CHALMERS

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

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]

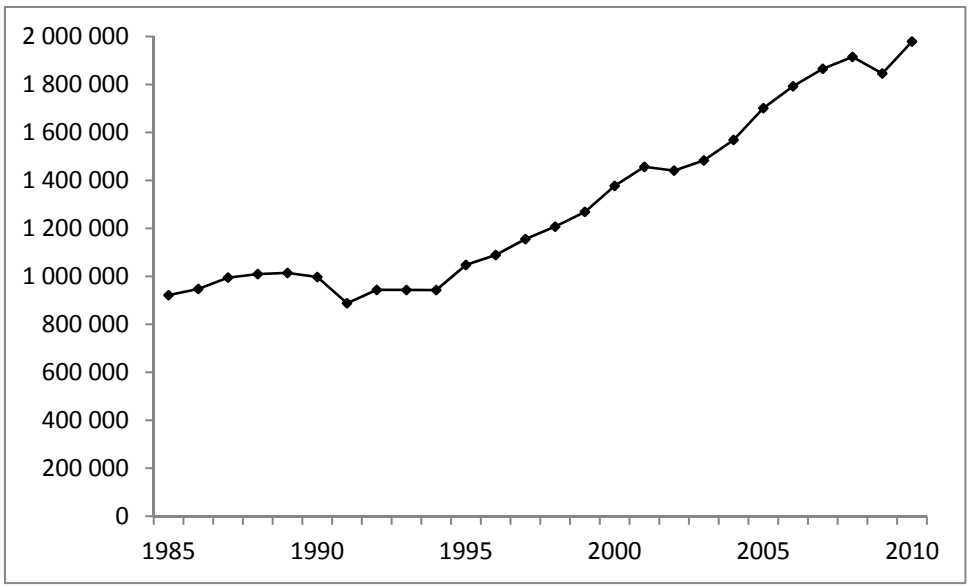
Table 2.1 Top ten patentees in terms of granted US utility patents in 1987, 2000, and 2011

	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.

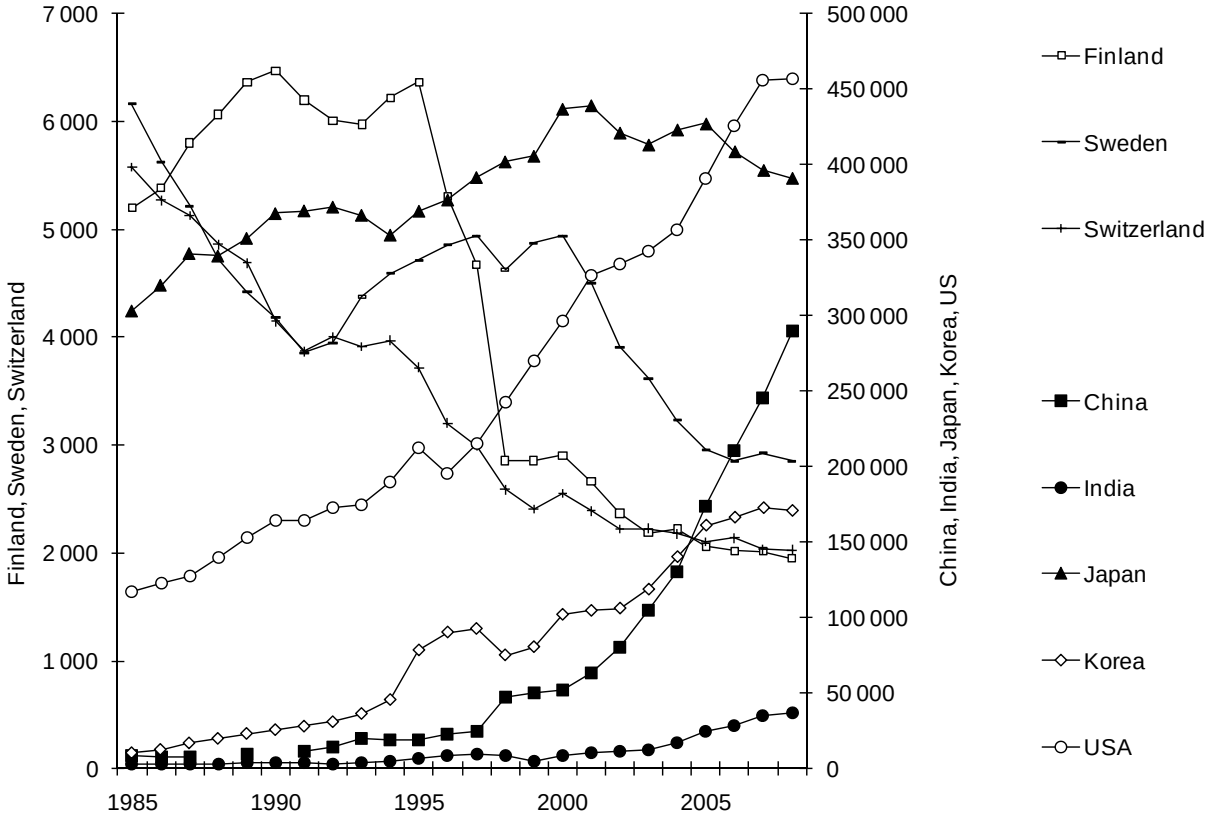
Third, some scholars compare market values of companies with low numbers of employees (e.g., Google) with market values of companies with high numbers of employees (e.g., Ford) to show that the relative value of intellectual capital in the world has risen since companies with only few employees nowadays 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 Product Service	Arundel and Kabla (1998), Brouwer and Kleinknecht (1999), Granstrand (1999)
Firm size	Large Small	Arundel and Kabla (1998), Brouwer and Kleinknecht (1999), Davis (2006), Hanel (2006), Kitching and Blackburn (1998), Mansfield (1986)
Industry	Chemical Electronics Mechanical Pharmaceutical Software	Chabchoub and Niosi (2005), Granstrand (1999), Hall and Ziedonis (2001), Mansfield (1986), O'Mahony (2003), Scherer (1983)
Technological complexity	Complex (‘Mul-tech’) Cumulative 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 Weak	Granstrand (2006b), Hu and Jefferson (2009), Keupp et al. (2010), Teece (1986, 2006)
Market structure	Competition Monopoly 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.

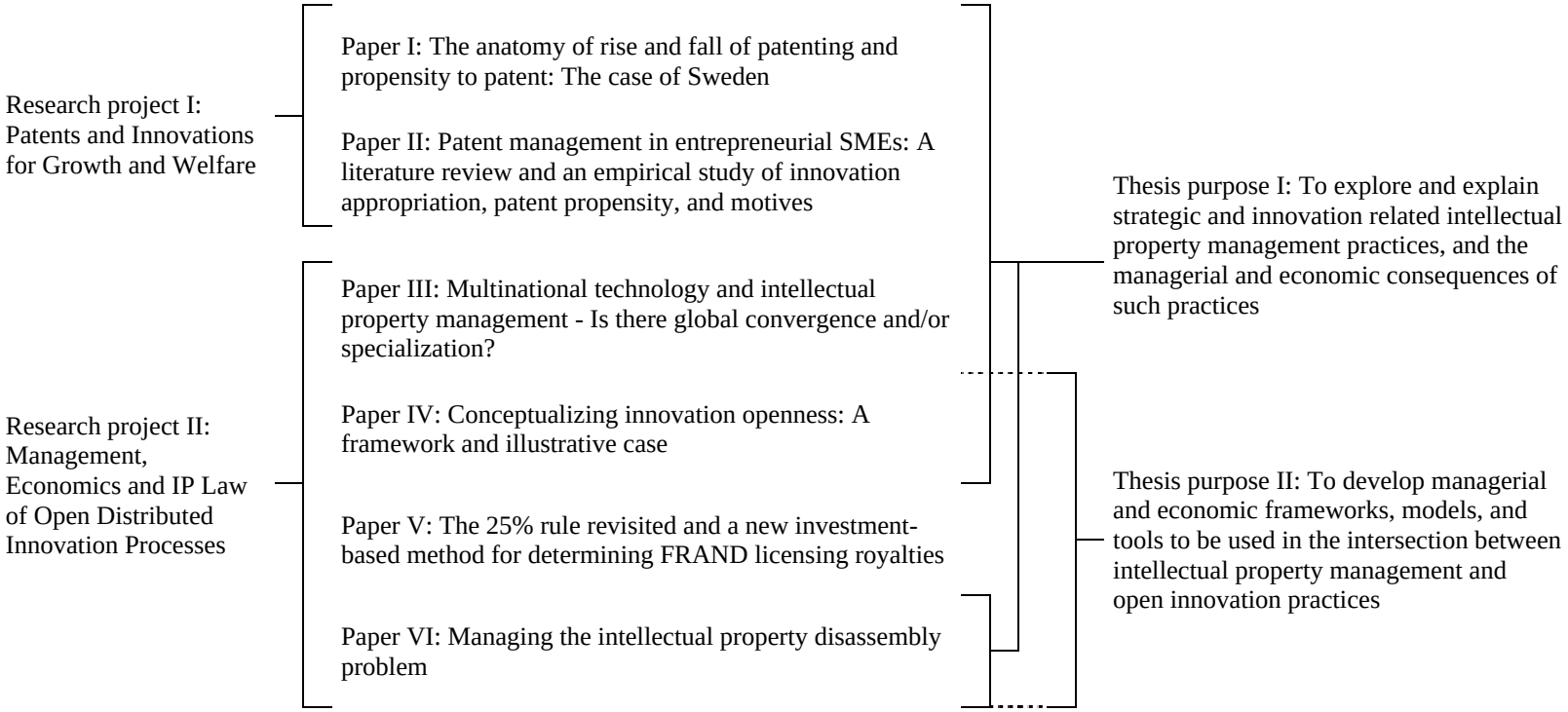


Figure 3.1 Relation between thesis purposes and appended papers

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? 2. What is the importance and role of patenting in entrepreneurial SMEs? 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? 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? 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.? 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 R&D Coordinator
Ericsson	Sweden	Vice President of Patent Strategies and Portfolio Management
EU-China IPR2	China	Team Leader
Evalueserve	India	Chairman Global Head of IP Operations
Huawei	China	IP Deputy Director 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 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 Researchers
Tata Consultancy Services	India	Head of Components Engineering Group Consultants
The Office of the Controller General of Patents, Designs & Trade Marks (CGPDTM)	India	Controller General 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 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

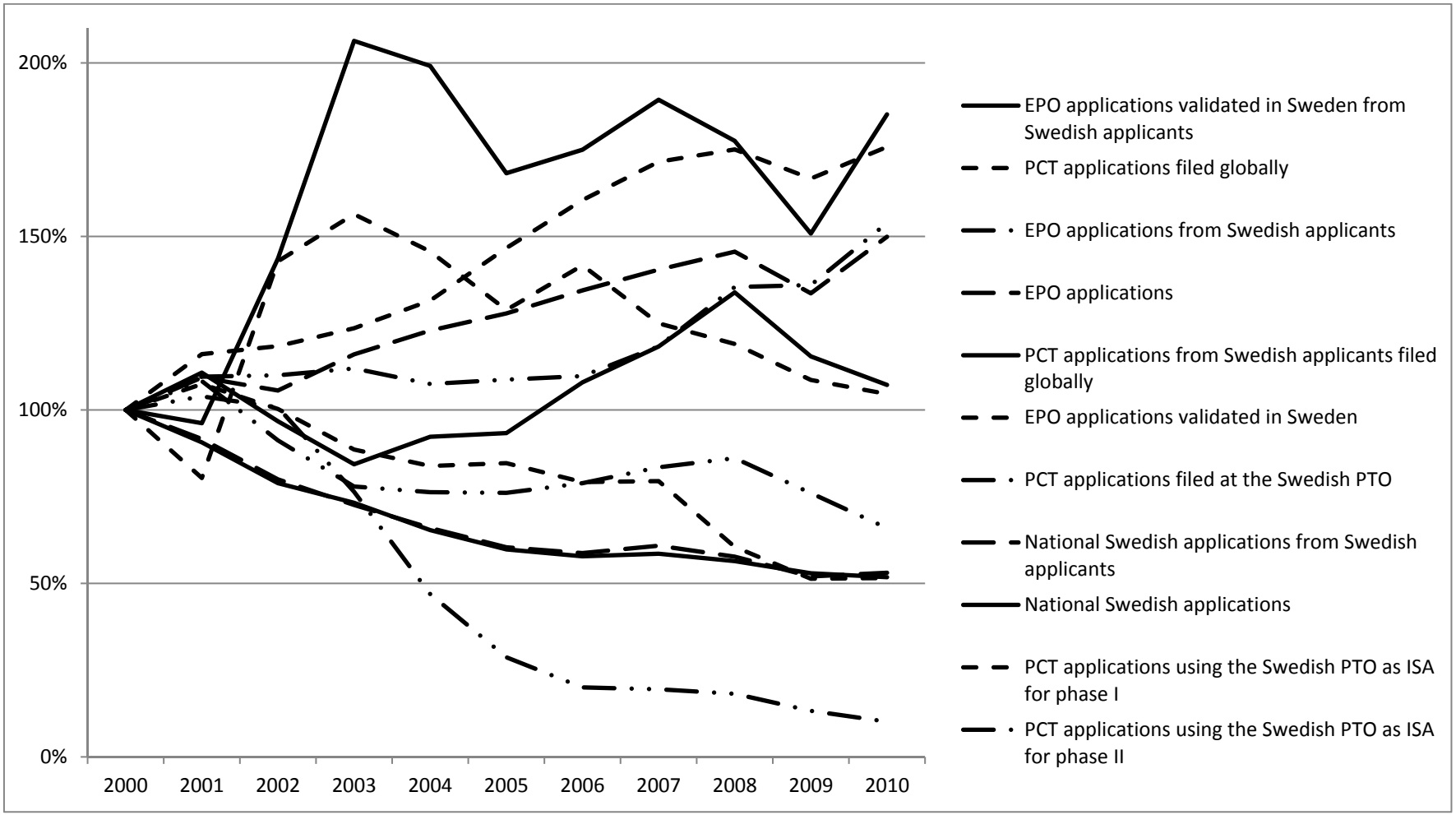


Figure 5.1 Normalized patent application streams (legend in order of normalized value for 2010, from highest to lowest)

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 applications[1)]
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.

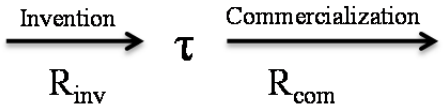


Figure 5.2 The innovation process

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, τ, 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, τ, 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.

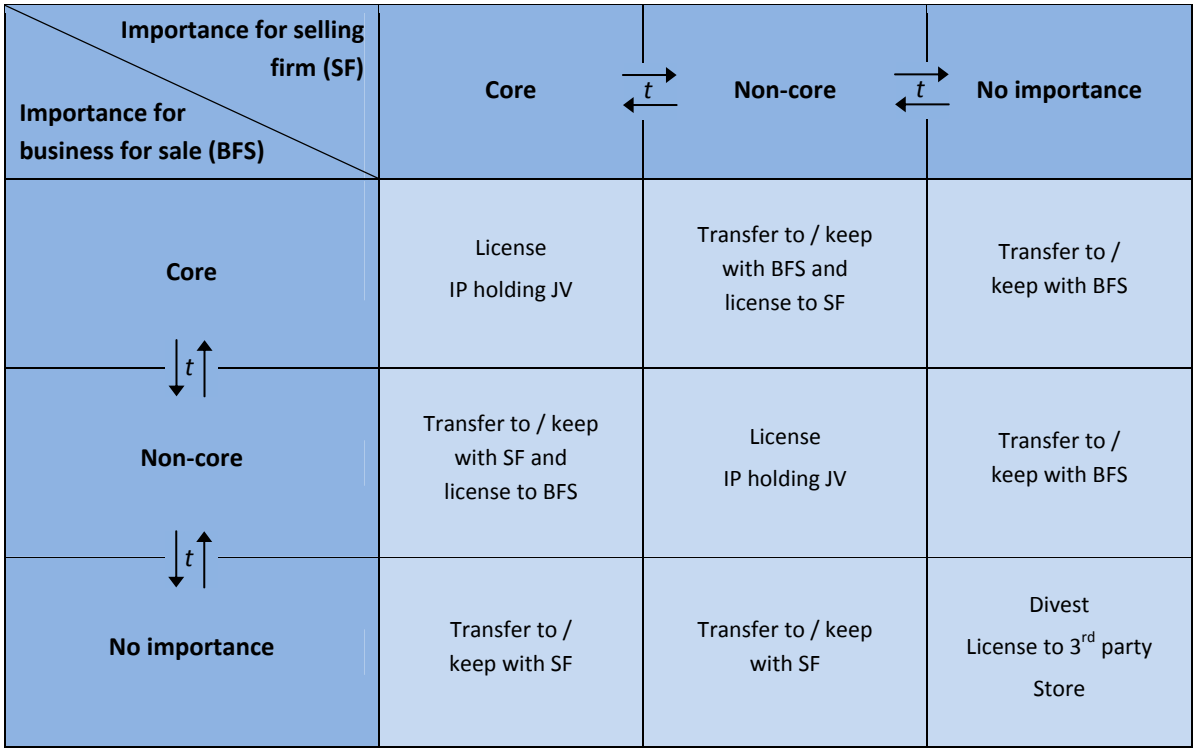


Figure 5.4 Framework for managing the IP disassembly problem with dynamics over time *t* (Paper VI)

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.

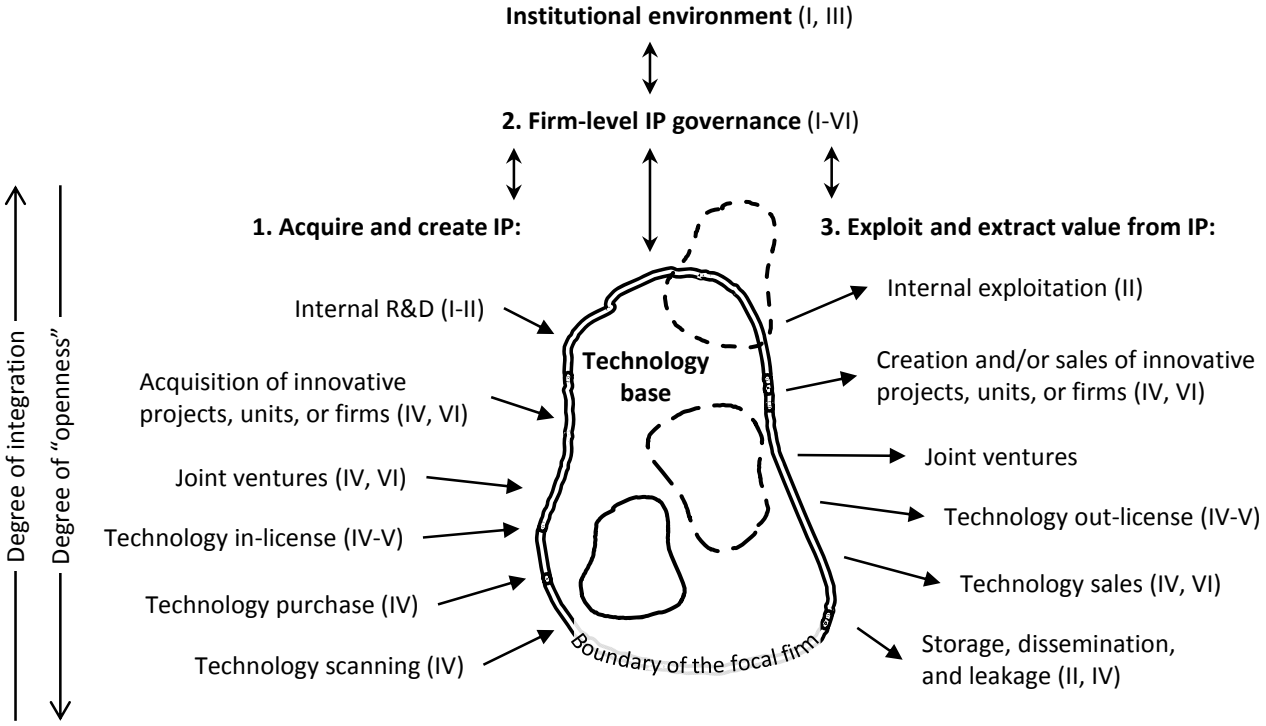


Figure 6.1 Elements of strategic management of technological IP (with parentheses indicating relations to the appended papers)

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

This paper is not included in the pdf-version of this thesis. Please contact Marcus Holgersson, marhol@chalmers.se, for a copy of the paper, or find it here:

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.

http://inderscience.metapress.com/content/6276u06048802585/

Paper II

This paper is not included in the pdf-version of this thesis. Please contact Marcus Holgersson, marhol@chalmers.se, for a copy of the paper, or find it here:

Holgersson, M. (2013) 'Patent management in entrepreneurial SMEs: A literature review and an empirical study of innovation appropriation, patent propensity, and motives', *R&D Management*, Vol. 43, No. 1, pp. 21-36.

http://onlinelibrary.wiley.com/doi/10.1111/j.1467-9310.2012.00700.x/full

Paper III

This paper is not included in the pdf-version of this thesis. Please contact Marcus Holgersson, marhol@chalmers.se, for a copy of the paper, or find it here:

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

http://www.ip-research.org/articles/multinational-technology-and-intellectual-property-management-is-there-global-convergence-andor-specialization/

Paper IV

This paper is not included in the pdf-version of this thesis. Please contact Marcus Holgersson, marhol@chalmers.se, for a copy of the paper. A version of the paper was presented at the 2012 R&D Management Conference:

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.

Paper V

This paper is not included in the pdf-version of this thesis. Please contact Marcus Holgersson, marhol@chalmers.se, for a copy of the paper, or find it here:

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.

http://www.lesi.org/les-nouvelles/les-nouvelles-online/september-2012/2012/09/06/the-25-rule-revisited-and-a-new-investment-based-method-for-determining-frand-licensing-royalties

Paper VI

This paper is not included in the pdf-version of this thesis. Please contact Marcus Holgersson, marhol@chalmers.se, for a copy of the paper, or find it here:

Granstrand, O. and Holgersson, M. (2013) 'Managing the Intellectual Property Disassembly Problem', *California Management Review*, Vol. 55, No. 4.