commons. Annual Review of Political Science 2(1), 493-535.

Ostrom, E., Burger, J., Field, C.B., Norgaard, R.B., Policansky, D. 1999. Revisiting the commons: Local lessons, global challenges. Science 284(5412), 278-282.

Partha, D., David, P.A. 1994. Toward a new economics of science. Research Policy 23(5), 487-521.

Pavitt, K. 1984. Sectoral patterns of technical change: Towards a taxonomy and a theory. Research Policy 13(6), 343-373.

Penrose, E.T. 1959. The Theory of the Growth of the Firm. Basil Blackwell, Oxford.

Richardson, G.B. 1972. The organisation of industry. The Economic Journal 82(327), 883-896.

Rogers, E.M. 1995. Diffusion of Innovations (4th ed.). Free Press, New York, NY.

Scherer, F.M. 1965. Firm size, market structure, opportunity, and the output of patented inventions. American Economic Review 55(5), 1097-1125.

Scherer, F.M. 1983. The propensity to patent. International Journal of Industrial Organization 1(1), 107-128.

Schumpeter, J.A. 1934. The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle. Harvard University Press, Cambridge, MA.

Scotchmer, S. 2004. Innovation and Incentives. MIT Press, Cambridge, MA.

Somaya, D. 2012. Patent strategy and management. Journal of Management 38(4), 1084-1114.

Stasik, E. 2010. Royalty rates and licensing strategies for essential patents on LTE (4G) telecommunication standards. LES Nouvelles 45(3), 114-119.

Teece, D.J. 1986. Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. Research Policy 15(6), 285-305.

Teece, D.J. 2010. Business models, business strategy and innovation. Long Range Planning 43(2-3), 172-194.

Tranekjer, T.L., Knudsen, M.P. 2012. The (unknown) providers to other firms' new product development: What's in it for them? Journal of Product Innovation Management forthcoming, Published online on June 28, 2012, DOI: 10.1111/j.1540-5885.2012.00974.x.

van de Vrande, V., de Jong, J.P.J., Vanhaverbeke, W., de Rochemont, M. 2009. Open innovation in SMEs: Trends, motives and management challenges. Technovation 29(6-7), 423-437.

von Hippel, E. 1988. The Sources of Innovation. Oxford University Press, New York, NY.

von Hippel, E. 2005. Democratizing Innovation. MIT Press, Cambridge, MA.

von Hippel, E. 2007. Horizontal innovation networks--by and for users. Industrial and Corporate Change 16(2), 293-315.

von Hippel, E., Katz, R. 2002. Shifting innovation to users via toolkits. Management Science 48(7), 821-833.

von Hippel, E., von Krogh, G. 2003. Open source software and the 'private-collective' innovation model: Issues for organization science. Organization Science 14(2), 209-223.

von Krogh, G., Rossi-Lamastra, C., Haefliger, S. 2012. Phenomenon-based research in management and organisation science: When is it rigorous and does it matter? Long Range Planning In Press, Published online, June 14, 2012, DOI: 10.1016/j.lrp.2012.05.001.

West, J. 2003. How open is open enough? Melding proprietary and open source platform strategies. Research Policy 32(7), 1259-1285.

West, J. 2006. Does appropriability enable or retard open innovation? in: Chesbrough, H.W., Vanhaverbeke, W., West, J. (Eds), Open Innovation: Researching a New Paradigm. Oxford University Press, Oxford, pp. 109-133.

West, J., Gallagher, S. 2006. Challenges of open innovation: The paradox of firm investment in open-source software. R&D Management 36(3), 319-331.

West, J., Vanhaverbeke, W., Chesbrough, H.W. 2006. Open innovation: A research agenda. in: Chesbrough, H.W., Vanhaverbeke, W., West, J. (Eds), Open Innovation: Researching a New Paradigm. Oxford University Press, Oxford, pp. 285-307.

Williamson, O.E. 1985. The Economic Institutions of Capitalism: Firms, Markets, Relational Contracting. Free Press, New York, NY.

## Appendix: A note on methodology

The empirical base of the illustrative case includes secondary data from a wide range of sources, including research papers, journal articles, annual reports, press releases, etc., complemented with primary data from interviews and patent statistics (see below), in order to provide as much opportunities as possible for triangulation (Jick, 1979; Langley, 1999). The interviews are both recent and dating back three decades based on hundreds of interview as part of a number of large studies.

Patent data is useful for providing additional information regarding the industry evolution. The patents necessary for the use of a standard are commonly called essential patents.[5] However, it is far from clear how to define a patent as either essential or non-essential despite the increasing importance of such a distinction. Essential patents for the standards under study are currently self-reported by companies to for example ETSI. Due to essential patents being self-reported, there is a high degree of non-essential patents being included in the count of reported essential patents as a result of companies' incentives to promote their roles as important innovators and licensors and thereby over-report essential patents with the aim to increase royalty income and bargaining power (see Table 1). Hence, the number of *reported essential patents* must be distinguished from the number of patents that are objectively evaluated essential, where *evaluated essential patents* are fewer and a subset of the reported essential patents. In addition, to receive a measure of the number of patented inventions, we are interested in the number of patent families (one family includes patents in various nations for the same invention) rather than the number of patents.

While the reported essential patents can be found in the records of ETSI these must be objectively evaluated to receive the evaluated essential patents—see for example Goldstein and Kearsey (2004) for some guidelines regarding this process. This has been done in various studies among which some are publicly available, including studies by Fairfield Resources International on GSM (Fairfield Resources International, 2007), UMTS/WCDMA (Fairfield Resources International, 2009; Goodman and Myers, 2005) and LTE (Fairfield Resources International, 2010), who has also presented figures on patent families rather than patents. The data in these reports is therefore used here, and the distribution of essential patents over different actors is used to calculate the concentration of essential patents in the standards with the Herfindahl index:

$$H = \sum_{i=1}^{N} {s_i}^2 \in \left[\frac{1}{N}, 1\right]$$

[5] The European Telecommunications Standards Institute (ETSI), which is an official European standards organization, states that essential "as applied to IPR means that it is not possible on technical (but not commercial) grounds, taking into account normal technical practice and the state of the art generally available at the time of standardization, to make, sell, lease, otherwise dispose of, repair, use or operate EQUIPMENT or METHODS which comply with a STANDARD without infringing that IPR. For the avoidance of doubt in exceptional cases where a STANDARD can only be implemented by technical solutions, all of which are infringements of IPRs, all such IPRs shall be considered ESSENTIAL" (ETSI Directives Version 27, May 2010, p. 39).

with

$$s_i = \frac{n_i}{\sum_{j=1}^{N} n_j}$$

where

$$N = total\ number\ of\ firms\ with\ essential\ patents$$

$$n_i = number\ of\ essential\ patents\ held\ by\ firm\ i$$

The Herfindahl index can then be normalized:

$$H^* = \frac{H - 1/N}{1 - 1/N} \in [0,1]$$

The concentration in terms of $H$ and $H^*$ can be used as measures of the technological ownership distribution within the standard and thereby also as a crude proxy of the innovation resource distribution.[6] The number of patent holders is then also a useful measure of this distribution.

[6] The concentration lies between $1/N$ and 1 when using the Herfindahl index and between 0 and 1 when using the normalized index. A low concentration indicates that the patents are fairly evenly distributed over many patent holders that need to cooperate by somehow sharing their technologies (with e.g. cross-licensing agreements or patent pools). A high concentration indicates that there are a few firms holding the majority of the patents, and less boundary crossing transactions are needed.

# Paper V

# The 25% rule revisited and a new investment-based method for determining FRAND licensing royalties

Ove Granstrand[a) b)] and Marcus Holgersson[a) c)]

Published in les Nouvelles, use the following reference:

Granstrand, O. and Holgersson, M. (2012) 'The 25% rule revisited and a new investment-based method for determining FRAND licensing royalties', *les Nouvelles*, Vol. 47, No. 3, pp. 188-195.

[a)] Industrial Management and Economics Research Group
Department of Technology Management and Economics
Chalmers University of Technology
SE-412 96 Gothenburg, Sweden

[b)] E-mail: ovegra@chalmers.se
Phone: +46-31-772 1209

[c)] E-mail: marhol@chalmers.se
Phone: +46-31-772 5288

## Abstract

This paper starts with briefly discussing the 25% rule and the argumentation for and against it. The paper continues with developing a new investment-based method for determining FRAND licensing royalties, a method not only applicable to one-to-one bilateral licensing deals but also to multilateral deals with multiple license sellers and multiple license buyers. The paper ends with discussing limitations and generalizations, opening up for further research.

## 1 Introduction

Contemporary technology-based businesses become increasingly dependent on technologies distributed over different technological areas and among different companies and other actors (Granstrand et al., 1997; Granstrand, 1999; Granstrand and Holgersson, forthcoming; Holgersson, 2011). Thus, companies must engage in an increasing amount of technology trade and technology collaborations, leading to various forms of licensing deals (Granstrand, 2004). In this process, methods for royalty determination and value sharing are of utmost importance, and standard bodies then often require their participants to offer Fair, Reasonable, And Non-Discriminatory (FRAND) licensing terms to potential licensees (license buyers). Each of these terms F, R, and ND is ambiguous, however, allowing for a variety of rules and methods to be used, more or less grounded in theory or data.

One method of establishing royalty rates is the *25% rule of thumb*, essentially saying that the licensee should pay 25% of operating profits (or sometimes gross profit or EBITDA) to the licensor (license seller) as a standard rate, although a more general version of the rule, the so called *classic 25% rule*, maintains that this should also be subject to further negotiations and adjustments to case specific factors, as described by Goldscheider (2011), e.g. by utilizing the 15 so called Georgia-Pacific factors. The 25% rule has in recent years attracted a great deal of attention and discussion, not the least in les Nouvelles, about whether it is alive or dead (if it ever lived) and what its destiny should be, especially after the dismissal of the 25% rule of thumb by the United States Court of Appeals for the Federal Circuit (CAFC) in early 2011.[1] Articles about the rule are then typically polarized into for and against the rule, where the proponents of the rule tend to view it more as a flexible methodology (the classic 25% rule), while the opponents tend to view it more narrow as a rule of thumb (the 25% rule of thumb), see Goldscheider (2012).

While Goldscheider (2011), Kemmerer and Lu (2009), and Lu (2011) argue that empirical evidence suggests that the 25% rule is (still) valid, Kidder and O’Brien (2011) counter-argue that the empirical evidence does not support the rule and that there are theoretical problems with it, e.g. since it does not consider that a product is often not based on only one licensed patent. Further, Epstein and Marcus (2003, p. 574) argue that “the 25% rule assigns royalties without regard to any of the determinants of a reasonable royalty rate”. Although adjustments can (and should) be made to the rule to account for case specific factors, as discussed by Goldscheider (2011), Kidder and O’Brien (2011) discuss the impact an initial “starting point” rate has on the final outcome after adjustments, and argue that utilizing 25% as a standard rate subject to further negotiations and adjustments would impact the final result due to anchoring (see Tversky and Kahneman, 1974) and lead to rates closer to 25% than would otherwise have

[1] Uniloc U.S.A., Inc. v. Microsoft Corp., 632 F.3d 1292 (Fed. Cir. 2011).

been the case. Smith and Parr (1998) and Razgaitis (1999) further argue that the 25% rule does not consider relative levels of investments.

So, how should a fact-based reasonable royalty rate be calculated? Epstein and Marcus (2003) argue that the maximum reasonable royalty is the amount that gives a net present value equal to zero for the licensee, considering alternative investments. A similar approach is suggested by Ruikka (2008). This can then act as a starting point for setting a reasonable royalty rate, as it sets a cap for the royalty payment. However, as argued by Sherry and Teece (2004), patents are rarely known to be valid at the time of a licensing negotiation (exceptions being patents that have already been tested in court), and hence the royalty needs to be adjusted for the fact that the patent might not be valid if tested in court, as well as for other factors.

Little emphasis has in this literature been put on the fact that the patents necessary to produce and market a product are many times held by more than one patent holder or licensor, and in addition often licensed to more than one licensee, which makes it meaningless to treat individual licensing deals separately, as argued by e.g. Ruikka (2008). This is especially true in systems technologies, e.g. information and communication technologies (ICTs) and other areas within electronic industries, where the essential patents related to a standard might be distributed among dozens of actors.

The purpose with this paper is therefore to develop and present a generalized method to calculate reasonable royalties, which works not only in one-to-one but also in many-to-many (as well as in one-to-many and many-to-one) licensing deals.

## 2 The investment-based method

Companies typically pay dividends to their shareholders in relation to the shareholders' invested capital, i.e. each stock has the same rate of return in form of dividend. This is a fairness principle that is well established in contemporary business. We argue that this principle for fair and reasonable value-sharing is applicable also in quasi-integrated organizational forms and open innovation (e.g. in licensing collaborations). Hence, fair and reasonable royalties can be calculated by equalizing the rates of returns on the investments made by the parties involved. This principle is then one out of several possible principles for fairness in value-sharing, and based on this principle an investment-based method for royalty determination can be developed.

According to the principle the returns from a licensing deal should be shared among the involved actors in proportion to their respective investment, $I$. Thus, we employ a FRAND rule that the rate of returns on investments, $R$, should be equal for all involved actors in order to develop a method for FRAND royalty determination. We start by case A with only one licensee (buyer), $b$, and one licensor (seller), $s$, based on the analysis in Granstrand (2006).[2] We then continue with case B by adding multiple licensees, and subsequently with case C by adding multiple licensors. Note that we use a separation between total profits, $\pi$, operating profits from product/service sales (not including investment depreciation or license payments), $\pi_{op}$, license payments, $L$, and finally the related investments by the licensor, $I_s$, and licensee, $I_b$, in R&D, production, and marketing (investments necessary to generate the operating profit). Also note that we for simplicity reasons use a one-period approach, which can be easily generalized in principle to a multi-period risk-adjusted approach, however (see Granstrand, 2006).[3] Throughout this chapter we use the assumptions that the total operating profits are large enough to cover the total investments (i.e. that the total return on investment for all actors as a collective is positive) and that each licensee's operating profit is large enough to cover its investment. The method is applicable not only to patent licenses, but to intellectual property (IP) licenses in general, including know-how licenses.

The choice of a useful language for presenting a model and its arguments is neither a small issue, nor a small task. Essentially, there are three options in presenting a mathematical model as in our case – using normal text, using symbols, or using a mixture of text and symbols. History provides many examples of how not only disciplines but whole civilizations have been helped or hindered by their choice of mathematical language in their daily practices, be they about economic or engineering or even legal calculations.[4] Unfortunately there is a long-lasting divide between economics and law in this respect. We certainly appreciate the need to bridge this divide, and have attempted to do so in this paper by complementing a more precise symbolic presentation of our model with a more accessible but less precise textual presentation.[5]

### 2.1 Case A: One licensor and one licensee

Case A includes one licensor $s$ with investment $I_s$, and one licensee $b$ with investment $I_b$ and operating profit $\pi_{op_b}$, and a license royalty payment $L$. The analysis starts by setting up the expressions for the rates of return on investment for the licensor, $R_s$, and licensee, $R_b$, respectively. The rate of return for each party is then the relation between its total profit and its investment. The licensor's total profit, $\pi_s$, is its received royalties, $L$, minus its

[2] Granstrand (2006) also showed that the 25% rule of thumb is only applicable in a very special case.
[3] Uncertainty, risk, and time preferences (including financial discounting) can be dealt with as in Granstrand (2006).
[4] See e.g. Struik (1987) or Al-Khalili (2010).
[5] On a concluding note, one may observe in all fairness how textual representations easily become cumbersome, just as algebraic calculations became cumbersome for ancient Greeks and Romans with their notation of mathematical relations. Making the textual explanations less cumbersome usually implies a loss of precision with ensuing misrepresentations. Hopefully a mix of text and symbols are reasonable and non-discriminatory to the readers.

investments, $I_s$. The licensee's total profit, $\pi_b$, is the operating profit, $\pi_{op_b}$, minus the royalties, $L$, paid to the licensor and the investments, $I_b$:

$$\begin{cases} \pi_s = L - I_s \\ \pi_b = \pi_{op_b} - L - I_b \end{cases} \quad => \quad \begin{cases} R_s = \frac{\pi_s}{I_s} = \frac{L}{I_s} - 1 \\ R_b = \frac{\pi_b}{I_b} = \frac{\pi_{op_b} - L}{I_b} - 1 \end{cases}$$

By employing the proposed principle of fairness $R_s = R_b$ (i.e. that the licensor and licensee should receive the same rate of return on investment) we can conclude that the reasonable royalty rate (with operating profit as royalty base) is equal to the licensor's share of the total investments ($\frac{I_s}{I_b+I_s}$):

$$R_s = R_b \quad => \quad \frac{L}{I_s} - 1 = \frac{\pi_{op_b} - L}{I_b} - 1 \quad => \quad \frac{L}{I_s} = \frac{\pi_{op_b} - L}{I_b} \quad => \quad L = \frac{I_s}{I_b + I_s}\pi_{op_b}$$

Thus, a share of the licensee's operating profits based on the licensor's share of the total investments should be paid to the licensor as licensing royalty in order to reach a fair and reasonable bilateral licensing agreement:

$$L = \frac{I_s}{I_b + I_s}\pi_{op_b}$$

Hence, if the licensor has made e.g. 35% of total investments, 35% of the operating profits should be paid by the licensee to the licensor. A virtue of the method, besides providing a basis for fair value-sharing is then that the objectives of the buyer and seller to maximize profits are aligned, since operating profit is used as royalty base (this is not the case if gross revenue is used as a royalty base).[6]

[6] The so called principal-agent problem arguably includes two important aspects; information asymmetries and unaligned incentives (see e.g. Pratt and Zeckhauser, 1985). In the case of licensing deals and the choice of royalty bases, the use of operating profits aligns the incentives of the licensee and the licensor on one hand, but the licensee's operating profits may on the other hand be less easily monitored than its revenues by the licensor, leading to information asymmetries.

### 2.2 Case B: One licensor and multiple licensees

Case B includes a single licensor $s$ with investment $I_s$, and multiple ($m$) licensees $b_i$, $i = 1, \dots, m$, with investments $I_{b_i}$, operating profits $\pi_{op_{b_i}}$, and license royalty payments $L_i$.[7] By calculations presented in the appendix we can conclude that licensee $i$ should make the following license payment to the licensor:

$$L_i = \frac{I_s}{\left(I_{b_i}+I_s\right)}\left(\pi_{op_{b_i}} - \sum_{j\neq i} L_j \frac{I_{b_i}}{I_s}\right) = \pi_{op_{b_i}} - \frac{I_{b_i}}{I_{b.}+I_s}\pi_{op_{b.}}$$

Thus, licensee $i$ should make a payment equal to the size of its operating profit minus a share of the collective operating profits for all licensees. This share of collective operating profits should be equal to the licensee's share of the total investments ($\frac{I_{b_i}}{I_{b.}+I_s}$). Notice that this solution in the special case with only one buyer then gives the same solution as in case A.

### 2.3 Case C: Multiple licensors and multiple licensees

Case C includes multiple ($n$) licensors $s_k$, $k = 1, \dots, n$, with investments $I_{s_k}$, and multiple ($m$) licensees $b_i$, $i = 1, \dots, m$, with investments $I_{b_i}$, operating profits $\pi_{op_{b_i}}$, and license royalty payments $L_{ik}$ from licensee $i$ to licensor $k$. This can again (see appendix for case B) be solved by initially treating the set of licensors and set of licensees, respectively, in a collective way. Thus, the royalties paid by licensee $i$ will again be (now with multiple investing licensors to be paid):

$$L_{i.} = \pi_{op_{b_i}} - \frac{I_{b_i}}{I_{b.} + I_{s.}}\pi_{op_{b.}}$$

These royalties can be collected in a pool and thereafter distributed to the various licensors (contributors) in accordance with their respective shares of the total licensor investments $I_{s.}$. Alternatively, the royalties can be collected by the licensors directly from the different licensees, so that a specific licensor $k$ will collect the specific royalty $L_{ik}$ from licensee $i$:

$$L_{ik} = L_{i.}\frac{I_{s_k}}{I_{s.}} = \left(\pi_{op_{b_i}} - \frac{I_{b_i}}{I_{b.} + I_{s.}}\pi_{op_{b.}}\right)\frac{I_{s_k}}{I_{s.}}$$

[7] Notice that the following convention is used throughout: $x_{.} = \sum_i \; x_i$

This is thus a general investment-based method for calculating reasonable royalties to be paid from licensee $i$ to licensor $k$ in cases of e.g. standard technologies with multiple essential patents. Notice that this solution in the special case with only one licensor then gives the same solution as in case B, and in the special case with only one licensor and one licensee the same solution as in case A.

### 2.4 Summary of the investment-based method

The algebra resulting in the generalized investment-based method above may seem complex, but it results in a simple and easy-to-use method, based only on the involved actors' operating profits and investments. The table below can be used in practice to calculate the royalties to be paid and collected by various actors in a multilateral royalty agreement. First, determine for each licensor and licensee their relevant amounts invested. Second, determine for each licensee their relevant operating profits related to the licensed IP. Third, determine the FRAND royalties to be paid by each licensee, and the amount that should be received by each licensor, either by using the formula above or the table below. The fairness principle to equalize all parties' rates of returns on investment then leads to license fees or royalties expressed as amounts in monetary units rather than royalty rates expressed as percentages of some royalty base (see the example in the next section).

Notice that a licensor might very well be also a licensee (which is most often the case in licensing standard technologies), which introduces no additional problems to the presented method. If using the table below for calculations, such an actor, being both licensor and licensee, should be included both as a seller and buyer, and the investments need to be divided into seller- and buyer-related (although this relative division does not impact the total return for such an actor – and does thereby not introduce any additional problems). A more extensive spreadsheet for the calculations to be used in practice can be found at www.ip-research.org.

| | Seller/licensor | A | B Investment | C Royalty income | D Profit | E Rate of RoI |
|---|---|---|---|---|---|---|
| 1 | | | Fill in | C10×(B1/B5) | C1-B1 | D1/B1 |
| 2 | | | Fill in | C10×(B2/B5) | C2-B2 | D2/B2 |
| 3 | | | Fill in | C10×(B3/B5) | C3-B3 | D3/B3 |
| 4 | | | Fill in | C10×(B4/B5) | C4-B4 | D4/B4 |
| 5 | **Total** | | Sum | Sum | Sum | D5/B5 |

| | Buyer/licensee | A Operating profit | B Investment | C Royalty payment | D Profit | E Rate of RoI |
|---|---|---|---|---|---|---|
| 6 | | Fill in | Fill in | A6-A10×B6/(B5+B10) | A6-B6-C6 | D6/B6 |
| 7 | | Fill in | Fill in | A7-A10×B7/(B5+B10) | A7-B7-C7 | D7/B7 |
| 8 | | Fill in | Fill in | A8-A10×B8/(B5+B10) | A8-B8-C8 | D8/B8 |
| 9 | | Fill in | Fill in | A9-A10×B9/(B5+B10) | A9-B9-C9 | D9/B9 |
| 10 | **Total** | Sum | Sum | Sum | Sum | D10/B10 |

### 2.5 An illustrative example

Assume that two different firms, $s_1$ and $s_2$, have developed different technologies that jointly (but not separately) enable a new product area within automotive security. They have invested $5M and $4M in R&D, respectively. None of these firms have production and marketing capabilities, however, and they therefore decide to license out their technologies to three different incumbent firms, $b_1$, $b_2$, and $b_3$, active in producing and selling automotive security products. Due to their various production and marketing capabilities, these firms need to make investments of $1M, $3M, and $2M, respectively, to enable operating profits of $7M, $10M, and $11M, respectively. Considering these numbers and using the table above we can now use the investment-based method to calculate the royalty payments, see table below. Notice the comparison with the 25% rule of thumb (based on operating profits minus investments as royalty base, considering that the definition of operating profit does not include investment depreciation in this paper), which results in a large variety of rates of return on investment.

| The investment-based method | | | | | | Comparison with the 25% rule of thumb | | |
|---|---|---|---|---|---|---|---|---|
| **Seller/licensor** | | **Investment** | **Royalty income** | **Profit** | **Rate of RoI** | **Royalty income** | **Profit** | **Rate of RoI** |
| $s_1$ | | 5 | 9.33 | 4.33 | 87% | 5.5 | 0.5 | 10.0% |
| $s_2$ | | 4 | 7.47 | 3.47 | 87% | 5.5 | 1.5 | 37.5% |
| **Total** | | 9 | 16.8 | 7.80 | 87% | 11 | 2 | 22.2% |
| | | | | | | | | |
| **The investment-based method** | | | | | | **Comparison with the 25% rule of thumb** | | |
| **Buyer/licensee** | **Operating profit** | **Investment** | **Royalty payment** | **Profit** | **Rate of RoI** | **Royalty payment** | **Profit** | **Rate of RoI** |
| $b_1$ | 7 | 1 | 5.13 | 0.87 | 87% | 3 | 3 | 300% |
| $b_2$ | 10 | 3 | 4.40 | 2.60 | 87% | 3.5 | 3.5 | 117% |
| $b_3$ | 11 | 2 | 7.27 | 1.73 | 87% | 4.5 | 4.5 | 225% |
| **Total** | 28 | 6 | 16.8 | 5.20 | 87% | 11 | 11 | 183% |

## 3 Discussion, generalizations, and limitations

Previous literature about the 25% rule has discussed a) to what extent the rule is based on heuristics (e.g. as a rule of thumb), conventional wisdom, and/or empirical statistics, b) whether the rule is generally applicable or limited only to special cases, and c) what would be the basis for the rule, EBITDA or something else (see e.g. Goldscheider, 2011, and Kidder and O’Brien, 2011). This literature discussion has also pointed at a number of pros and cons of the rule, which by and large has led to interpreting the rule more as a flexible guideline or methodology (the classic 25% rule) than a rigid rule for determining royalty rate and royalty base across industries and business situations (the 25% rule of thumb).

However, previous literature has, despite its normative underpinnings, rarely presented any evidence-based alternative to the 25% rule, let alone an alternative with more general applicability. This paper has presented an alternative; a generalized investment-based method to determine fair and reasonable royalties in the case of one or many buyers of non-exclusive licenses from one seller or from a consortium of many sellers pooling their patents and know-how.

The question then is: What are the generalizations and limitations of this method of determining FRAND terms? A few points can be made here.

First, in case an improvement of an underlying technology is made based on an investment $\Delta I = I_1 - I_0$, separable from the original investment $I_0$, and this improvement has an added value $\Delta V = V_1 - V_0$, separable from the original value $V_0$, then a second round of FRAND terms could be determined with respect to $\Delta V$, $\Delta I$, and related previous investments $sI_0$. In a similar way the rates of return on investment for the relevant parties are equalized with respect to their shares of added value $\Delta V$ and their respective shares of the relevant investments ($\Delta I + sI_0$, where $s$ is the share of previous investments leading to the added value in a complementary way with $\Delta I$). In case of a patent pool newcomers will thus not be favored or free-riding. On the contrary, there is an incentive to join the pool at an early stage, and early mover advantages could thus be designed by the original pool members by defining the relevant investment base for latecomers, e.g. in terms of essential patents.

Second, if the FRAND licensing arrangement concerns a component, feature, or subsystem of a larger product or system, similar principles as for an improvement could be applied, assuming that relevant investments (or costs) and returns (or revenues) could be identified.

Third, if e.g. the licensor wants to impact the industrial organization of the sellers, a somewhat modified method can be used in which the rates of returns on investments for licensors and licensees as collectives are equalized, while the individual rates of returns on investments for various licensees are allowed to vary. Such a setup then promotes competition among the licensees (product/service sellers), for instance in order to mitigate anti-trust risks or to promote efficiency. Other modifications can be made in order to promote collaboration, for instance in order to promote collective learning (as was the case in the licensee family of VHS).

As to limitations of the investment-based method, a few ones could be pointed out here. Differences in R&D productivity are not taken into account, e.g. essential vs. non-essential patents. There are many ways to insert correction factors for such differences, however. Notice especially that the given method might create incentives for unnecessary high investments *ex ante* (since profits are later shared in accordance with investment levels), which is why adjustments might need to be made for the productivity of each actor's investments. Further, synergies and substitutes across businesses and technologies are not taken into account (note e.g. that two essential patents could be substitutes, so that they are jointly non-essential). Again, there are methods to deal with such situations (e.g. by focusing on incremental operating profits for the collective as a whole), albeit cumbersome, and the method proposed here then serves as a first approximation.

The method in an extended form allows for a dynamic perspective, as described above. This introduces boundary conditions, however, since new entrants should not imply lower profits for any of the already included members (which might be the case if a newcomer provides a positive incremental profit, but with a lower rate or return on investment than the one obtained by the original collective). Additional boundary conditions might need to be considered in cases of infringement, e.g. that the incremental total profit (considering also cannibalism on infringed sales) should be shared at the same time as the licensor (plaintiff) should be at least as profitable as without infringement, but this depends on the jurisdiction.

## 4 Summary and conclusions

The received 25% rule of thumb is only applicable in a very special case, and then only in case of bilateral licensing, and should consequently be dismissed as a general rule, just as the CAFC did. The method is simple, but overly so, and its widespread use in the past does not justify its use in the future. More accurate methods are called for, not the least in light of the evolving pro-patent and pro-licensing era (Granstrand, 1999, 2004, 2012) with larger and more rapid deal flows with more complex deal structures, calling for more sophisticated management tools. The investment-based method proposed in this paper offers a new approach to royalty determination in FRAND terms that results in equal rates of return on investments. This method is not only applicable to one-to-one licensing deals, but is also applicable to non-exclusive multi-lateral licensing as well as to patent pools and other forms of open innovation, using licensing for governance. The method is far from the final say in these situations, but rather a first step in a promising direction, hopefully leading to decreased transaction costs from e.g. bargaining and litigation. More developments are needed by analysts and practitioners, however. Court decisions raising the bar and burden of proof are welcome in this process. Old methods, just as old technologies, sooner or later have to say farewell and be gracefully acknowledged.

## Appendix: Calculations

Case B includes one licensor $s$ with investment $I_s$, and many ($m$) licensees $b_i$, $i = 1, \dots, m$, with investments $I_{b_i}$, operating profits $\pi_{op_{b_i}}$, and license royalty payments $L_i$. We start by repeating the analysis in case A:

$$\begin{cases} \pi_s = L. - I_s \,,\ L. = \sum_{i=1}^{m} L_i \\ \pi_{b_i} = \pi_{op_{b_i}} - L_i - I_{b_i} \end{cases} \quad => \quad \begin{cases} R_s = \frac{L.}{I_s} - 1 \\ R_{b_i} = \frac{\pi_{op_{b_i}} - L_i}{I_{b_i}} - 1 \end{cases}$$

$$\frac{L.}{I_s} = \frac{\pi_{op_{b_i}} - L_i}{I_{b_i}} \quad , \quad i = 1, \dots, m \quad => \quad L.I_{b_i} = I_s \left(\pi_{op_{b_i}} - L_i\right)$$

$$\therefore L_i I_{b_i} + \sum_{j\neq i} L_j\, I_{b_i} = -L_i I_s + I_s \pi_{op_{b_i}} \quad => \quad L_i\left(I_{b_i} + I_s\right) = I_s \pi_{op_{b_i}} - \sum_{j\neq i} L_j\, I_{b_i}$$

$$\therefore L_i = \frac{I_s \pi_{op_{b_i}} - \sum_{j\neq i} L_j I_{b_i}}{\left(I_{b_i} + I_s\right)} = \frac{I_s}{\left(I_{b_i} + I_s\right)}\left(\pi_{op_{b_i}} - \sum_{j\neq i} L_j \frac{I_{b_i}}{I_s}\right)$$

Although this introduces additional unknown variables to the equation ($L_j$), this can be solved by considering that all licensees can be treated collectively, as well as individually, meaning that the rate of return on investment should be the same for the licensor, the licensee, and all licensees as a collective:

$$\begin{cases} \pi_s = L_. - I_s \\ \pi_{b.} = \pi_{op_{b.}} - L_. - I_{b.} \end{cases} \quad => \quad \begin{cases} R_s = \frac{L_.}{I_s} - 1 \\ R_{b.} = \frac{\pi_{op_{b.}} - L_.}{I_{b.}} - 1 \end{cases}$$

$$R_s = R_{b.} \quad => \quad \frac{L_.}{I_s} = \frac{\pi_{op_{b.}} - L_.}{I_{b.}} \quad => \quad L_. = \frac{I_s}{I_{b.} + I_s}\pi_{op_{b.}}$$

Now, using the relation $L_. = L_i + \sum_{j\neq i} L_j$ it is possible to create an expression for $L_i$ without any unknown variables:

$$L_i = \frac{I_s}{\left(I_{b_i} + I_s\right)}\left(\pi_{op_{b_i}} - \sum_{j\neq i} L_j \frac{I_{b_i}}{I_s}\right) = \frac{I_s}{\left(I_{b_i} + I_s\right)}\left(\pi_{op_{b_i}} - \frac{I_{b_i}}{I_s}\frac{I_s}{I_{b.} + I_s}\pi_{op_{b.}} + L_i \frac{I_{b_i}}{I_s}\right)$$

$$\therefore L_i\left(I_{b_i} + I_s\right) = I_s \pi_{op_{b_i}} - I_s \frac{I_{b_i}}{I_{b.} + I_s}\pi_{op_{b.}} + L_i I_{b_i}$$

$$\therefore L_i = \pi_{op_{b_i}} - \frac{I_{b_i}}{I_{b.} + I_s}\pi_{op_{b.}}$$

## Acknowledgements

The work with this paper has been conducted under the auspices of IMIT (Institute for Management of Innovation and Technology) at Chalmers University of Technology within the project "Management, Economics and IP Law of Open Distributed Innovation Processes". The financial support from the European IP consultancy firm Zacco, the German energy corporation E.ON, and the Swedish government research foundation Vinnova is gratefully appreciated.

## References

Al-Khalili, J. (2010) *Pathfinders: The Golden Age of Arabic Science*, Penguin Books Ltd.

Epstein, R.J. and Marcus, A.J. (2003) 'Economic Analysis of the Reasonable Royalty: Simplification and Extension of the Georgia-Pacific Factors', *Journal of the Patent & Trademark Office Society*, Vol. 85, No. 7, pp. 555-583.

Goldscheider, R. (2011) 'The Classic 25% Rule And The Art Of Intellectual Property Licensing', *les Nouvelles*, September 2011.

Goldscheider, R. (2012) 'The Current Realities Of The Classic 25% Rule: An Attempt To Put The House In Order', *les Nouvelles*, March 2012.

Granstrand, O. (1999) *The Economics and Management of Intellectual Property: Towards Intellectual Capitalism*, Cheltenham: Edward Elgar Publishing.

Granstrand, O. (2004) 'The economics and management of technology trade: towards a pro-licensing era?', *International Journal of Technology Management*, Vol. 27, Nos. 2/3, pp. 209-240.

Granstrand, O. (2006) 'Fair And Reasonable Royalty Rate Determination – When Is The 25% Rule Applicable?', *les Nouvelles*, September 2006.

Granstrand, O. (2012) *Patents and Innovation for Growth and Welfare*, Cheltenham: Edward Elgar Publishing.

Granstrand, O. and Holgersson, M. (forthcoming) 'Multinational technology and intellectual property management – Is there global convergence and/or specialization?', forthcoming in *International Journal of Technology Management*.

Granstrand, O., Patel, P. and Pavitt, K. (1997) 'Multi-Technology Corporations: Why They Have "Distributed" Rather Than "Distinctive Core" Competences', *California Management Review*, Vol. 39, No. 4, pp. 8-25.

Holgersson, M. (2011) *Intellectual Property Strategies and Innovation: Causes and Consequences for Firms and Nations*, Licentiate Thesis, Chalmers University of Technology.

Kemmerer, J.E. and Lu, J. (2008) ‘Profitability and Royalty Rates Across Industries: Some Preliminary Evidence’, *Journal of the Academy of Business and Economics,* March 2008.

Kidder, D.G. and O’Brien, V.E. (2011) ‘Simply Wrong: The 25% Rule Examined’, *les Nouvelles*, December 2011.

Lu, J. (2011) ‘The 25% Rule Still Rules: New Evidence From *Pro Forma* Analysis in Royalty Rates’, *les Nouvelles*, March 2011.

Pratt, J.W. and Zeckhauser, R.J. (1985) ‘Principals and agents: An overview’, In Pratt, J.W. and Zeckhauser, R.J. (Eds.) *Principals and agents: The structure of business*, Cambridge: Harvard Business School Press.

Razgaitis, R. (1999) *Early-Stage Technologies: Valuation and Pricing*, New York: John Wiley & Sons, Inc.

Ruikka, T. (2008) ‘”Frand” Undertakings In Standardization – A Business Perspective’, *les Nouvelles,* September 2008.

Sherry, E.F. and Teece, D.J. (2004) ‘Royalties, evolving patent rights, and the value of innovation’, *Research Policy*, Vol. 33, No. 2, pp. 179-191.

Smith, G.V. and Parr, R.L. (1998) *Intellectual Property: Licensing and Joint Venture Profit Strategies*, New York: John Wiley & Sons, Inc.

Struik, D.J. (1987) *A concise history of mathematics* ($4^{th}$ ed.), New York: Dover Publications, Inc.

Tversky, A. and Kahneman, D. (1974) ‘Judgment under Uncertainty: Heuristics and Biases’, *Science*, Vol. 185, No. 4157, pp. 1124-1131.

Paper VI

# Managing the intellectual property disassembly problem

Ove Granstrand[a) b)] and Marcus Holgersson[a) c)]

[a)] Industrial Management and Economics Research Group
Department of Technology Management and Economics
Chalmers University of Technology
SE-412 96 Gothenburg, Sweden

[b)] Phone: +46-31-772 12 09
E-mail: ovegra@chalmers.se

[c)] Corresponding author
Phone: +46-31-772 52 88
E-mail: marhol@chalmers.se

**Abstract**
This paper deals with the *intellectual property (IP) disassembly problem*. The IP disassembly problem refers to the problem of separating and disintegrating intellectual property rights (IPRs) for enabling a sale of a part of a company / business / project. Managing this problem becomes increasingly important, as it is amplified by a number of current trends, such as technological convergence, technological diversification, open innovation, and an increasing number of mergers, acquisitions, and divestments. Based on a comparative case study of Saab Automobile and Volvo Car Corporation, this paper describes the problem and suggests a framework for managing it.

## Prologue

On December 12, 2011, the long-time ailing Swedish car manufacturer Saab Automobile filed for bankruptcy in Sweden. Saab's previous owner General Motors (GM) had already in early 2008 indicated its intentions to shut down Saab Automobile, but a number of moves had been taken by the Saab Automobile management and others in order to save the company. In early 2010 GM agreed to divest Saab Automobile to the Dutch sports car manufacturer Spyker Cars. Spyker Cars subsequently needed capital in order to finance Saab Automobile's business and approached the Chinese automotive manufacturer Youngman for partnering. However, such a deal could never be finalized as GM wanted to control future competition on the Chinese market. An important deal breaker that finally made Saab Automobile file for bankruptcy was an intellectual property (IP) issue in form of change of control clauses (CCCs) in the contracts related to the sale from GM to Spyker Cars, giving GM the option to withdraw its technology licenses in case of changes in the ownership of Saab Automobile (or parent firms), thereby limiting future financing and exit opportunities for Saab Automobile and its owners.

Less than 100 km from the Saab Automobile headquarter is the Volvo headquarter. Volvo had sold its passenger car business Volvo Car Corporation (VCC) to Ford Motor Company in 1999 in order to concentrate on trucks and heavy vehicles. A later financially troubled Ford sold VCC to the Chinese firm Geely Holding Group in 2010, a deal in which a large number of IP interdependencies had to be cleared. The similarities of these cases of successful and failing corporate transactions are palpable indeed, including a number of transactions of Swedish automotive firms during the same time span and involving both giant American automotive firms and Chinese (potential) acquirers.

These cases then prompt a couple of questions:

1. Could more skilful IP management have "saved" Saab Automobile?
2. How could more skilful IP management be developed in general in order to avoid IP related market failures on the global market for corporate control?

With this paper we primarily aim to address the second question, by focusing on a specific problem related to IP management in divestments and mergers and acquisitions (M&As), which we refer to as the IP disassembly problem, that is further described below. We do so by first briefly explaining the economic background of the problem at hand, also introducing key concepts and previous literature. The cases of Saab Automobile and VCC are then presented, followed by a framework for managing the IP disassembly problem which is finally discussed and summarized.

## Background

Economists have since long realized the implications of assigning property rights to resources in general[1], for example to scarce resources that could otherwise be diluted, misused or preempted by overuse if multiple individuals were to act independently. The latter has been described as a *tragedy of the commons.*[2] *Common goods* are then typically defined as goods that are rivalrous (in consumption) and non-excludable, and property rights could be used for turning such goods into *private goods* that are rivalrous and excludable. In contrast, a *public good* is a good being both non-rivalrous and non-excludable. Knowledge is a type of resource that has these characteristics.[3] Investing in the creation of new and valuable knowledge, i.e. investing in R&D and *innovations*, then creates a problem for the investor/innovator to appropriate or secure sufficient returns on the investment by excluding others for some time from also commercializing the innovations. Innovators then typically use various forms of intellectual property rights (IPRs) in order to enable value appropriation[4] together with other means, such as controlling complementary and excludable assets[5], thereby enabling excludability, in turn leading to knowledge with characteristics of an *impure public good*.[6]

Since the processes of knowledge creation and innovation are mainly cumulative in nature and often involving multiple interacting contributors, the resulting IPRs related to new knowledge, e.g., in form of a set of new technologies, are commonly dispersed across different IPR holders. Users of such technologies for commercial purposes (for example aiming to introduce and/or produce new products or processes covered by IPRs owned by multiple IPR holders) then face the problem of acquiring and integrating the necessary technologies and their associated IPRs scattered across owners in order to ensure their *freedom to operate*. We will refer to this problem as the *IP assembly problem*. This in turn might possibly lead to underuse of knowledge from a social welfare point of view, i.e. a type of *tragedy of the anticommons* (which refers to the underuse of resources due to too many holders of exclusion rights).[7] The IP assembly problem is a fairly well-known managerial problem that can be managed through an explicit or implicit contractual arrangement for technology and IP acquisition in general, and more specifically by M&As, organizational integration, standardization efforts, licensing schemes, patent pools, etc.

This paper will however focus on another problem related to propertized knowledge, a problem of reverse nature that we will call the *IP disassembly problem*. The IP disassembly problem refers to the set of problems involved in separating or disintegrating (disentangling) the intellectual properties of two or more firms/business units/individuals/resource sets that previously have been integrated in some way. More specifically it refers to the problem of finding an explicit or implicit contractual arrangement for allocation of IPRs that allows for separating out (disintegrating) a business unit, company, or project entity in order to enable a transaction or organizational transfer of it. The very nature of knowledge (with technology, i.e. technical knowledge, as a special case) and IP, allowing it to be shared but not physically transferred between transacting parties, then calls for contractual arrangements between parties that meet their needs for ownership, control, and access for a substantial period of time in contrast to a physical property transaction. Managing this problem becomes increasingly important for technology management and corporate management, since a number of current trends, further described below, increase the frequency and importance of the problem.

Table 1 summarizes the two opposing legal (institutional) problems (‘tragedies’) and the two opposing managerial problems. It should be noted that both of the managerial problems typically are magnified by the number of related rights and rights holders, i.e. by the tragedy of the anti-commons, but management could still face these problems with few but strongly related rights and rights holders.

**Table 1 Key concepts and descriptions**

| Concept | Description |
|---|---|
| Tragedy of the commons | Overuse of scarce, rivalrous, and non-excludable resources due to absence of exclusion rights and owner control |
| Tragedy of the anti-commons | Underuse of resources due to presence of too many exclusion rights and rights owners |
| IP assembly problem | The problem of acquiring and integrating all IPRs needed for manufacturing, selling and/or using a product/process/service |
| IP disassembly problem | The problem of separating and disintegrating IPRs for enabling a sale of a part of a company/business/project |

**Underlying trends and examples of IP disassembly problems**

A number of trends increase the frequency and importance of the IP disassembly problem. The number of corporate transactions in form of mergers and acquisitions and divestments (MADs) has increased in the last few decades, especially cross-border ones, along with globalization, increasing foreign direct investments (FDIs), and MADs in and from emerging economies. Further, new products and innovations become increasingly based on multiple technologies (i.e. they become "mul-tech", not only "hi-tech")[8], leading to a technology assembly problem[9], and new technologies become increasingly propertized with IPRs distributed across different IP owners, leading to an IP assembly problem.[10] At the same time IP regimes are being strengthened globally[11]. In addition, new generic (general purpose, multi-product) technologies emerge, for example information and communication technologies or new material technologies. Finally, innovative companies increasingly use various forms of open innovation[12], in which resources distributed among multiple resource holders are combined and integrated, and technological alliances and R&D partnerships become increasingly common and important.[13] All in all this leads to an increasing amount of interdependencies between different technology areas, businesses areas, and resource holders (firms), interdependencies that must be managed in cases of MADs, but also in other cases of structural changes.

The IP disassembly problem may then typically arise in large technology-based firms with many cross-cutting business/technology links when a business unit, a technology unit, or an IP unit is to be "carved out" and sold or transferred. However, there are a multitude of other situations in which the IP disassembly problem occurs, e.g., when a research joint venture, a technology collaboration, an R&D contract, or an open innovation project is terminated, when a party wants to leave a collaboration (e.g., in standardization), when a key employee leaves an organization, when a project or a business is spun off, exited, sold, or transferred, when a firm is bankrupted and sold in pieces, and more generally when a package of certain IP assets is disintegrated from a portfolio (or an organization) with interdependent IP.

A type of unmanaged or unplanned IP disassembly also occurs when IP is simply dissolved or diffused more or less spontaneously without necessarily presenting a clear decision problem to any decision-making body or being a direct result from a disassembly decision. An example is when the likelihood of an exit or termination of an R&D project becomes imminent and key qualified scientists and engineers (QSEs) and holders of human embodied IP in form of know-how leave to start their own business or are hired-over by competitors. Exit interviews, debriefings, and disembodying (tapping) employees of their know-how might slow down such a "spontaneous" disassembly but only up to a point, as a number of "hostile spin-offs" demonstrate. The IP disassembly problem is actually unavoidable as soon as some form of IP is involved in some form of transaction, since by the very nature of human embodied ideas, knowledge, and information, IP as a resource cannot be physically transferred but only shared as pointed out above.[14] In other words, a buyer/user of human embodied IP cannot dispossess the seller/producer from it and the transacting parties thus have to resort to control over each other through other means, including IPRs, which are transferrable.

In summary the IP disassembly problem, or the IP disassembly phenomenon more generally, appears to increase in frequency, importance, and varieties, due to a number of causal factors and trends. As soon as there are interdependencies between different sets of IP and related businesses, which are to be disassembled, managers are likely to confront IP disassembly problems that need to be coped with by contractual or other means.

### Previous literature

Despite the importance of the subject, academic literature related to IP management in MADs is scarce. A structured literature search in Web of Science gives 245 records in the subject area 'business economics' and 50 records in the subject area 'government law'.[15] However, out of these records only a few are actually related to IP management issues in relation to M&As and divestments.[16] Nevertheless, these few records point at the importance for buyers of assets and business units to ensure that all necessary IP is included in the purchase, but also at the importance for sellers to ensure that the rights to use the IP that is necessary or desirable in remaining businesses are retained within the seller, for example by co-ownership or license arrangements.[17] These activities could be seen as involving buyer and seller IP clearance, respectively, which is closely related to the IP assembly/disassembly problem. Legal scholars have then for example emphasized implications for license agreements from M&A processes.[18] A finding in that context is that firms hiring new recruits significantly increase their use of the recruits' prior inventions.[19] This is measured by patent citations and thereby indicates the important tacit dimension of otherwise relatively explicit patented technologies and the importance of considering human embodied knowledge when disassembling IP.

## Empirical cases from the automotive industry

We now turn to a couple of cases of the IP disassembly problem in the automotive industry. The automotive industry is characterized by a kind of worldwide web of technological and IP interdependencies (an "IP WWW"). These interdependencies arise from shared platforms and architectures as well as from shared supplier networks and tools. In addition, there are frequent "carve-outs" and changes of ownership and control such as, e.g., Ford's divestments of Jaguar and Land Rover to Tata Motors (2008) and VCC to Geely (2010) and GM's divestment of Saab Automobile to Spyker Cars (2010).[20] The interdependencies, the long-lasting and overlapping product and technology generations, the long life times of IPRs, and the frequent changes of control make the IP disassembly problem common and complex in the automotive industry. Here we use the cases of Saab Automobile and VCC as cases in point of the IP disassembly problem and its complexity, as well as illustrations of managerial solutions.

The choice of Saab Automobile as the first case was opportunistic, as it presented a current and clear high-profile case of the IP disassembly problems related to the disintegration of businesses. VCC was then selected as a comparative case, as it exhibits one clear dissimilarity in the outcome in terms of success/failure in disentangling the business as well as a rare number of similarities in background variables. For example, both cases include Swedish passenger car firms, first being disintegrated from Swedish industrial groups and sold to American automotive groups (GM and Ford, respectively) in the 1990s, and then being subsequently sold again in 2010 during the financial crisis.

All in all 15 interviews with 15 interviewees have been conducted in the two companies, covering current and/or previous CEO and CTO positions in both firms, as well as other important executive/management/R&D positions for the study at hand, such as legal, IP, market, key QSEs, etc. Additionally, 5 interviews with 7 interviewees were conducted covering large law firms and other automotive company personnel and observers. The interviews were extensive, typically lasting in between one and three hours and performed face to face (with a few exceptions of shorter telephone interviews). In addition to primary data through interviews, secondary data in the form of hundreds of newspaper articles, press releases, and other company and media documentations have been studied, especially regarding the case of Saab Automobile. Two additional high-profile cases of IP disassembly problems have been studied (from chemical and electronics industries), but sensitivity of the matters prevents us from disclosing them. Nevertheless, the suggestions and findings presented here are applicable also to them.

**Saab Automobile**

In 1937, Svenska Aeroplan Aktiebolaget was started in order to satisfy the Swedish air force's need of military airplanes. Already in 1939, Svenska Aeroplan Aktiebolaget was acquired by its Swedish competitor ASJA, controlled by the Swedish Wallenberg family. The two were merged under the name SAAB AB, and after World War II the business was diversified into car production in order to offset the decreasing airplane orders. SAAB AB was subsequently merged with another Wallenberg controlled automotive firm, Scania-Vabis, now under the name Saab-Scania.

*The first divestment process and the integration with GM*

In 1990, after many years of large losses, 50% of the Saab cars division, Saab Automobile AB, was divested to GM, and the remaining 50% was divested in 2000. In this divestment process the technological overlaps between Saab Automobile and the remaining Saab-Scania were very limited and patents that were passenger car-related were transferred to the newly established Saab Automobile in 1990 while the rest were kept within Saab-Scania.

The Saab trademark was kept within Saab-Scania initially, and within Saab AB when Scania was also divested. Saab Automobile received a license to use the Saab trademark for its automobile business as long as the company stayed within this business. (Therefore, in cases where Saab Automobile wanted to connect to its airplane heritage, which was commonly done in commercials, permission had to be received from the trademark owner Saab AB.) This license was limited neither in time nor in ownership structure of Saab Automobile, i.e. no change of control clause (CCC) was included in the license. A similar license to use the griffin logo was received from Scania, the truck and bus unit subsequently divested from Saab AB.

Around 2003, GM's massive organization initiated processes in order to integrate production, R&D, etc., and in 2005 ownership to all technologies were collected in a US company called GTO. All previous as well as future technological IP was to end up with GTO. The reasons for this were arguably more related to practicalities in managing the large technology portfolio than to tax issues and cross-border profit transfers, even if opportunities for the latter came as a result of the new organizational setup. However, due to tax reasons Saab Automobile's IP obtained until 2005 was kept within the Swedish firm, a circumstance that would have important implications later on.

*The second divestment process*

By 2006 the future looked promising for Saab Automobile, producing a record of 134 000 cars and planning for product diversification. However, in connection with the financial crisis in 2008 when the sharp downturn in demand hit the automotive industry, GM faced a possible bankruptcy and had to cut costs and then indicated its intentions to either close down or sell Saab Automobile (as well as other brands/businesses within GM, such as Pontiac and Saturn). In June 2009, the Swedish extreme sports car manufacturer Koenigsegg (backed by Norwegian and US investors) initiated negotiations with GM about purchasing Saab Automobile and later declared its intentions to go through with the acquisition.

However, the negotiations were delayed due to the complexity of the deal and the actor network related to it, but also due to continuous recontracting since separation agreements had not been established *ex ante*. Both GM and Saab Automobile were or had been subject to reconstruction, and besides GM, Saab Automobile, and Koenigsegg, other important stakeholders to consider in negotiations were the US and Swedish governments, the European Investment Bank (EIB), owners of the Saab-related trademarks, the financial investors backing Koenigsegg, GM's partner in China (SAIC), etc.

Apart from multiple involved stakeholders, Saab Automobile's current and future product line had at that time important technological interdependencies with GM. For example, the Saab 9-3 shared the Epsilon I platform with other GM models, and the Saab 9-5 introduced in 2010 shared the Epsilon II platform with Opel Insignia. The 9-4X, finally, was a "licensed vehicle" owned and produced by GM in Mexico. In addition, Saab's platform architecture for the future product line, the so called Phoenix architecture, had some important interdependencies that needed to be cleared, despite being independently developed. However, the necessary licenses could never be secured at a reasonable cost before Koenigsegg had to pull out from the deal in November 2009, arguably due to the delayed and extended negotiations.

Part of the intended Koenigsegg deal involved selling technology to the Chinese automotive manufacturer Beijing Automotive Group (BAIC). After Koenigsegg pulled out, Saab Automobile was in severe need of cash, and a couple of the firm's legal advisors suggested the management to independently approach BAIC with an offer to sell parts of the "old" technology. Ownership to this technology was retained within Saab at the time of the integration within GM in 2005 when technologies were collected in GTO, which opened up for this opportunity to disintegrate the technologies. BAIC accepted and Saab Automobile collected about 200 MUSD for technologies related to old sedan versions of their two product lines[21] (the larger 9-5 and the smaller 9-3), and this capital injection bought some time for Saab Automobile's management in relation to GM in order to find a new buyer of the firm.[22] A second sports car manufacturer, the Dutch firm Spyker Cars, soon thereafter became the new potential acquirer, and after relatively quick negotiations, pushed by GM's threat to close down Saab Automobile, Spyker Cars finalized the acquisition on February 23, 2010, including licenses to GM technologies necessary for Saab Automobile's business.

*The IP disassembly problem unsolved*

A year later, Spyker Cars was in urgent need of financial capital to finance the ongoing losses within Saab Automobile. The solution presented was to let the Chinese firms Pang Da and Youngman invest in Saab Automobile.[23] However, such an investment would imply a change of control, and both IP license agreements and supplier agreements between Saab Automobile and GM had to be cleared with GM, who refused to agree upon continuing the IP license deals after such a change of control. The agreements included CCCs, and in order to protect its own interests on the Chinese market GM clearly stated its intentions to execute their rights to terminate the agreements in case of a change of control implying direct or indirect Chinese ownership of Saab Automobile.

In the end, the CCCs in the agreements between Saab Automobile and GM implied that Saab Automobile was strongly dependent upon GM, and the IP necessary for Saab Automobile's business had not been sufficiently disentangled in the first divestment to go forward with a second one. Thus, continuous financing of Saab Automobile's business was impossible, exit opportunities were severely limited, and the firm filed for bankruptcy on December 12, 2011.

In connection with the bankruptcy the licenses to the Saab trademark owned by Saab AB and to the griffin logo owned by Scania were terminated, and the value of the bankruptcy estate was thereby further limited. On June 13, 2012, it was announced that electric car consortium National Electric Vehicle Sweden AB (Nevs) was to acquire most of the assets from the bankruptcy estate, in order start up production of electric cars in the old facilities. Licenses to GM technologies and Saab and Scania trademarks were however not included in the deal. These had been terminated by the bankruptcy and/or CCCs, and to date (August 2012) it is unclear whether Nevs will be able to finance the acquisition with licenses neither to the trademarks, nor to some of the key technologies.

**Volvo Car Corporation**

VCC is the second out of two major Swedish manufacturers of passenger cars. The Volvo trademark (Volvo is Latin for “I roll”) was registered by the Swedish bearing manufacturer SKF in 1915, but was not used until SKF initiated automobile production in 1926/1927. The automotive business AB Volvo was divested from SKF and listed on the Swedish stock exchange in 1935. AB Volvo had at that time already diversified into trucks, and subsequently diversified into buses, construction equipment, marine engines, and aircraft engines. The latter was actually a result from buying the aircraft engine unit of SAAB AB in 1941.

*The first divestment process and the integration with Ford*

More than 70 years after the production of its first automobile, AB Volvo decided to divest its passenger cars division VCC to Ford in order to focus completely on commercial vehicles. At the time of the divestment, in 1999, all patents were owned centrally within AB Volvo. Before the divestment to Ford was finalized, negotiations were made regarding how to deal with the IPRs in a process lasting more than half a year. Volvo’s patents had to be reviewed in order to structure the transfers and licenses of IP. Patents of main importance to passenger cars were to be transferred to Ford, while the rest were to be kept within AB Volvo. Roughly 70% of the patents were obvious in terms of whether they were related to passenger cars or AB Volvo’s other businesses, so the main negotiation work was related to the remaining 30%. After this process, patents that were clearly relating to passenger cars were transferred to Ford (more specifically to the subsidiary Ford Global Technologies). Patents that were less clear in terms of which business they were related to were kept within AB Volvo. Any dependence on such patents from VCC’s side was cleared by a collective license to Ford, stipulating that VCC and Ford could keep using all IP that was used by the passenger cars business at the time of the purchase. The IP disassembly problem related to trademarks was solved by placing the Volvo trademarks within a holding company, Volvo Trademark Holding AB, co-owned by AB Volvo and Ford/VCC.

After the purchase, VCC was placed within Ford’s Premier Automotive Group (PAG) together with their other high-end brands (Aston Martin, Jaguar, Land Rover, Lincoln, and Mercury). VCC’s platform for large cars, P2, was introduced on conceptual level to Ford, leading to the Ford D3 platform used for Ford, Lincoln, and Mercury cars. All IP that was purchased together with VCC was placed within the parent company Ford, and ownership to all new IP was also placed within Ford, enabling internal licensing schemes.

The integration of VCC was slowed down by the internal resistance among VCC engineers. In addition, cost control was much stricter within Ford than within VCC, also leading to friction between the two. One former top management executive described it as two cultures that met and could not collaborate. This resistance could have led to a decline in patenting at VCC in order to avoid ownership transfer to Ford. However, such a pattern was not developed. Instead, patenting increased within VCC. The patent culture was much stronger within Ford, and this culture was transferred to VCC during the time of Ford’s ownership.

Despite the internal resistance, VCC was closely interrelated with other parts of Ford by the middle of the first decade of the 2000s. The Volvo models C30, S40, V50, and C70 were all built on Ford’s C1 platform (for small cars), being shared with a number of Ford and Mazda models, and within which VCC had not much competence. VCC's main competence was on the larger platform Volvo P2 (Ford D3), which was however replaced by Ford's midsize platform EUCD for VCC's larger models, including Volvo S60, V60, XC60, V70, XC70, and S80, during the second half of the first decade of the 2000s (the XC90 was still based on VCC's P2 platform). The EUCD platform was shared with a number of Ford models, including Mondeo, Galaxy, and S-MAX. Thus, by the end of the first decade of the 2000s there were large technological overlaps and IP interdependencies between Ford and VCC, both for smaller (based on C1) and larger vehicles (based on EUCD or P2/D3).

*The second divestment process and the disintegration with Ford*

At this time, the dissolution process of PAG was initiated by the divestment of Aston Martin in 2007. In 2008, the process continued with the divestment of Jaguar and Land Rover to Tata Motors. Thus, by 2008/2009 when the divestment process of VCC (the last remaining business within PAG) picked up pace Ford had extensive experience from managing the IP disassembly problems and other disintegration issues during its previous divestments and employed a structured approach to deal with them. Nevertheless, the separation process took roughly two years and required large amounts of management resources.

Ford's approach to managing the IP disassembly problem included a categorization of different technologies and IP. Technologies that were owned by VCC at the time of Ford's purchase in 1999 were to accompany VCC to its new owner, and were thus transferred back to VCC ownership if previously transferred to Ford. Technologies developed after the purchase in 1999 were in general kept within Ford, while VCC received licenses for the technologies that were used by VCC at the time of the divestment. Such technologies were categorized according to its importance to Ford. The most important technologies were licensed to VCC by "limited licenses", meaning that there were strict limitations to the licenses, e.g., that the technologies could only be used in Volvo-branded vehicles built in VCC plants (this was a major potential deal-breaker that Geely acknowledged). The less important technologies were licensed by "broad licenses" that were, e.g., sub-licensable with Ford authorization. Finally, technologies developed by VCC after 1999 but completely without Ford involvement were to be transferred back to VCC (if formally owned by Ford).

In general, any technologies transferred to VCC were to be licensed back to Ford. VCC's vehicle architecture, Scalable Platform Architecture (SPA), and engine architecture, Volvo Environmental Architecture (VEA), to be used in VCC's future models were exceptions that did not include licenses back to Ford, since Ford had no need or plans to use these technologies. In general, the licenses were royalty-free and without time limitations, and the agreements included both patented and non-patented technologies. VCC's trademarks were still overlapping with the former owner AB Volvo, but trademark interdependencies could be easily handled thanks to the previous setup of Volvo Trademark Holding, and Ford's 50% share of the holding company was transferred to VCC in connection with the divestment.

In November 2009 Geely Holding Group was introduced as the preferred buyer. In contrast to the Saab case, separation agreements were mainly established before initiating negotiations, thus limiting negotiation-related transaction costs and hold-ups by clearly defining the business for sale *ex ante*. In the end, the deal was finalized when Geely acquired the VCC shares from Ford on August 2, 2010.

## A framework for managing the IP disassembly problem

So far we have characterized the IP disassembly problem, and related it to some of its causal factors and trends as driving forces in general and then illustrated it in some detail with a couple of cases. Now, what about its consequences and the possibilities to deal with them through management in general and technology and IP management in particular?

Just as the IP assembly problem increases transaction costs and thereby might impede product markets, the IP disassembly problem increases transaction costs and might, and in fact does as our cases show, impede the market for corporate control. Intertwined processes of corporate diversification and technology diversification, based on technology relatedness and genericness, offer strong economies of scale and scope, and curbing that driving force behind the IP assembly and disassembly problems is not justified as a means to reduce these problems. Similar arguments could be used for the other driving forces. Abolishing or reducing IPRs is not a realistic remedy either.[24] Reducing the IP assembly problem would reduce the IP disassembly problem in general but neither IP policy decisions nor IP management decisions can eliminate the problem.[25]

Rather, the approach taken here is to actually use IPRs and IP contracting as a governance tool for reducing coordination and transaction costs and risks of market failures. This approach is in line with viewing IPRs not only as incentivizing innovation investments and innovation disclosure but also as governance tools in and of innovation systems.[26] The economic perspective is then not only on correcting a market failure to provide sufficient innovation investments but also on transaction and coordination costs, while the legal perspective is not only competition law but also contract law and property law.[27] The management perspective has to be shifted accordingly from not only R&D and technology management but also to technology markets and licensing. IPRs are then two-edged in the sense that they could be used for solving the problems they create just as technological development could.

### Framework

A general approach to deal with an IP disassembly problem related to the divestment of a business consists of structuring the IP and technology portfolios according to specific IPs' and technologies' importance to the selling firm (SF) and the business for sale (BFS), respectively. A simple distinction can be made between (1) IP of core importance, (2) IP of non-core importance, and (3) IP of no importance, see Figure 1.[28] Each combination of importance for the SF and for the BFS, respectively, can then be matched with various types and combinations of IP contract provisions. Such provisions include (a) IP ownership transfer, (b) IP license, and (c) IP holding joint venture (JV). The suitability of various provisions depends partly on the symmetry of the importance for the SF and BFS, respectively, and Figure 1 provides a general guidance for the design of deal structures that could subsequently be subjected to negotiations.

| Importance for business for sale (BFS) \ Importance for selling firm (SF) | Core | Non-core | No importance |
|---|---|---|---|
| Core | License<br>IP holding JV | Transfer to / keep with BFS and license to SF | Transfer to / keep with BFS |
| Non-core | Transfer to / keep with SF and license to BFS | License<br>IP holding JV | Transfer to / keep with BFS |
| No importance | Transfer to / keep with SF | Transfer to / keep with SF | Divest<br>License to 3rd party<br>Store |

**Figure 1 Framework for managing the IP disassembly problem with dynamics over time *t***

An IP that is of roughly equal importance for the SF and the BFS typically requires a contract setup with roughly symmetrically distributed access and control (but not necessarily ownership) of the IP across the SF and the BFS. Direct co-ownership of IPRs is typically not recommended (despite its symmetry) since each party's control over the other's use of the IPR is then limited (in the US and many other jurisdictions one of the owners can, e.g., license a patent to a third party without the consent of any other owner). Co-ownership of IP can instead be accomplished by co-ownership of an IP holding JV, as in the case of Volvo's trademarks (being of core importance for both VCC and AB Volvo). An alternative is a license agreement, which was used for, e.g., the C1 and EUCD vehicle platforms in the case of VCC and the Epsilon II vehicle platform in the case of Saab Automobile (being of core importance for both the SFs and BFSs). When licensing in a symmetric relation, and especially for IP of core importance for both actors, the license can be designed to safeguard the interest of the licensee, but also of the licensor, by stipulating various clauses such as, e.g., grant-back clauses regarding future improvements. When Spyker Cars acquired Saab Automobile, the licenses were clearly not designed to obtain symmetry in terms of access and control for GM and Saab Automobile, respectively, and this had severe consequences for the latter. Such licenses are of course subject to negotiation and proper pricing, however. Less important IP can be licensed on broader terms, by contrast, which was the case for, e.g., various electronic details and interior designs that were of non-core importance to both Ford and VCC.

When an IP is of different importance for different actors, the IP is preferably transferred to or kept with the actor where it is of most importance, while possibly licensed to the other actor (if of any importance for the latter). In the case of VCC, ownership of the SPA vehicle platform and the VEA engine platform was transferred to VCC without a license back to Ford, since these architectures were of no importance to the latter, while most other technologies transferred to VCC involved a license back to Ford.

Finally, a by-product from the categorization work of available IP is the identification of IP of no importance to any of the involved actors. Such IP can then possibly be monetized by divestment or licensing to third parties.

**Dynamics, uncertainty, and diversity**

The long life time perspectives (e.g., 20 + 20 years backward and forward for old and new patents, respectively, much longer for well-kept trade secrets and copyrights, and indefinitely long for trademarks), the uncertain business and technology dynamics, and the frequent ownership and control changes are important sources of risk and uncertainty when managing the IP disassembly problem. A specific technology will not keep its importance in relation to the SF and the BFS forever. For example, it is likely that a divested BFS utilizing a firm-specific platform technology of the SF (e.g., GM’s Epsilon II in the case of Saab Automobile) will eventually switch this technology for something else, such as a technology of the acquirer or a BFS-specific technology, demonstrated by both cases. Thus, even though such a technology is of core importance to the BFS at the time of the divestment, its importance will eventually decline. The categorization of IP will therefore change over time, and the IP contract provisions designed at the time of the divestment should preferably consider such dynamics. Additionally new and future technologies with uncertain utilities must also be handled, explicitly or implicitly.

In the case of VCC, a number of measures were taken in relation to the dynamics and uncertainties of the IP disassembly problem. A few examples can be given here. Firstly, IP of core importance to Ford was licensed to VCC with a “limited license”, with strict limitations on how the IP could be used (see above). However, such licenses typically included clauses stipulating that the license would become a “broad license”, with much fewer limitations for the licensee, at a certain date in time at which the importance for Ford was forecasted to have declined. Such clauses then governed moves from core to non-core importance. Secondly, the license agreements typically included provisions stipulating options to overtake ownership of patents held by any of the parties if the current holder was about to terminate them, thus safeguarding the interests of the licensee if the patent would lose its importance for the licensor and patent holder. Finally, emerging and future technologies were reviewed internally at Ford by surveying R&D personnel, then classifying them either into the “limited license” (for core technologies) or “broad license” (for non-core technologies) category.

There is clearly a wide diversity of provisions available to mitigate the IP disassembly problem, and various licensing schemes provide a useful and adaptable governance tool. Apart from clauses regarding change of control, sub-licensability, grant-back provisions, etc., licenses can also be “segmented”, stipulating allowed use of the licensed IP in different applications, products, and markets. It is then easier in general to handle the IP disassembly problem if the SF and the BFS are not competing on the same markets.[29] Therefore, the first rounds of divestments in the two cases were less complex to handle than the second rounds, also from a pricing point of view since issues of cannibalizing sales and impact from future competition did not need to be taken into account.

The variety of contract models, modules, and clauses available for dealing with the IP disassembly problem, and for IP governance more generally, then calls for some kind of platform thinking in the legal area, i.e. to develop IP contractual platforms or contractual architectures, which are also scalable and customizable, similar to the thinking in automotive industry about their physical products.[30] Thus, managerial learning about how to arrange and rearrange contractual agreements and standardization of contracts as well as contractual innovations are called for in the process of mitigating the IP disassembly problem. Contractual development in a broader sense could also be observed to take place in general in different industries over several decades with different rates of learning, also as a result of different frequencies of disputes, which tend to drive contractual developments.

Although there is a wide range of contractual means to handle the IP disassembly problem, contingent claim contracting is costly and imperfect[31], as also illustrated by the cases. Therefore, and despite the diversity of contractual provisions available, personal relationships between the SF, the BFS, and the acquirer are playing an important role, even after a finished deal. In the case of Saab Automobile, the lack of personal relationships arguably played an important role in why a deal in the end could never be reached. By contrast, personal relationships and mutual respect between Ford, VCC, and Geely were arguably important in the case of VCC. Post-divestment disagreements and other issues regarding the separation were handled by a formalized business relationship group, and issues that could not be agreed upon were then raised to a CEO meeting. The fact that the CEO of Ford Europe was the former CEO of VCC then limited potential friction.

## Conclusion

The IP assembly problem, being related to but not determined by the tragedy of the anti-commons, has a reverse problem of disentangling or disintegrating IPRs between parties transacting on markets for technology and corporate control. We coin the term IP disassembly problem to denote the problem of separating and disintegrating IPRs for enabling a sale of a part of a company/business/project. This problem has almost went unnoticed in the literature, despite its occurrence in various business situations, occurrences that are likely to grow in numbers and varieties as a result of more frequent corporate restructuring and transactions, as well as a result of technological changes with increasing interdependencies and more frequent use of open innovation and IPRs. This paper presents two comparative cases from the automotive industry, representing various aspects of success and failure. In general, the IP disassembly problem is amplified by large overlaps in technologies, products, and markets, illustrating the interdependencies between the markets for products, technologies, and corporate control. Further, the problem is mainly related to management failures rather than inherent failures of the IPR system (as argued above), primarily calling for managerial remedies in order to mitigate the problem. This paper then presents a general framework for managing the IP disassembly problem by categorizing relevant IP in relation to its importance for the SF and the BFS, respectively, and matching it with IP contract provisions.

The paper has mainly emphasized contractual designs as solution approaches to the IP disassembly problem. However, models for IP valuation must accompany such contractual designs, and pricing of IP is then contingent upon the contractual solution of the IP disassembly problem, as illustrated by the Saab Automobile case. Fairness principles, such as fair, reasonable, and non-discriminatory (FRAND) licensing terms, is central for such valuation models, in private negotiations as well as in courts and legislative bodies (e.g., in cases of bankruptcy and compulsory licensing), and the use of such principles can limit transaction costs. Complex contractual designs make fair valuation a challenging task in both practice and theory, however, and much of this task has to be left for further research.

## Abbreviations

| | |
|---|---|
| BAIC | Beijing Automotive Group |
| BFS | Business for sale |
| CCC | Change of control clause |
| CEO | Chief executive officer |
| CTO | Chief technology officer |
| FDI | Foreign direct investment |
| FRAND | Fair, reasonable and non-discriminatory |
| GM | General Motors |
| IP | Intellectual property |
| IPR | Intellectual property right |
| JV | Joint venture |
| M&A | Merger and acquisition |
| MAD | Merger, acquisition, and divestment |
| PAG | Premier Automotive Group |
| QSE | Qualified scientist and engineer |
| R&D | Research and development |
| SAIC | Shanghai Automotive Industry Corporation |
| VCC | Volvo Car Corporation |
| WWW | World Wide Web |

## Notes

[1] Harold Demsetz. "Toward a Theory of Property Rights." *The American Economic Review* 57, no. 2 (1967): 347-59.

[2] Garrett Hardin. "The Tragedy of the Commons." *Science* 162, no. 3859 (1968): 1243-48.

[3] Paul A. David. "Intellectual Property Institutions and the Panda's Thumb: Patents, Copyrights, and Trade Secrets in Economic Theory and History." In *Global Dimensions of*

*Intellectual Property Rights in Science and Technology*, edited by M.B. Wallerstein, M.E. Mogee and R.a. Schoen. 19-61. Washington DC: National Academy Press, 1993.

[4] Gary P. Pisano, and David J. Teece. "How to Capture Value from Innovation: Shaping Intellectual Property and Industry Architecture." *California Management Review* 50, no. 1 (2007): 278-96.

[5] David J. Teece. "Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy." *Research Policy* 15, no. 6 (1986): 285-305.

[6] Joseph E. Stiglitz. "Knowledge as a Global Public Good." In *Global Public Goods*, edited by Inge Kaul, Isabelle Grunberg and Marc A. Stern. 308-25. Oxford: Oxford University Press, 1999.

[7] Michael A. Heller. "The Tragedy of the Anticommons: Property in the Transition from Marx to Markets." *Harvard Law Review* 111, no. 3 (1998): 621-88; Michael A. Heller, and Rebecca S. Eisenberg. "Can Patents Deter Innovation? The Anticommons in Biomedical Research." *Science* 280, no. 5364 (May 1, 1998 1998): 698-701.

[8] Ove Granstrand, Pari Patel, and Keith Pavitt. "Multi-Technology Corporations: Why They Have 'Distributed' Rather Than 'Distinctive Core' Competences." *California Management Review* 39, no. 4 (1997): 8-25; Deepak Somaya, David J. Teece, and Simon Wakeman. "Innovation in Multi-Invention Contexts: Mapping Solutions to Technological and Intellectual Property Complexity." *California Management Review* 53, no. 4 (2011): 47-79.

[9] Ove Granstrand. "Multi-Technology Management." In *The Economics and Management of Technological Diversification*, edited by John Cantwell, Alfonso Gambardella and Ove Granstrand. 296-332. London: Routledge, 2004.

[10] See, e.g., Ove Granstrand. *The Economics and Management of Intellectual Property: Towards Intellectual Capitalism*. Cheltenham: Edward Elgar Publishing, 1999; Bronwyn H. Hall, and Rosemarie Ham Ziedonis. "The Patent Paradox Revisited: An Empirical Study of Patenting in the U.S. Semiconductor Industry, 1979-1995." *The RAND Journal of Economics* 32, no. 1 (2001): 101-28.

[11] Ove Granstrand and Marcus Holgersson. “Multinational technology and intellectual property management - Is there global convergence and/or specialization?” *International Journal of Technology Management* (forthcoming).

[12] Henry W. Chesbrough. *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Boston, MA: Harvard Business School Press, 2003.

[13] John Hagedoorn. "Understanding the Rationale of Strategic Technology Partnering: Nterorganizational Modes of Cooperation and Sectoral Differences." *Strategic Management Journal* 14, no. 5 (1993): 371-85; John Hagedoorn. "Inter-Firm R&D Partnerships: An Overview of Major Trends and Patterns since 1960." *Research Policy* 31, no. 4 (2002): 477-92; Grazia D. Santangelo. "Corporate Strategic Technological Partnerships in the European Information and Communications Technology Industry." *Research Policy* 29, no. 9 (2000): 1015-31.

[14] Kenneth J. Arrow. "Economic Welfare and the Allocation of Resources for Invention." In *The Rate and Direction of Inventive Activity: Economic and Social Factors*, edited by National Bureau of Economic Research. 609-25. Princeton, NJ: Princeton University Press, 1962.

[15] The search was made on May 3, 2012, searching for Topic=("intellectual propert*" OR patent*) AND Topic=(merger* OR acqui* OR divest* OR "M&A*").

[16] Most records instead focus on the impact from M&As on innovativeness of firms and individuals, see e.g. Gautam Ahuja, and Riitta Katila. "Technological Acquisitions and the Innovation Performance of Acquiring Firms: A Longitudinal Study." *Strategic Management Journal* 22, no. 3 (2001): 197-220; Marianna Makri, Michael A. Hitt, and Peter J. Lane. "Complementary Technologies, Knowledge Relatedness, and Invention Outcomes in High Technology Mergers and Acquisitions." *Strategic Management Journal* 31, no. 6 (2010): 602-28; Srikanth Paruchuri, Atul Nerkar, and Donald C. Hambrick. "Acquisition Integration and Productivity Losses in the Technical Core: Disruption of Inventors in Acquired Companies." *Organization Science* 17, no. 5 (2006): 545-62.

[17] Terje Gudmestad, and Ove Tobia Gudmestad. "Protecting Intellectual Property During Divestitures and Acquisitions." *Research Technology Management* 41, no. 5 (1998): 36-39.

[18] Ziff, E.D. (2002) ’The effect of corporate acquisitions on the target company's license rights’, *The Business Lawyer*, Vol. 57, No. 2, pp. 767-792.

[19] Jasjit Singh, and Ajay Agrawal. "Recruiting for Ideas: How Firms Exploit the Prior Inventions of New Hires." *Management Science* 57, no. 1 (2011): 129-50.

[20] Land Rover was owned originally by British Leyland, then BMW, then Ford, then Tata Motors; and Saab Automobile by Saab, Saab-Scania, (Investor), GM, and Spyker Cars.

[21] This price tag was arguably more a result of Saab Automobile’s financial needs at the time than a result from a thorough valuation (independent commentators have been impressed by the amount of cash Saab Automobile managed to raise from these old technologies).

[22] The sales process had from the outset been driven more by Saab Automobile management than by GM management, and had actually been presented by executives at Saab Automobile to GM management as an alternative to closing down the business.

[23] The first solution presented, which involved the Russian investor Vladimir Antonov, had been refused by both GM and EIB.

[24] This is a big discussion as is well known, which must be left aside here.

[25] A list of remedies to the IP assembly problem at policy and management level is provided in Granstrand (1999) *op. cit.*; Ove Granstrand, ed. *Economics, Law and Intellectual Property*. Dordrecht: Kluwer Academic Publishers, 2003.

[26] See, e.g., Ove Granstrand. "Intellectual Property Rights for Governance in and of Innovation Systems." Chap. 10 In *Intellectual Property Rights: Innovation, Governance and*

*the Institutional Environment*, edited by Birgitte Andersen. 311-43. Cheltenham: Edward Elgar Publishing, 2006.

[27] As is well known IPRs such as patent rights with origins preceding industrialization have only in the recent century plus been regarded as property rights rather than privileges or concessions, a legal transition that has been criticized for overly strengthening the patent system and facilitating its capture by corporate rather than consumer interests. However, a property approach to inventive and creative ideas in return for their disclosure conveys advantages as property rights facilitates governance of them through management of and markets for ideas.

[28] Similar distinctions are, e.g., essential vs. non-essential, primary vs. secondary, and unique vs. non-unique.

[29] Note that complementary businesses might create other problems in relation to disintegration, since the future business of the SF is contingent upon the business of the BFS, and vice versa, and the two actors might therefore need to be interdependently governed in a similar way as for competing businesses.

[30] In fact, much work in law firms consist of reusing clauses in new contracts (cf. cut and paste).

[31] See, e.g., Oliver E. Williamson. *The Economic Institutions of Capitalism: Firms, Markets, Relational Contracting*. New York, NY: Free Press, 1985.