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

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

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

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

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

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

Abstract

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

Keywords

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

1 Problem

1.1 Background

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

1.2 Purpose

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

1.3 Concepts

A number of concepts are central for this paper. *Patenting frequency* concerns the number of patents per time unit (usually per year), while *patenting propensity* refers to the propensity (probability) to apply for and/or obtain a patent, given a patentable invention (Mansfield, 1986). A number of qualifying distinctions need to be made in connection with the concept of patenting frequency. Firstly, patenting frequency may relate to the number of patent applications being applied for at a specific receiving office (national, e.g. the Swedish PTO, or regional, e.g. EPO), by a specific applicant (firm or individual), or concerning inventions invented by a specific inventor. (The latter is not studied in this paper, however.) Secondly, patenting frequency may relate to the number of patents applied for or the number of patents granted. Thirdly, we also need to distinguish between basic patents and counterpart patents. A basic patent application, also called *priority patent application* or first filing (FF), is the first patent application for a specific invention, defining the priority date at which prior art should be evaluated. Counterpart patents in different selected countries are based on the same

original invention as the priority patent, and the corresponding subsequent applications are referred to as *counterpart patent applications*/filings or subsequent filings. Every priority application (first filing) at some patent office in a country being a Paris Convention signatory state gives international priority to any counterpart filing for one year after the filing of the priority application at the patent offices of other Paris Convention signatory states. A *patent family* is a set of patents constituted by the priority patent and its corresponding counterpart patents, usually limited to countries of special importance and value to the *patentee* (the patent applicant), e.g. in Europe plus Japan and the US (so-called 'triad families'). Finally, a patent application can be a national application, a regional application (e.g. to EPO), or an international (PCT) application. The concept of patenting propensity can then also be broken down into (conditional) probabilities to apply for a patent, using different filing strategies in terms of preferred application routes. Note that the nationality of a patent application is ambiguous, since it can refer to the nationality of the receiving PTO, the nationality of the applicant(s), or the nationality of the inventors. Issues of multi-nationalities of applicants or inventors complicate the picture further (see also section 4).

1.4 Outline of paper

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

2 Previous research and determinants of patenting

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

Kortum and Lerner (1998) investigated the reasons behind the increase in US patenting during the 1980's and 1990's and concluded that the increase was driven by changes in R&D management and increases in innovative activities with more applied R&D, and not as a result

of the establishment of the new, specialized Court of Appeals of the Federal Circuit (CAFC) in 1982. The latter had commonly been argued to impact patenting positively, as it strengthened US patents rights and thereby increased patent values in general. On the other hand, the study of US semiconductor firms by Hall and Ziedonis (2001) showed that this strengthening of patent rights had resulted in entry by specialized firms, vertical disintegration and patent portfolio races, and that it had actually spurred patenting.

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

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

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

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

The literature above has explicitly or implicitly pointed at a number of determinants of patenting frequency. Changes in R&D and patenting resources naturally have direct effects on patenting frequency. New technologies and patenting opportunities, shifts in R&D, product, or industry structures, leading to e.g. fewer patentable inventions per R&D dollar or shifts in the propensity to patent, also impact patenting. Studies (Granstrand, 1999; Hall and Ziedonis, 2001) have also shown that the role and importance of patenting might change, e.g. compared

to other appropriation strategies, again affecting patenting frequency. These determinants were used for developing the questionnaire used in this study, as further described below.

3 Method and data

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

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

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

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

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

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

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

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

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

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

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

4 The decline in Swedish patenting

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

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

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

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

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

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

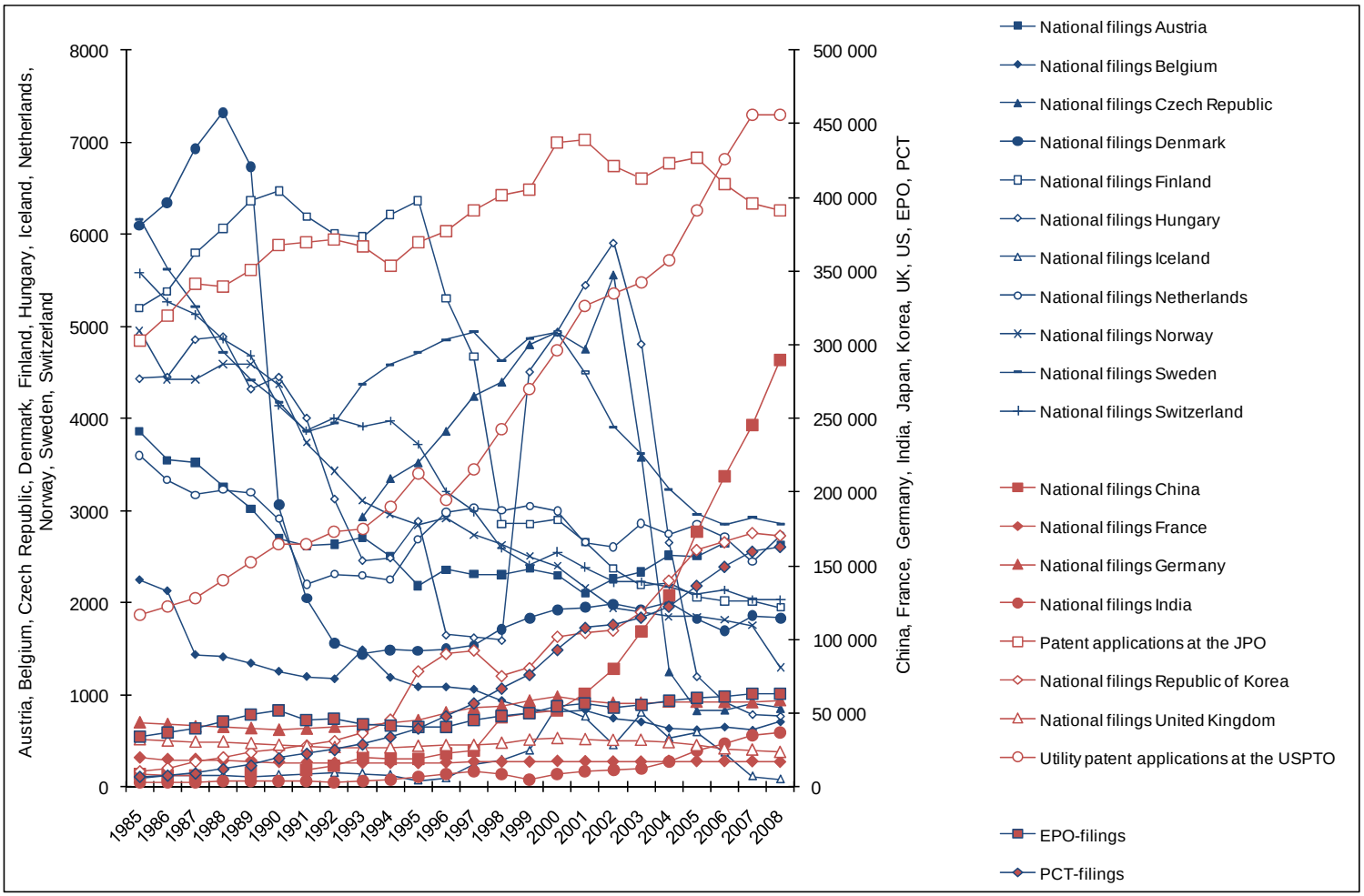
Thus, since 1992 the total number of national filings at the Swedish PTO (SFs) grew fairly continuously with a peak in 2000, from which a decrease by roughly a third occurred during a 4-year period. Table 1 besides SFs also shows the number of SFFs during 1998–2004. Similar to SFs, the number of SFFs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

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

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

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

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



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

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

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

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

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

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

Source: Swedish PTO data

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

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

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

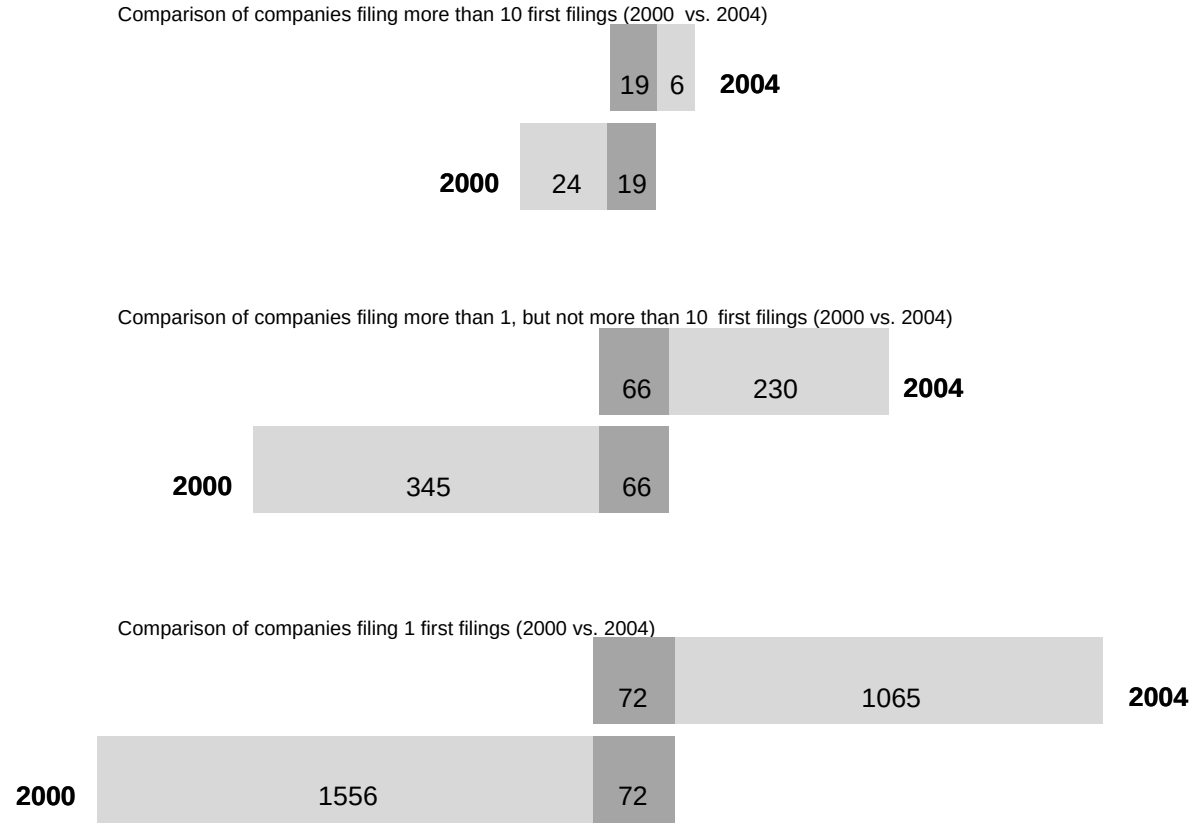
Source: Swedish PTO data

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

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

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

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



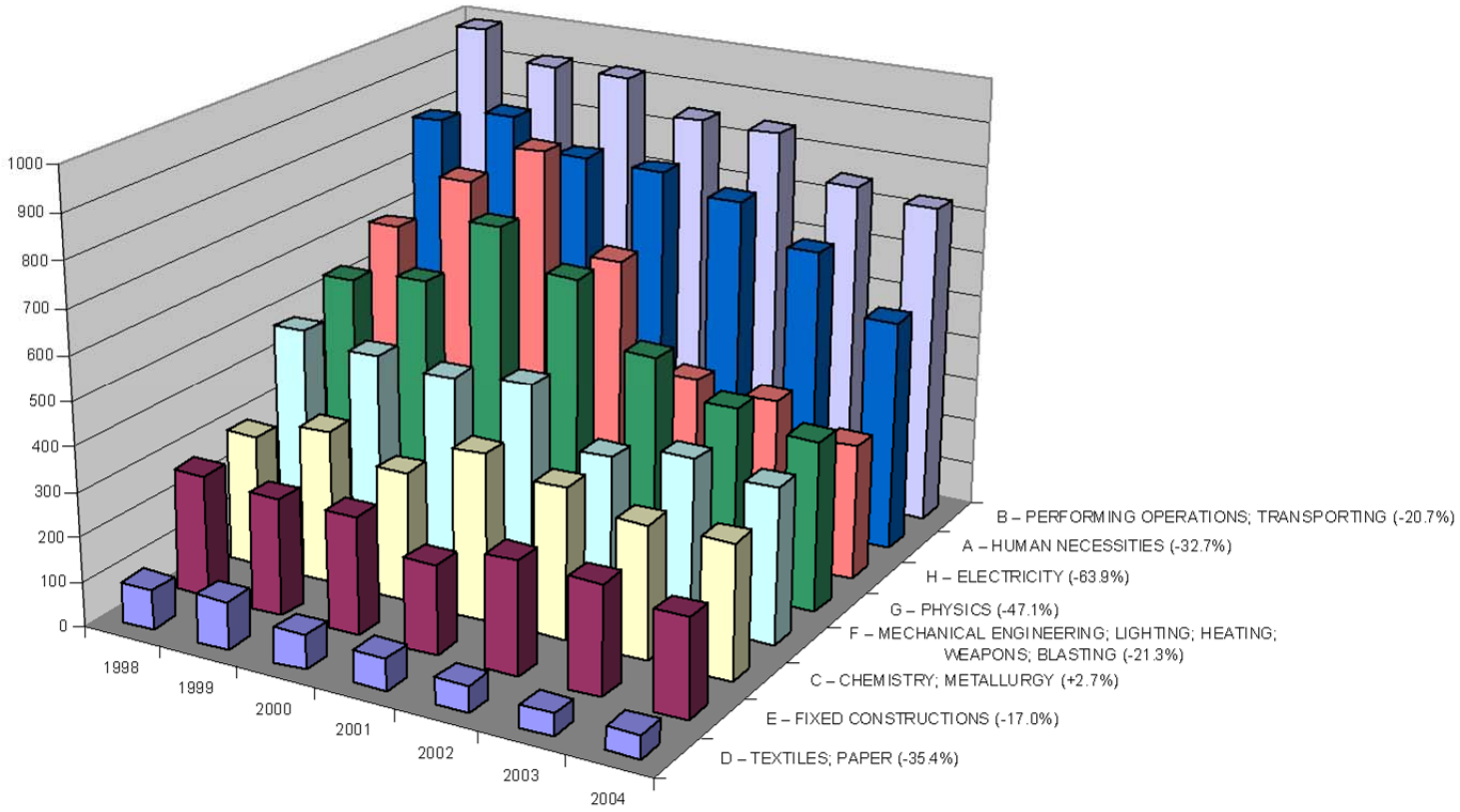
Legend:

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

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

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

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



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

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

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

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

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

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

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

Legend:

Avg # = Average number of

Tot # = Total number of

Diff # = Difference in number of

*Sourc*e: Swedish PTO data

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

the 1969-71 list. So in very rough terms there are about 30% exits and 30% entries over a 30-year period. This low turnover is in stark contrast with the high turnover of small, infrequent patentees, as shown above.

5 Explanatory factors behind changes in firms' patenting frequency

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

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

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

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

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

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

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

Weights of various factors as explanations for a decrease in first filing applications (scale: 0 = no weight, 4 = of decisive weight) [1]	**Large patentees 1998-2004**	**Small patentees 1998-2004**	**Patent consultancy firms 2001-2005** [2]	**Large patentees 1998-2004**	**Large patentees 1990-1997**	**Small patentees 1990-1997**	**Patent consultancy firms 1990-2000** [2]	Weights of various factors as explanations for an increase in first filing 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.

Source: Surveys

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

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

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

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

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

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

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

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

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

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

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

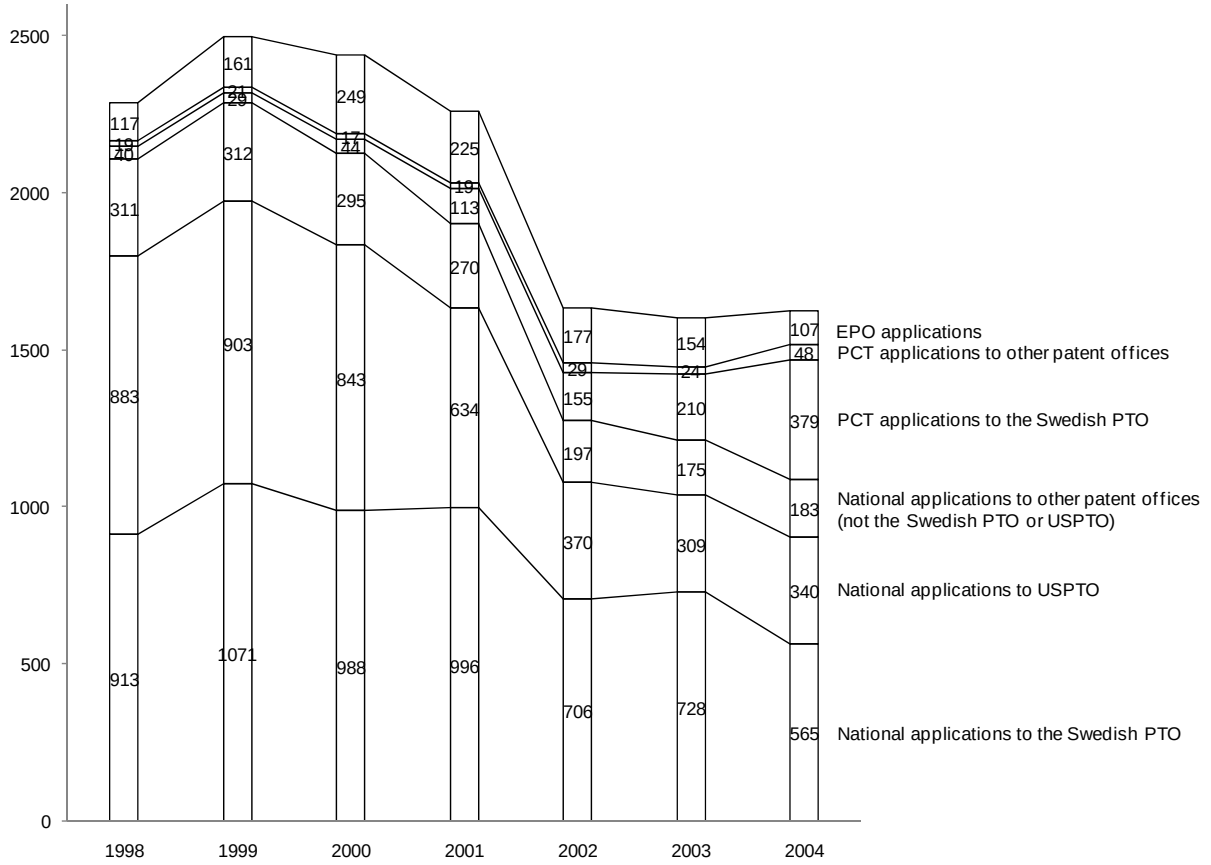
Source: Surveys

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

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

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

Source: Survey



Source: Survey

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

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

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

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

Source: Survey

5.1 Patenting in the USA by Swedish large companies

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

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

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

Source: USPTO statistics

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

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

5.2 Patenting in the USA by top country patentees

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

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

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

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

Source: USPTO statistics

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

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

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

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

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

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

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

7 Discussion

Traditionally, domestic companies and inventors in a country have chosen to submit first filings as national patents (i.e. not PCT applications or EP applications) to the patent office in the country in question. This traditional picture is changing, in that companies, especially large technology-intensive multinational companies such as Ericsson, ABB, and Nokia, internationalize their patent work and create managerial structures and processes for the submission of first filings of various types, e.g. for different product areas and technological areas, at different national and multinational patent offices through various routes (see Section 6). This change may quickly pick up pace, since patenting activities in large companies have become both more costly and more valuable during the pro-patent era, and have thereby also become a clearer target for thinking in terms of investments, cost savings, returns and economic efficiency and effectiveness. Such a change in turn quickly creates changing conditions especially for small patent offices in small countries with industries dominated by

domestic large multinational companies, for example Holland, Switzerland and Sweden. This leads, other things being equal, to a decrease of incoming patent applications for patent offices in small countries with many large multinational companies, such as Sweden. Statistics also show that a decrease occurred for national applications in Sweden, Norway, Finland and many other small industrialized countries during the early 2000s, simultaneously with a steady rise during virtually the entire pro-patent era since the 1980s in the USA, Japan and Korea, and lately also China and India. The decrease in Sweden during the first half of the 2000s was primarily attributable to Swedish applicants and in great measure to the patenting of large companies.

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

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

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

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

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

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

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

8 Summary and conclusions

Researchers have become increasingly interested in fluctuations in patenting frequency and propensity to patent since the productivity and patenting slowdown in the US in the 1970s and

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

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

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

for patent office resources, possibly opening up new opportunities for PTOs like the Swedish one through international collaborations, search services, and other service offers to firms as well as to foreign PTOs.

Acknowledgements

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

List of abbreviations

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

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