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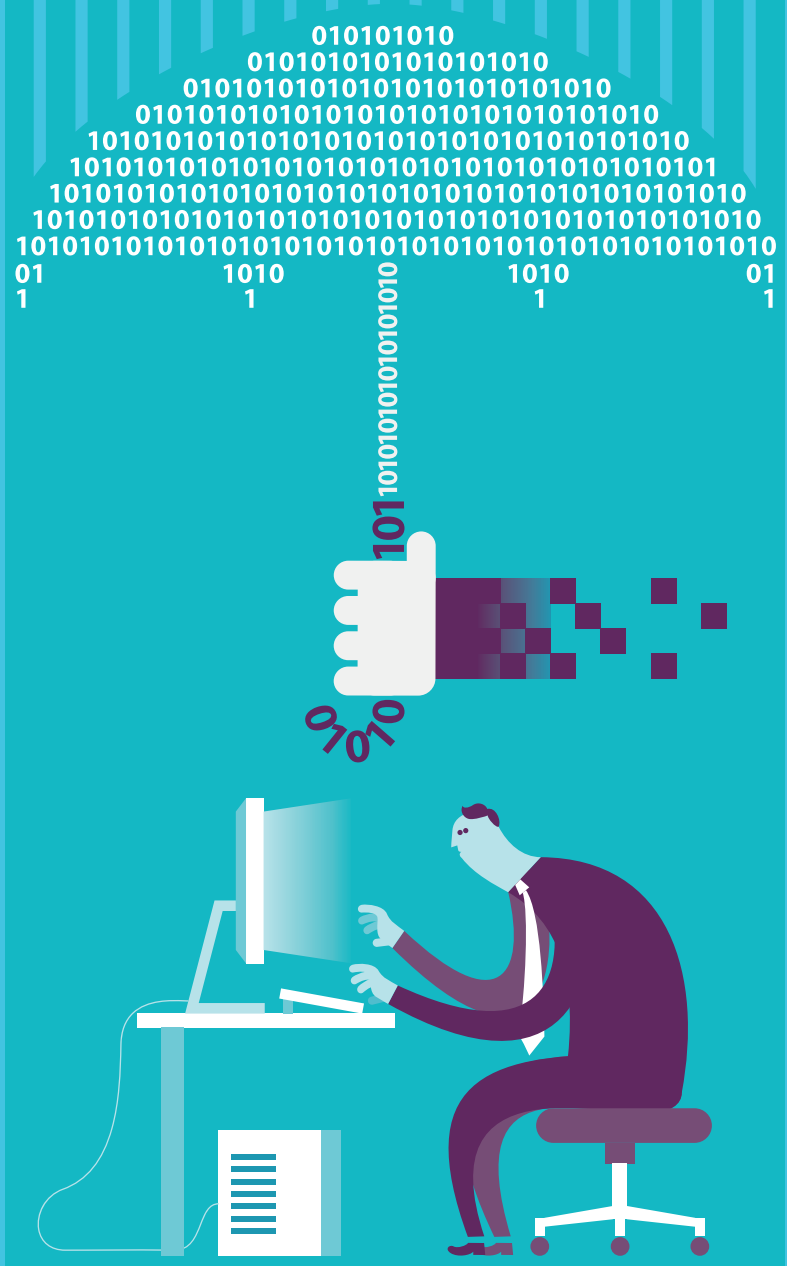

The economic impacts of computer-implemented inventions at the European Patent Office

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Content

Figures

Tables

1 Executive Summary

- We apply a rather “conservative” definition of Computer-implemented inventions (CII), strictly excluding “software as such” – in consequence, our data are minimum numbers
- Since about 2002, more than 35% of total filings at the EPO are CII patents.
- Non-EPC members have higher shares of CII patents at the EPO than EPC member countries.
- Germany is able to afford a rather low share of CII in total filings of about 21.5% in the 3-years period 2009-2011.
- However, the shares of CII patents also filed at the international level (EPO) is higher for CII than for the total of German patents, hence they are more relevant for the international competitiveness.
- CII more frequently target international markets, thereby securing international competitiveness – this holds at least for German applicants.
- CII plays a more important role in a number of sectors in Germany than in many other countries.
- Compared to all countries (54%), the share of “Computer, electronic and optical products” in total CII filings is lower in Germany (35%). This means that in Germany the role of CII in other sectors is higher than in most other countries.
- CII plays a more important role in a number of sectors in Germany than in many other countries.
- The most important motive also for CII patenting is the freedom to operate motive, followed by market motives, whereas exchange motives are less important. For large enterprises, all three motives (freedom to operate, exchange, and market) to file CII patents are more important than for SMEs.
- The vast majority of respondents with CII patents expects no or low positive consequences of a restrictive amendment of patent law for CII as neutral or even low.
- The impact on employment and market shares is rated higher by SMEs.
- In total, almost 1.4 million jobs were directly or indirectly dependent on CII in 2010 in Germany. These are 3.9% of total employment.
- In the manufacturing sector 14.2% (abs.: 963.000) of the jobs are dependent on CII

2 Introduction

From an economic perspective, the patent system is supposed to encourage investments in new technologies and inventions by reducing uncertainties for companies and researchers and allowing them to recoup their investments in research and development. It is thus designed to positively contribute to the development of the international competitiveness of an economy. Proponents of patent systems emphasize its planning reliability, the clarity of the rules and the resulting incentives for innovation. The opponents of patents, on the other hand, argue that the creation of temporary monopolies by patents slows down innovation activities and prevents competition for the best technological solutions.

In the field of patents for computer-implemented inventions (CII), this dispute continues. Critics argue that a computer program is not an invention in the strict sense, but a creative work that is to be excluded from patentability. They argue that, if anything, copyright protection is the right tool for the protection of computer programs.

These discussions, that are viable in many countries, have led to different practices for CII patenting at the patent offices in the world. While some harmonization has been seen in practice lately between US and Europe, e.g. via *Alice Corporation v. CLS Bank International (US Supreme court, 13-298),* substantial differences still remain, for example, in comparison with India and China. The practice within Europe has also during the 21st century been harmonized, but at least in theory, there are still some differences between the practice of the European Patent Office (illustrated by *T154/04 Duns Licensing* of the Technical Board of Appeal) and some European national practices, e.g. in Germany and the UK.

Besides these legal issues, it still remains an open question which economic effects arise from the possibility to patent computer-implemented inventions at the EPO and other European national offices. Software patents at the USPTO have been studied extensively (see for example Allison/Tiller 2003; Bessen 2011; Bessen/Hunt 2007; Graham/Mowery 2003; Graham/Mowery 2005; Hall/MacGarvie 2010), yet there are only few studies analysing the European system (Blind et al. 2005; Hart et al. 2000; Rentocchini 2011).

With regard to the policy side, the European Commission has made an advance to harmonise the patentability of computer implemented inventions in Europe in the year 2001. The aim was to achieve harmonized rules via a directive, which was pro patentability of computer implemented inventions with the intention to provide an increased incentive for R&D, investment and innovation. The EU institutions, however, could not agree on an appropriate text and the directive was never ratified. The serious attempts

from the European Commission ended in 2005, when the EU Parliament voted against the draft directive.

In the year 2013, a cross-party initiative was launched in the German Bundestag, which essentially would have had the effect of a strict restriction or even abolishment of the patentability of computer implemented inventions, if it would have been ratified. The argumentation was, essentially, that the copyright would be sufficient to protect also this kind of inventions. This initiative was mainly in favour of programmers and software developers who wanted to abolish protection of CIIs through patents and it was essentially asserting that these groups would suffer from the current practice of the patent offices in Germany and Europe.

Current European policy-making – and also policy-making in Germany – focuses on digitalisation of industry and products of daily life. Keywords like *Industry 4.0* or *Key Enabling Technologies (KETS)* (which also contain micro- and nanoelectronics) are guiding innovation policy making in many countries.

All these aforementioned activities, especially the approach by the German Bundestag, was completely lacking empirical evidence of the economic impact of computer implemented inventions and the potential threats of an abolishment of patentability. The research project that is documented in this report aims to provide this urgently needed empirical evidence – at least some of it. The focus is on the effective trends, activities, and competitive advantages/disadvantages of national economies from all around the globe at the European Patent Office. In addition, the contribution of economic sectors and the concentration of computer implemented inventions to certain economic sectors are also in the core of this analysis. Finally, we were interested in the companies' assessment of the current situation in Europe, both of those filing computer implemented inventions and those who do not. This also includes their motivation for filing patents in general and filing patents for computer implemented inventions as well as their expectations and the current and potential future impact on their competitiveness.

In this report we will address the following research questions:

- What is the share of computer implemented inventions at the EPO?
- Which industrial sectors file CII patents? How important are CII within certain sectors?
- How much employment and production volume is directly and indirectly dependent on CII patents?
- What is the motivation to file CII and how do companies assess the consequences of a change of the system in one direction or the other?

The aim of this study is thus to assess the importance of computer-implemented inventions for the German and European economy and to analyze how a change in the patent system towards abolishing patent protection for computer-implemented inventions would affect the international competitiveness of German and European firms.

3 The Legal Situation in Europe

3.1 The Definition and its Application

According to Article 52 paragraph 2 EPC and Article 1 paragraph 3 of the German Patent Law, programs for computers shall not be seen as patentable inventions. However, this rule is relativised in the subsequent paragraphs of both articles in the way that this only applies to computer programs/software “as such”. In the practice of patent offices in Europe, any solution which solves a specific technical problem by technical means is treated as patentable.

The above mentioned effective definition of computer-implemented inventions as "solutions that solve technical problems with technical means" says nothing about the context of the technical solution that is claimed, but expresses that an invention containing an element in the form of software is a computer implemented invention. Basically, three forms of computer-implemented inventions can be found:

- Firstly, devices in which some or all processes are controlled by a microprocessor, which is controlled by the means of software. Such devices have been in widespread use in the course of an increasing automation where the use of microprocessors but also complete computers is obvious; purely mechanical or discrete solutions, in contrast, are increasingly on a decline, mainly because of their lower stability and performance.
- Another range of computer-implemented inventions are processes (methods) which are computerized, i.e. where software-controlled computer or microprocessor monitors, regulates and/or controls the process. Their greater reliability and speed are the main reasons for their increased usage and the replacement of conventional designs.
- A subset is formed by software "as such", where indeed a tendency to permit patenting in Europe in at least a superficial departure from the legal patentability can be found, if it contains a technical effect that goes beyond the normal interaction of computers and software.

3.2 Counter positions and their assessment

One often heard objection – next to the assertion that software is adequately protected by copyright – is that patenting CII especially rushes small and medium-sized enterprises (SMEs) as well as independent programmers into economic problems. The associated distortions of competition are in favour of large and strong players, so the line of argumentation. In addition, prior art searches are lengthy and costly so that SMEs

could not afford them. Even if such a search does not identify a potentially infringed patent, this does not guarantee that actually no patent is offended, especially as the sometimes cryptic or only very general descriptions of the protected technology make their secure identification almost impossible. Patents are filed which do only describe the problem and the steps to solve the problem, but do not provide any precise and clear description of the technical means. Some of these objections will be discussed in more detail below.

3.2.1 Protection by copyright

Some argue that CII inventions are adequately protected by copyright. This protection fails, however, already in essential cases of technically oriented software; adequate protection for computer-implemented (microprocessor-based) methods cannot be reached this way. It is true that software enjoys copyright protection, as it can be directly derived from the inclusion of computer programs in the copyright law (§§ 69a et seq Copyright Act). However, these schemes cannot provide sufficient protection for technical solutions. This is true in terms of scope and especially with regard to the requirements for protection.

According to its legal consequences, copyright essentially retains its owner from decompilation (§ 69e) and unauthorized copies or other dissemination of the program (§ 69c of the Copyright Act), where it is always about the exact program written by the programmer. From the perspective of copyright, variations are only relevant to the extent in which it is still the same program. A replication in the sense of the patent law doctrine of equivalents is only to a limited extent covered by this scheme according to its own terms. For example, to control the braking force or to determine the ignition timing is not about whether competitors may copy or decompile this procedure or it incorporates software, but it is about protecting this particular process in itself.

It is of much greater importance that copyright does not offer – according to its premises – sufficient protection for technical solutions. A precondition for such protection is a copyrightable work, whose existence depends on what is called design height (originality) and for which the technical performance of the program has no relevance. For a protection under copyright law, the decisive factors are the form and manner of collection, classification and arrangement of the material as well as the individual design as an expression of personality and individuality of the work. Due to these factors, the protection by copyright fails in the case of "technical solutions by technical means" because this may cover the software used, but cannot capture the entire apparatus constituting the sensitive and vulnerable creation of the human mind. A comparison with a technically oriented state of the art is not foreseen by copyright laws. The protection of

such technically oriented methods is excluded according to the criteria of copyright. Copyright essentially protects the expression, while patent law protects the function contained therein, as longs as the conditions for patentability are given. The power of patent law is not lower than that of copyright.

3.2.2 Triviality of technical content

Significantly more weight is brought to the argument that process patents often only contain a special performance outside the technological aspect, while the technical elements are merely trivial or virtually non-existent. It is primarily about technical solutions which are dealing with processes that are solely or primarily not attributable to the field of technology. There is sometimes only an unspecifically illustrated note that these steps are to be processed by a machine – usually a special or general purpose computer. Such patents is common that only the individual steps of the method are determined while the technical implementation is referring to at most a very general description of the device or software used. The selection or design is left to the user, which also implies that both can be accomplished by average qualified users.

Such patents suggest providing patent protection for a technical solution not due to its technical peculiarities, but because it is an extraordinary, superior performance that originates in non-technical fields. In contrast, the technical performance already appears as trivial and insignificant, because from the perspective of the patent the user does not need any further explanation. The protection of such inventions is – and in so far the criticism of opponents of the patent systems is entitled – turning patent protection upside down, but on the other hand this kind of inventions are generally not patentable anymore.

3.2.3 Software Patents

Currently, the concept of computer-implemented inventions also increasingly subsumes such inventions that primarily have only a software reference and those where the hardware part is limited to the elements needed to run the software. Thus, a weighting is shifted in the direction of the software component, which is only defined by the intended result, the precise implementation in the necessary code is left open to the user. Probably the most highly contested group comprises patents which protect software (i.e. programs for computers). At first glance, it seems that such rights must not exist, as Article 52. 2 and 3, EPC and § 1 paragraph 2 and 3 of the Patent Law in Germany prohibit patents for such programs as such. In the reality of the patent system, a number of such programs exist, which only cover software in their patent claims. Usually, the steps to be followed and the desired result are described, but not the source

code itself (source code is in general prohibited in patent applications).The legal background is, first, that there seems to be a need for patent protection for software in industry. On the other hand, there is also the uncertainty of the practice of dealing with the prohibition on patenting. The German as well as the European law are founded on comparatively firm principles, which are, however, to a large extent implemented on an individual basis and a clear line is often not visible since the view on what is technical varies.

3.2.4 Legal status information

Another counter argument is that the room to manoeuvre for software developers and SMEs would be limited, since the effort to monitor the legal status would require too many resources. And even then legal uncertainty would linger on. A programmer, who developed a new procedure or used a method known to him, and added it to his program code (i.e., the source code written by him) for business purposes, should inform himself or know if this method is protected by a patent. However, this is the same situation as in all other fields of technology. The other way around, with regard to the program source code, a violation under copyright law is unlikely as far as the programmer creates his own form of expression. An "accidental infringement" of existing patents seems unlikely. The described methods usually require a considerable effort in the field of technical development. They do not occur as an accidental by-product while programming (writing the source code).

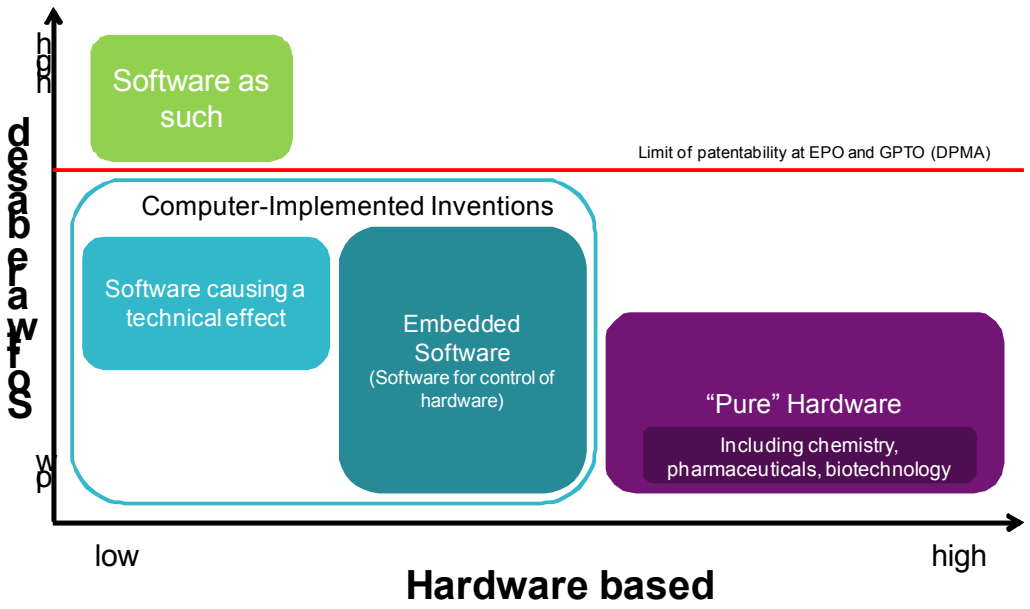
4 Methods and data sources

To carry out empirical analyses on the patenting activities for computer-implemented inventions, a technical definition for CII within the patent database is required. This technical definition can be achieved in various ways, for example by means of a technology classification (e.g. the International Patent Classification (IPC)) or by applying text search within the patents.

The prerequisite for a technical definition, however, is a literal definition of computer-implemented inventions. The definition applied here is based on the works by Allison and Lemley (2000), Bergstra and Klint (2007), Bessen and Hunt (2007), Rentocchini (2011) and Xie and Miyazaki (2013) as well as the definitions used by the European Patent Office (2007) and the European Commission (2002).

A computer-implemented invention describes any invention implemented on a computer or similar apparatus, which is realized by one or more computer programs and which has at least one new feature implemented with the computer program(s). The invention can directly cover ICT-related subjects (e.g. making backups, data compression) or indirectly cover ICT-related subjects that are used to operate other devices or apparatus. Although programs for computers as such are explicitly excluded from patentability at the EPO, a product or a method which is of a technical character may be patentable even if the claimed subject matter defines or at least involves a computer program. The definition, as well as a graphical representation of the definition for further clarity (Figure 1), can be found below.

Figure 1 Graphical representation of the definition of CII



Source: Own compilation.

4.1 Earlier works

Several previous studies have dealt with the technical definition and delineation of computer-implemented inventions. The different definitional approaches, however, do differ. This is due to the fact that the definition of computer-implemented inventions per se is difficult to capture, which is further complicated by the very technical description of inventions in patent documents. In addition, the objective pursued by the respective authors differs, which is even amplified by the differences in patentability of computer-implemented inventions.

Graham and Mowery (2003; 2005) used a purely IPC-based definition of "software-related inventions" for their analyses at the USPTO. A total of eleven IPC classes[1] (Graham/Mowery 2003) or twelve classes of the US Patent Classification[2] (USPC) (Graham/Mowery 2005), respectively, were applied for their definitions. The assumption hereby was that not precisely the entire universe of software patents can be mapped, but the chosen IPC or USPC classes, "[…] provide longitudinal coverage of a particularly dynamic and important segment of the overall software industry" (Graham/Mowery 2005, p. 15). To increase the accuracy of their hits, Graham and Mowery additionally limited their analyses to the patents of the 100 largest software companies in the United States. Bessen and Hunt (2007), however, argue in their study on software patents at the USPTO that patent classifications (e.g. IPC or USPC) are not sufficient for the identification of software-related inventions, as it does not become clear from a patent classification whether the technology actually is a software-related invention. The authors of this study therefore use a broad keyword search in the specification and the description of the patents in which the words "software" or "computer" and "program" must occur. A combination of several approaches, i.e. a selection of patent classes and keywords is possible. This was applied, for example, by Allison and Tiller (2003) in their study on USPTO software patents associated with internet technologies. The combination of keyword searches with the restriction to software manufacturing companies also represents a possible strategy to identify the relevant patents. This was for example used by Chabchoub and Niosi (2005) in a study of American and Canadian companies.

A comparison of these definitions by Layne-Farrar (2005) (with the exception of Chabchoub and Niosi (2005)) shows that Bessen and Hunt (2004) identified by far the largest amount of patents as "software patents", i.e. the keyword approach provides a fairly

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1 These are the IPC-classes G06F 3/*, 5/*, 7/*, 9/*, 11/*, 12/*, 13/*, 15/*; G06K 9/*, 15/* und H04L 9/*.

2 These are the USPC-classes 345, 358, 382, 704, 707, 709-711, 713-715, 717.

broad base of results. However, Layne-Farrar could also show that classification based search by Graham and Mowery led to patents that were not related to software and can thus be characterized as pure hardware in about 10% of the cases.

Similar to Bessen and Hunt (2007), Xie and Miyazaki (2013) used a keyword search to define relevant filings at the USPTO in their study on software-related patents in the automotive industry. Unlike Bessen and Hunt (2007), however, a larger number of keywords for searches in the title, abstract and claims of the patents was used. In addition, Xie and Miyazaki (2013) calculated the quality criteria *recall* and *precision* for each of their keywords to evaluate the accuracy of the matches for each keyword.3

4.2 Operationalization of the CII definition

The operationalization by Xie und Miyazaki (2013) serves as the basis for our operationalization of CII that is applied for all of the analyses throughout the study. We use all keywords identified by Xie und Miyazaki (2013) with precision values of 90% and above (compare Table 1). While this reduces the overall number of hits, it leads to a higher probability of only identifying patents that actually protect computer-implemented inventions. With the help of these keywords, in a first step, all patent filings at the EPO were searched within their title, abstracts and claims.

In the second step, the patent filings identified via the keyword searches were crossed with a prefabricated list of technology fields (35 fields of the WIPO list (Schmoch 2008)) in order to calculate the proportions of the identified patents in total patents filed in the respective technology fields. In the fields of "computer technology" and "data processing" nearly 74% and nearly 70%, respectively, of all patent filings were found using the search keywords. It thus becomes clear that, as Layne-Farrar (2005) had already indicated, there are patents filed in these two fields that actually feature pure hardware. Across the other fields the percentage of patents that have been identified as CII with the help of keywords is much smaller. However, it appears that computer-implemented inventions can be found across the entire range of technology fields. In addition to "electrical engineering", where the shares of CII patents mostly lie beyond 50%, comparatively high levels can be observed in medical technologies (almost 24%) and in "machinery and transport equipment" (between 10% and 18%). Even in chemistry and

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3 The precision measures the share of correctly identified elements in all identified elements, while the recall measures the shares of all correctly identified elements in all relevant elements. Consequently, the precision points towards the accuracy of a procedure, the recall towards its yield. Typically, an increase in precision leads to a lower number of errors but also to a lower recall and vice versa.

pharmaceuticals, shares between 4% and 6% can be found. The dispersion of CII patents across all fields indicates that a limitation to certain technology fields is not feasible. A purely IPC-based definition, on the other hand, would be bound to produce a large number of irrelevant hits.

Table 1 List of employed keywords (including Recall and Precision reported by Xie und Miyazaki (2013))

Keyword	Recall	Precision
[Micro]processor	18,6	100
Chip	0,7	100
Comput* program	8,8	100
Controller	26,0	100
Data	31,9	100
Digital	7,8	100
Integrated circuit	2,0	100
Image processing	1,7	100
Information processing	0,5	100
Processing unit	3,7	100
Program*	13,7	100
Software	5,4	100
Comput*	28,2	99,1
Signal processing	15,0	98,4
Identify*	10,0	97,6
Control unit	15,2	95,4
Memory	15,9	94,2
Calculat*	19,6	94,1
Electronic*	18,1	93,7
Monitoring	10,3	93,3
Imaging	2,9	92,3

Note: Here, recall and precision values by applying keyword searches in title, abstract and claims of patents based on Xie and Miyazaki (2013) are shown. For our analyses, only keywords with a precision of more than 90% were used. In addition, the keyword "information" was dropped due to too many Type II errors.

Source: Own compilation based on Xie and Miyazaki (2013).

In the third step, ten patents per technology field were manually examined in full text to check whether it is indeed a patent that protects a computer-implemented invention. The manual classification showed that none of the filings in the field "pharmaceuticals" actually protects a computer-implemented invention. In order to eliminate these erroneous assignments, all patents that exclusively belong to this field of technology (and not to any other field as cross-classifications are possible in WIPO35), were excluded from the analysis.

In a final step, the distribution of the identified CII patents across IPC classes was calculated (at the 4-digit level). The results largely reflect the picture from the analysis of the technology fields. CII patents are widely spread over IPC classes. As part of the manual identification, however, some patent filings, which are suspected to protect software "as such", have been found (these were not necessarily granted). To rule out that patents for software "as such" appear in our analysis, the patent classes H04L 29/06, G06F 11/30, G06F 17/24, G06F 17/30, G06Q 10, G06F 9/00, G06F 9/06, G06F 9/2, G06 9/3, G06F 9/4 und G06F 9/5 incl. occurring subclasses were excluded from the analysis in case they had been designated as a stand-alone class on a patent filing. This does not mean that all of these patents actually concern software "as such", but simply patents in these classes would generate a high level of uncertain hits. In this respect, the distinction used in this work represents a rather conservative estimate. The numerical results are thus to be interpreted as "real" towards the lower end of the distribution.

Even this complex process, however, might still lead to erroneous mappings in a certain share of patent filings, although this should be largely ruled out by the conservative approach of excluding certain IPC-classes. Yet, as Graham and Mowery (2003) argued, the entire universe of CII patents can not exactly be identified, although potential sources of error have largely been eliminated in advance.

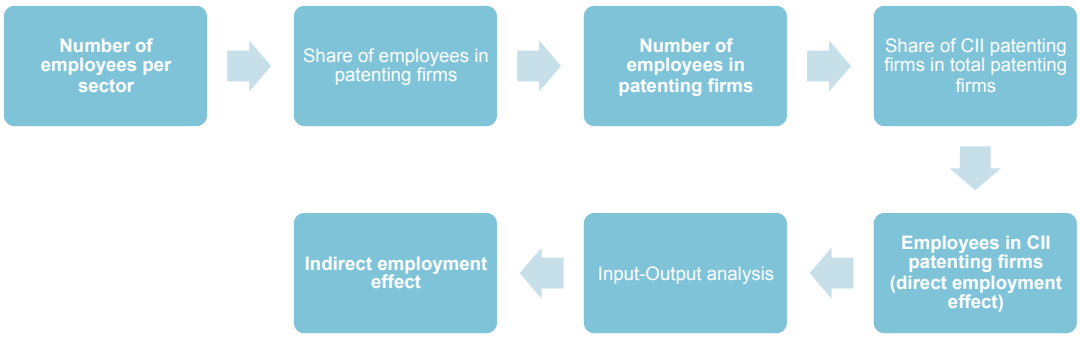
4.3 The data

The data we use for the study were extracted from the "EPO Worldwide Patent Statistical Database" (PATSTAT), which provides information about published patents collected from 83 patent authorities worldwide. All the patents in the dataset are counted according to their year of worldwide first filing, the so-called priority date. This is the earliest registered date in the patent process and is therefore closest to the date of invention. For the analyses, only filings at the EPO (including filings forwarded from the WIPO via the PCT system) from the priority years 2000 to 2010 are used. For the differentiation by countries, the country of the applicant is used, i.e. the address of the patent applicant is used for the country identification.

For more in-depth analyses, we also differentiate patent filings by the type of the patent applicant, that is large enterprises are distinguished from small and medium-sized enterprises (SMEs), individual inventors or universities and public research institutes. For this differentiation, first of all, individual inventors were identified by comparing applicant and inventor names. In case the applicant and inventor names were equal, the patent was coded as a single-inventor patent. In the next step, universities and public research organizations were identified with the help of keyword searches. This results

in a dataset where only companies are included. By using a matched dataset of Bureau van Dijk's ORBIS and the PATSTAT database, all companies with less than 500 employees were allocated to SMEs in a third step. Companies for which no information on employees was available and the ones that had not been matched the ORBIS dataset, were classified according to their filing numbers, i.e. all companies with less than ten patent filings in the period 2000 to 2011 were coded as SMEs. The final step included a manual check of our assignment of companies to SMEs and large enterprises.

Figure 2 Estimation of direct and indirect employment and production effects



For the estimation of direct and indirect employment and production effects a multistep process was applied. On the basis of sectoral employment and production data from the OECD, the shares of patenting firms (in total and in the field CII) were used (see Figure 2).

4.4 The survey

The aim of the survey was to find out how companies deal with patents as a protection tool for intellectual property in general and with regard to computer-implemented inventions. For this purpose, companies were asked to evaluate the existing and future developments (five-year period) of the number of patent filings as a whole and for CII. They should further indicate which other instruments or mechanisms they use for IP protection in general and for CII and to rank these instruments by their importance. Further motives to patent and the intensity of competition in the field of CII as well as their change in the last five years were to be assessed. This was followed by an assessment of the potential consequences of an amendment in patent law for CII.

Table 2 Overview of the questionnaire

Question nr.	Content
Q1	Existence of inventions within the firm
Q2	Number of inventions in 2013 (total) Number of CII inventions in 2013 Number of patented inventions in 2013 (total) Number of patented CII inventions in 2013
Q3	Evaluation of the general experience with patents as a tool of intellectual property protection
Q4	Evaluation of the current and future development of patent filings as a whole and in the case of CII (five-year period)
Q5	Usage of other instruments/mechanisms for the protection of inventions (total and CII)
Q6	Ranking of the importance of instruments: patents, other formal and informal instruments (total and CII)
Q7	Patent motives (total and CII)
Q8	Motives not to file patents for inventions (total and CII)
Q9	Assessment of the competition intensity with regard to CII and its change in the last five years
Q10	Assessment of the consequences of a restrictive amendment in patent law for CII
Q11	Assessment whether protection should be extended to software „as such“
Q12	Assessment whether protection mechanisms should be altered to improve the protection of CII
Q13	Assessment whether protection mechanisms should be altered to improve the protection of software "as such"
Q14	Assessment of alternatives to the current legal arrangements for IP protection for CII
Q15	Evaluation of the cooperation intensity for the purpose of product development
Q16	Position of the respondent in the company
Q17	Main activity (=highest share of value added) of the company
Q18	Year of foundation Number of employees in 2013 Number of R&D employees in 2013 Sales on the domestic market in 2013 Share of sales with new (new for your company) products in 2013 Export rate in% of sales in 2013
Q19	Estimated annual sales of the company by product type (Software, CII, other products)

Source: Own compilation.

Both, the letter and the questionnaire were available in three languages (German, English and French). German and Austrian companies were automatically provided with a German questionnaire, French companies with the French version. All other businesses were asked to complete the questionnaire in English, although they were able to switch the language depending on their preferences. The field work of the questionnaire lasted five weeks. Table 2 provides a substantive overview of the questionnaire.

Selection of the sample

By combining the information on patent applicants from the PATSTAT database with company information for the *Hoppenstedt* company database, our sample was selected according to various criteria. These are summarized in the list below:

- German companies with CII filings (n=2,051);
- Foreign companies with CII filings within the EU (n=784);
- Foreign companies with CII filings outside of the EU (n=1,295);
- Control group: German companies with non-CII patent filings (n=2,038);
- Control group: German companies without patent filings (n=2,158).

Table 3 Survey waves

Date	sur-name.lastname@domain.com	S.lastname@domain.com	Slastname@domain.com	name@domain.com	Via mail	Sum
05/13	7,983					7,983
05/14	35	4,554				4,589
05/14	1,442	3	3,791			5,236
05/16		182		974		1,156
05/19	77	198	373	378		1,018
05/22		48	53	54		155
05/27	65	456	426	2,849		3,795
06/04					1,920	1,113
Sum	9,602	5,441	4,643	4,255	1,920	25,861
Delivered	4,161 43%	798 15%	388 8%	354 8%	1,635 85%	

Source: Own compilation.

In sum, 8,291 companies were selected and asked to participate in an online survey with regard to patenting in the field of CII. After two weeks, the respondents were reminded to fill out the questionnaire. The respondents hat the possibility to participate in several ways, i.e. online or by printing the questionnaire and sending it back via mail, fax, scan or e-mail. In case where no e-mail addresses were available, the questionnaire including the cover letter was sent by mail, with the option of responding online or via the above mentioned channels. Due to the distribution of e-mails to different ad-

dress variants, the questionnaire was split into several waves. Table 4 provides an overview of the distribution paths.

The net response rate of the questionnaire was 5.4%, i.e. 361 responses were collected. An overview of the response rate by type of distribution channel can be found in Table 4. The firms in the sample are responsible for 1.8% of all EPO filings and 1.5% of all CII filings at the EPO in the period 2009 to 2011. The German companies, which have the highest response rates in the survey, are responsible for 9.7% of all EPO filings and for 13.9% of all CII filings by German applicants. A non-response analysis (comparison of those who answered and those who did not) revealed no significant difference between respondents and non-respondents in terms of size (both employees and turnover). However, a significant difference can be found in terms of sectors, i.e. there is a slight sectoral bias with regard to the respondents, which has to be kept in mind for the interpretation of the results.

Table 4 Response rate by distribution channel

Channel	**Contacted**	**net contacts**	**bounced**	**responses**		**net contacts**	**bounced**	**net response**
E-mail	8.281	5.040	3.241	280		3,4%	39,1%	5,6%
Mail	1.920	1.590	330	81		4,2%	17,2%	5,1%
Total	10.201	6.630		361		3,5%		5,4%
additional reactions								
abortions				168				2,5%
denials				101				1,5%
total reactions				630				9,5%

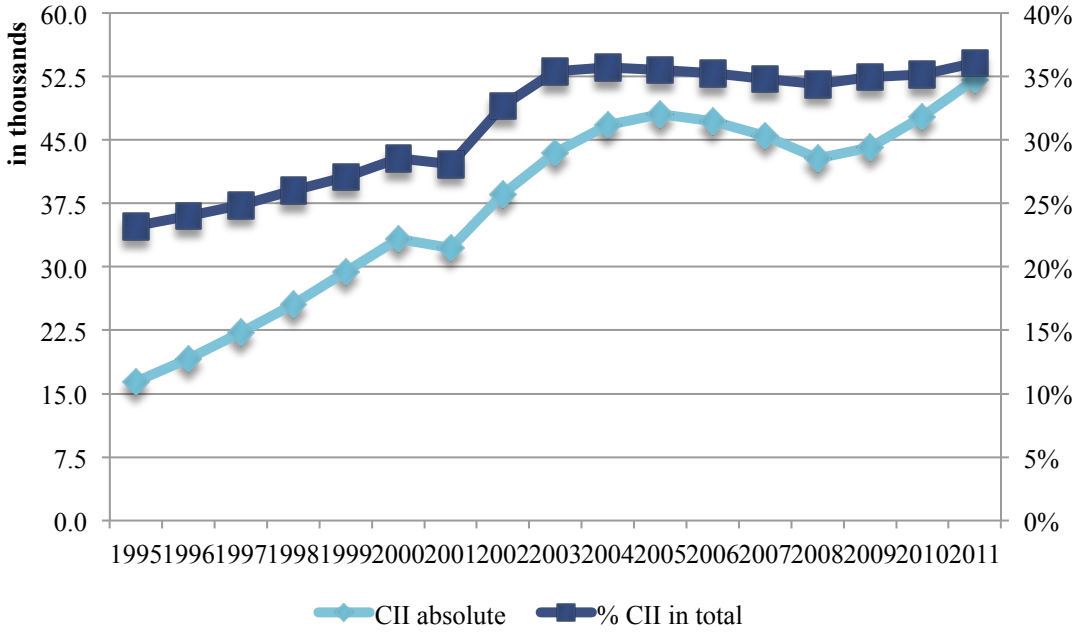
Source: Own compilation.

5 Empirical Results

5.1 Database analysis

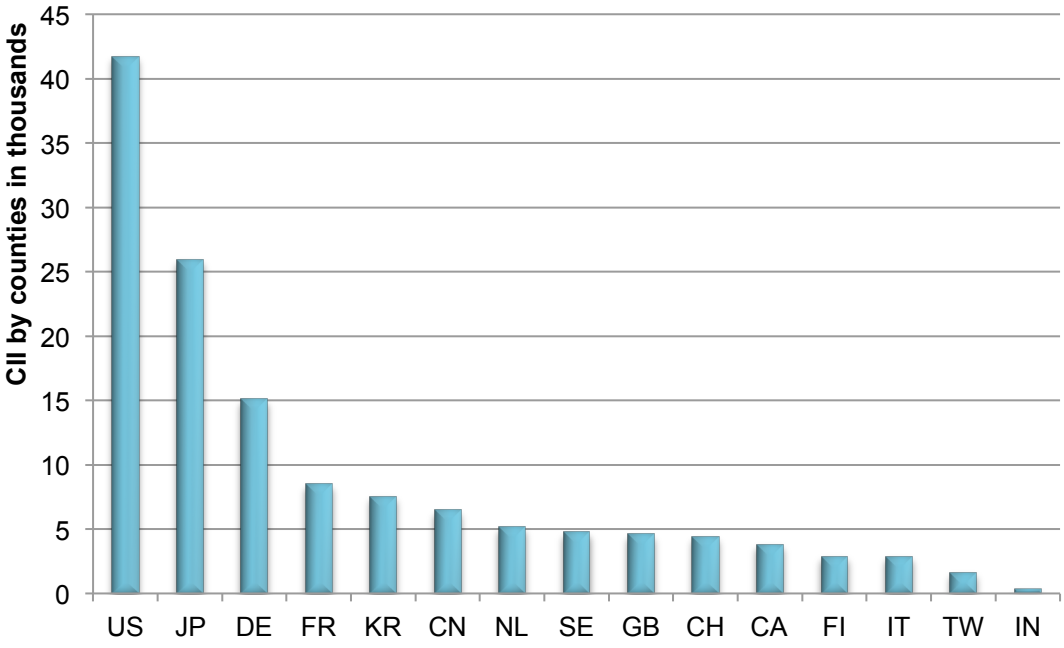
The absolute number of CII filings has grown steadily since the mid 1990s - with two exceptions by the financial crises in 2001 and between 2007 and 2009. Since 2002, more than 35% of all filings at the EPO are CII filings. The shares of the EPC member states in total applications are higher than for CII applications (not shown). This means that companies from non-EPC member states show higher levels of CII filings than EPC member states. The majority of the CII patents are filed from applicants from the USA and Japan, followed by Germany, France and Korea. China has greatly caught-up in recent years, but still ranks just ahead of the Netherlands, Sweden and the UK. The highest shares of CII filings in total filings by country can be found for Canada and Finland, followed by Sweden and China, each with around 50% of CII within all EPO filings of the respective country. Germany ranges at a comparatively low level with 21.5% in the period 2009 to 2011. The proportion of patents, however, which is not only nationally (at the GPTO), but also internationally (at the EPO) filed, i.e. the internationalization rate, is above average for Germany, which demonstrates a high relevance for international competitiveness. When differentiating the filings by SMEs and large enterprises, it can be found that the largest shares of CII filings come from large firms. However, it is interesting to note that SME shares at the USPTO are lower than at the EPO and, even more interestingly, the shares of filings in the field of CII (at the EPO and at the USPTO) are below the average shares of SME filings.

Figure 3 Absolute number and shares of CII priority filings in total filings at the EPO



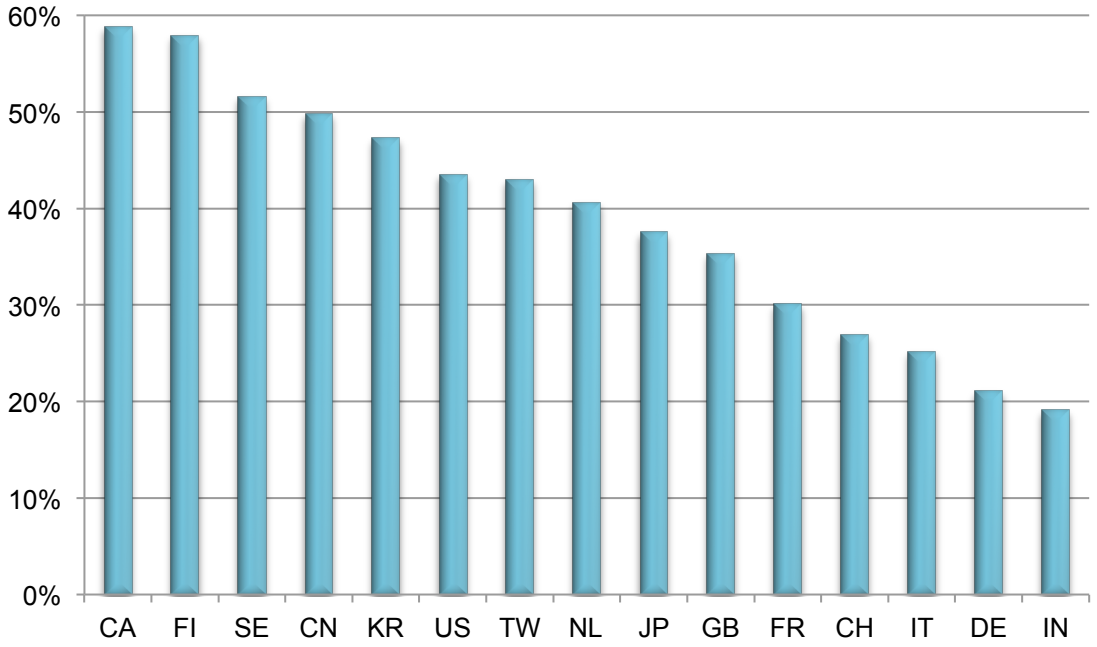
Source: EPO - PATSTAT, calculations of Fraunhofer ISI.

Figure 4 Absolute numbers of CII priority filings at the EPO by applicant countries, 2009-2011



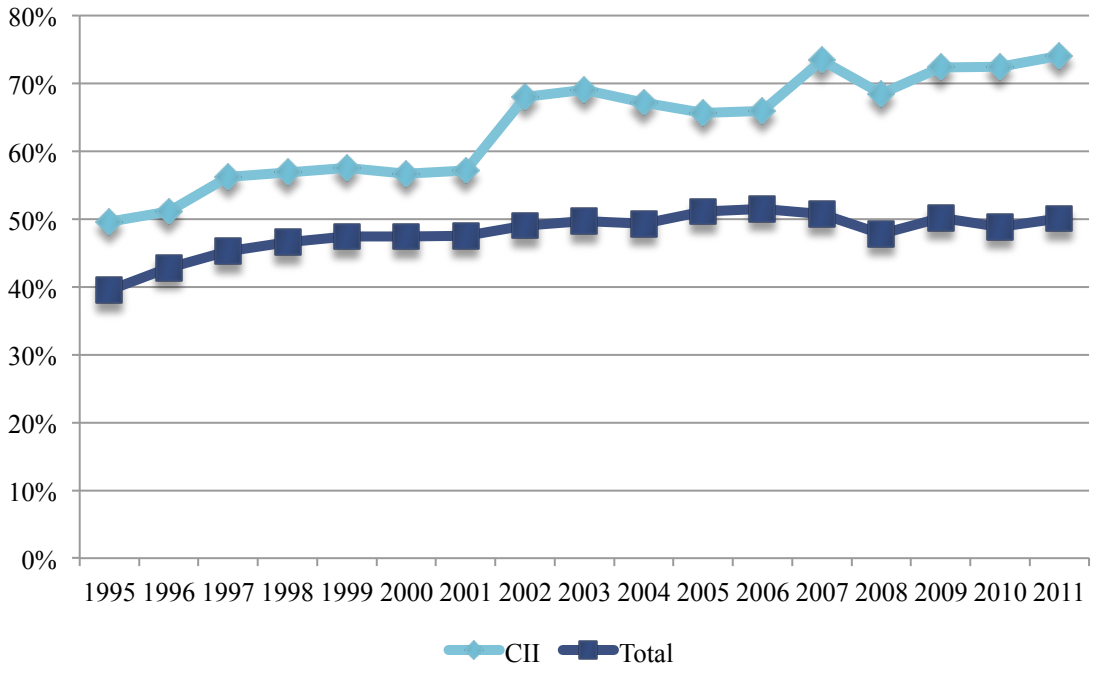
Source: EPO - PATSTAT, calculations of Fraunhofer ISI.

Figure 5 Shares of CII priority filings in total filings per country, 2009-2011



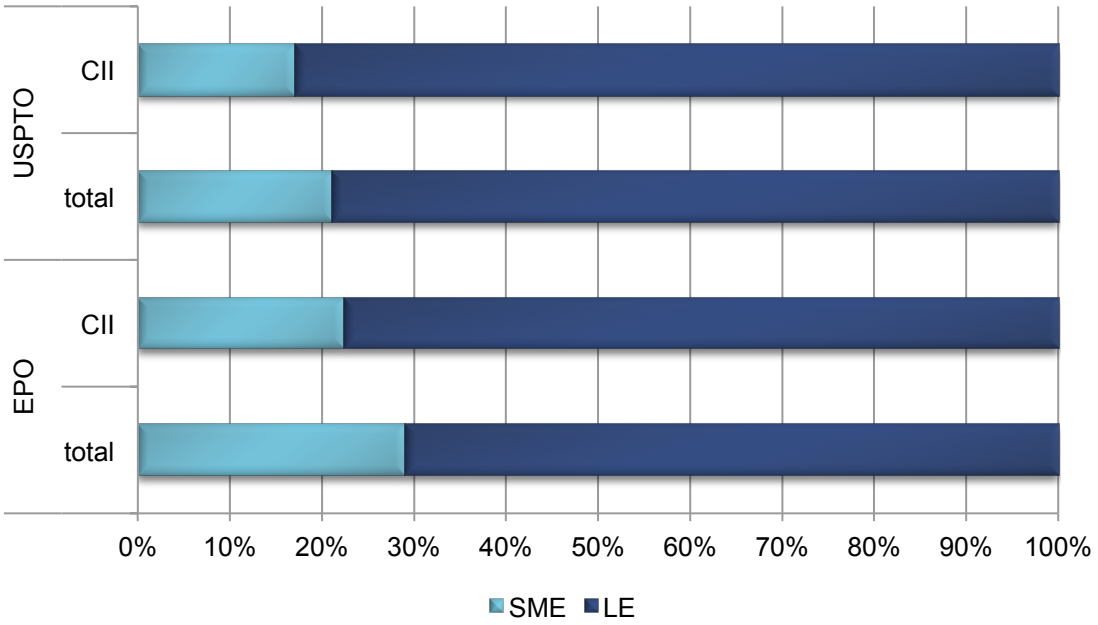
Source: EPO - PATSTAT, calculations of Fraunhofer ISI.

Figure 6 Shares of German applications at the GPTO also filed at the EPO – "Internationalization rate"



Source: EPO - PATSTAT, calculations of Fraunhofer ISI.

Figure 7 Shares of SME/LE filings in total filings by companies, 2010

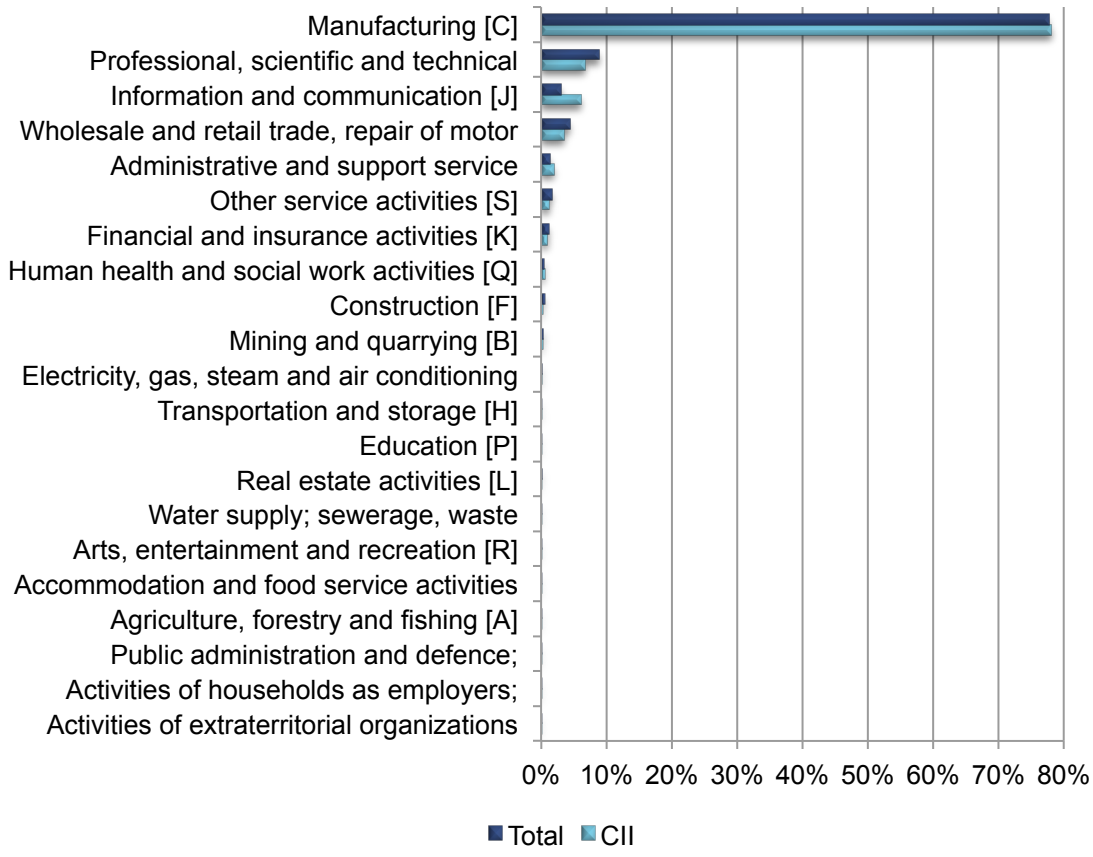


Source: EPO - PATSTAT, calculations of Fraunhofer ISI.

By using the matched dataset of Bureau van Dijk's ORBIS and the PATSTAT database, patent filings of CII can be differentiated alongside economic sectors. As we can see from this analysis, about 78% of all patent filings by companies originate from the manufacturing sector. This is similar for total as well as CII filings. For Germany (not shown), this share is slightly lower at a level of 75%. However, this is mainly because the sector "Other service activities" (which also includes the sub-sector "Repair of computers") reaches higher levels.

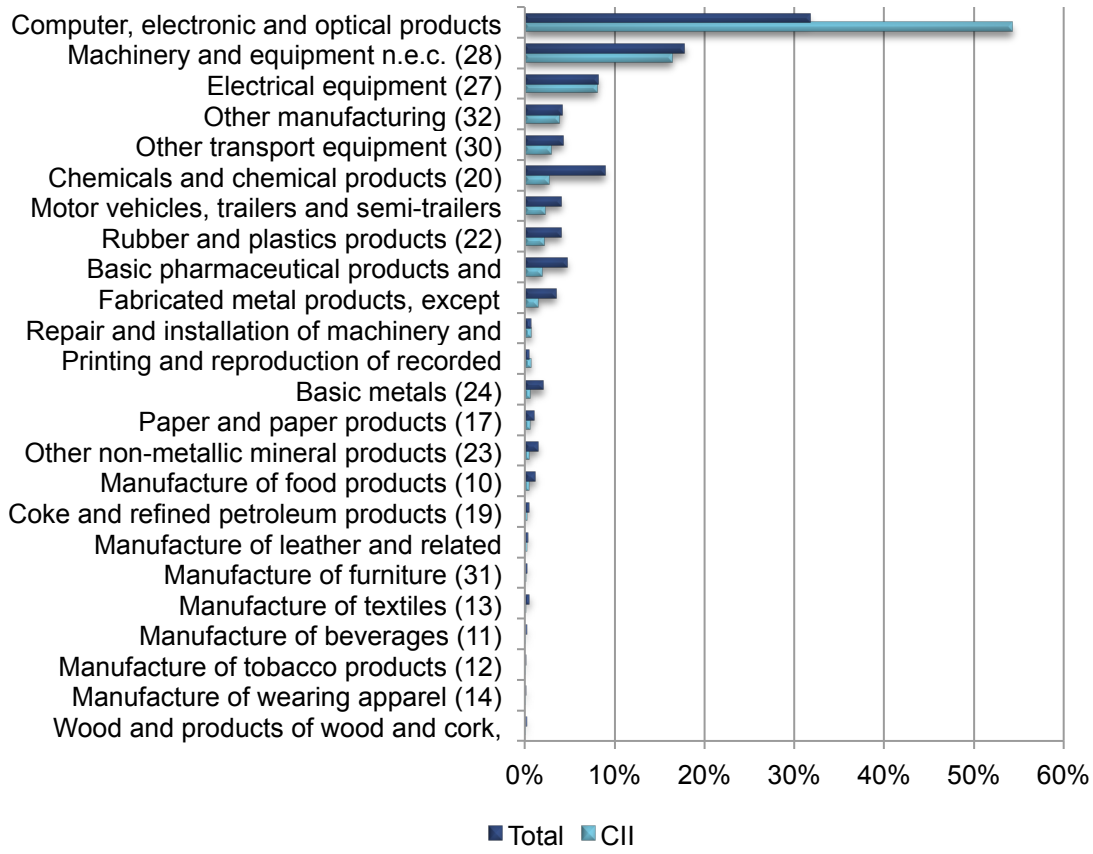
Within the manufacturing sector, the majority of the CII filings at the international level comes from the sectors "Manufacture of computer, electronic and optical products", followed by "Machinery and equipment" and "Electrical Equipments". In Germany, the share of filings from the sector "Manufacture of computer, electronic and optical products" is much lower, implying that the role of CII in other sectors in Germany is significantly larger than in other countries. In Germany, CII thus plays an important role in a larger number of sectors. The sectoral concentration of CII filings by German applicants has decreased between 2000 and 2009 (HHI = 0.26 vs. 0.23), which in turn points to the increased importance of CII for other sectors.

Figure 8 Shares of EPO patent filings in total filings by industrial areas, all countries 2009-2011



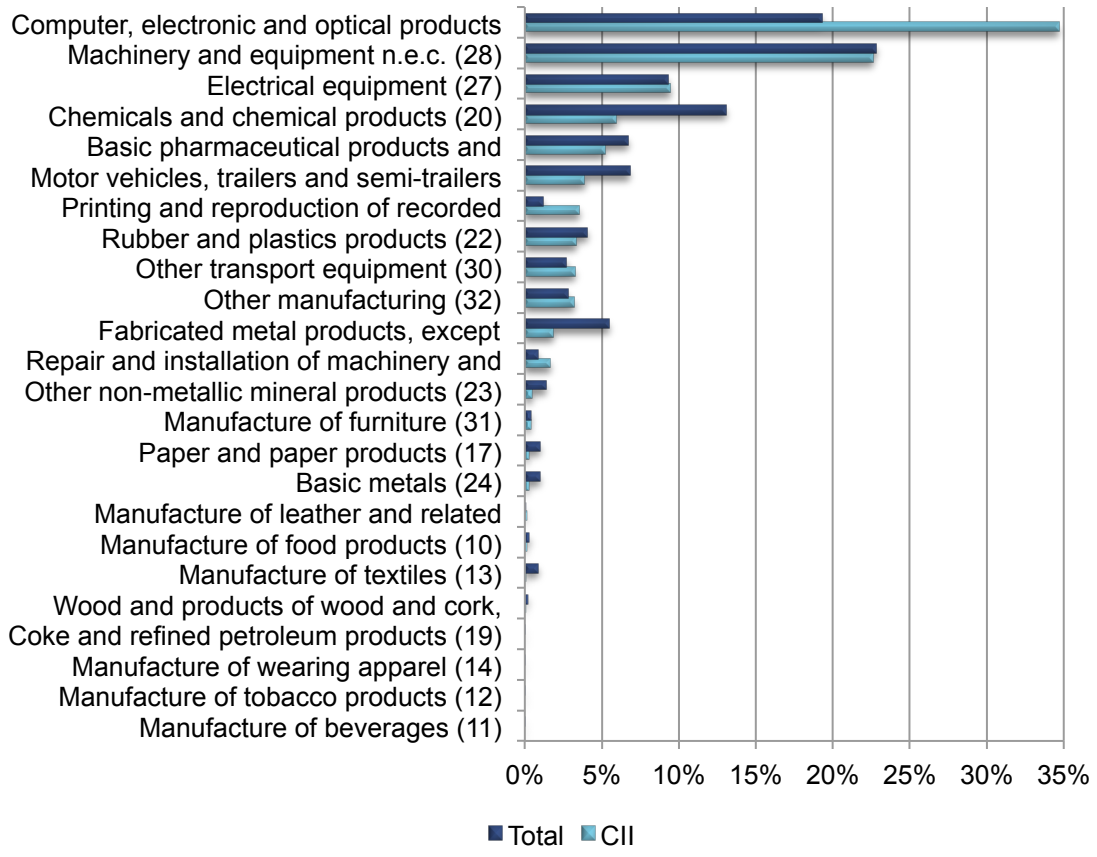
Source: EPO - PATSTAT, BvD-Orbis, calculations of Fraunhofer ISI.

Figure 9 Shares of EPO patent filings in total filings by manufacturing sectors, all countries 2009-2011



Source: EPO - PATSTAT, BvD-Orbis, calculations of Fraunhofer ISI.

Figure 10 Shares of EPO patent filings in total filings by manufacturing sectors, Germany 2009-2011

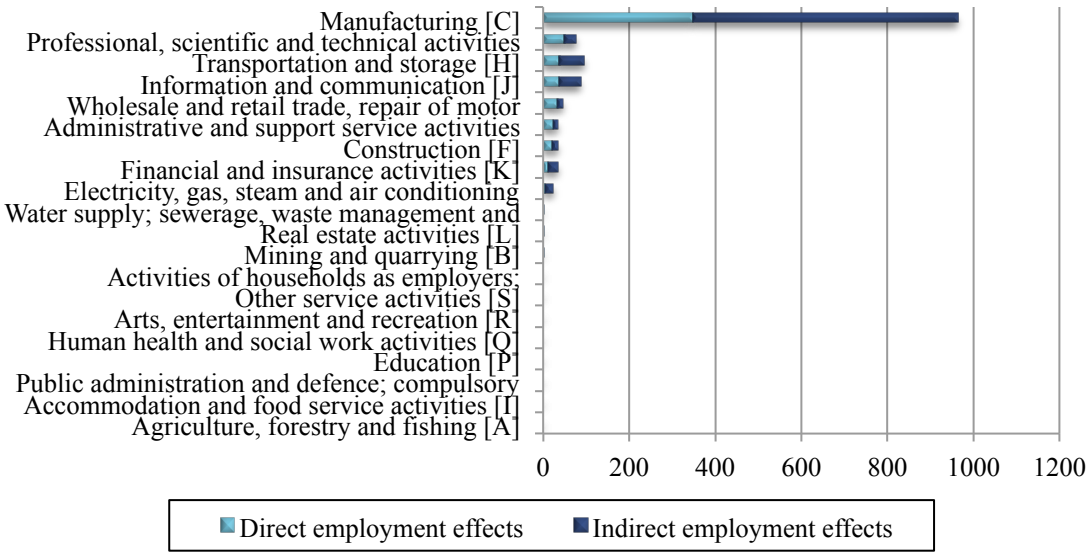


Source: EPO - PATSTAT, BvD-Orbis, calculations of Fraunhofer ISI.

5.2 Economic data

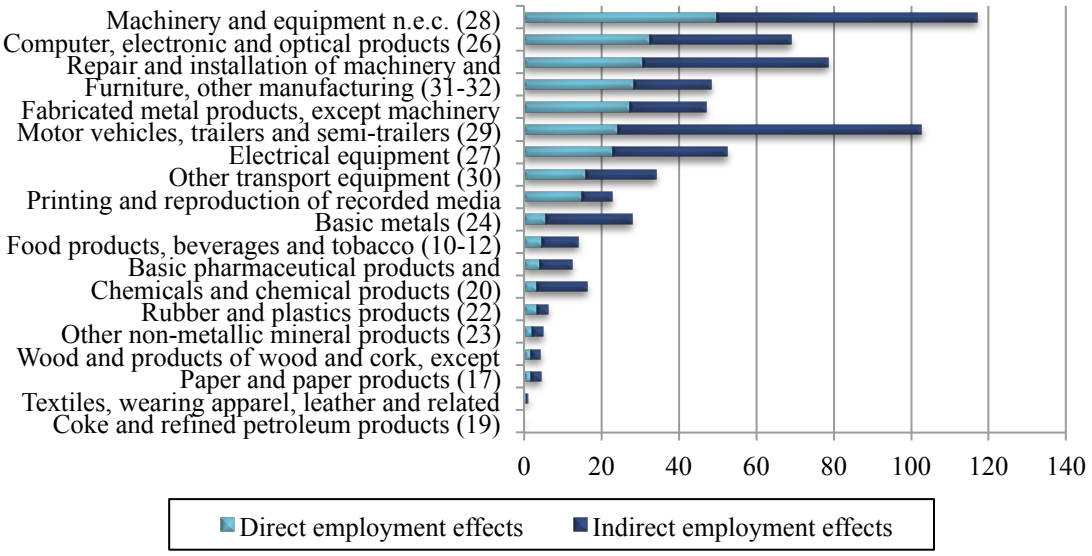
In the year 2010, CII had direct employment effects on 567,000 jobs in Germany. Indirectly, i.e. via intermediate sectors and companies, another 826,000 employees were affected. Thus, 1.4 million jobs were directly or indirectly dependent on CII, representing about 3.9% of all jobs in Germany. The largest portion is attributable to the manufacturing sector (964,000 jobs), which corresponds to a share of 14.2% of all jobs in the manufacturing sector.

Figure 11 Direct and indirect employment effects in Germany by sectors, in thousands, 2010



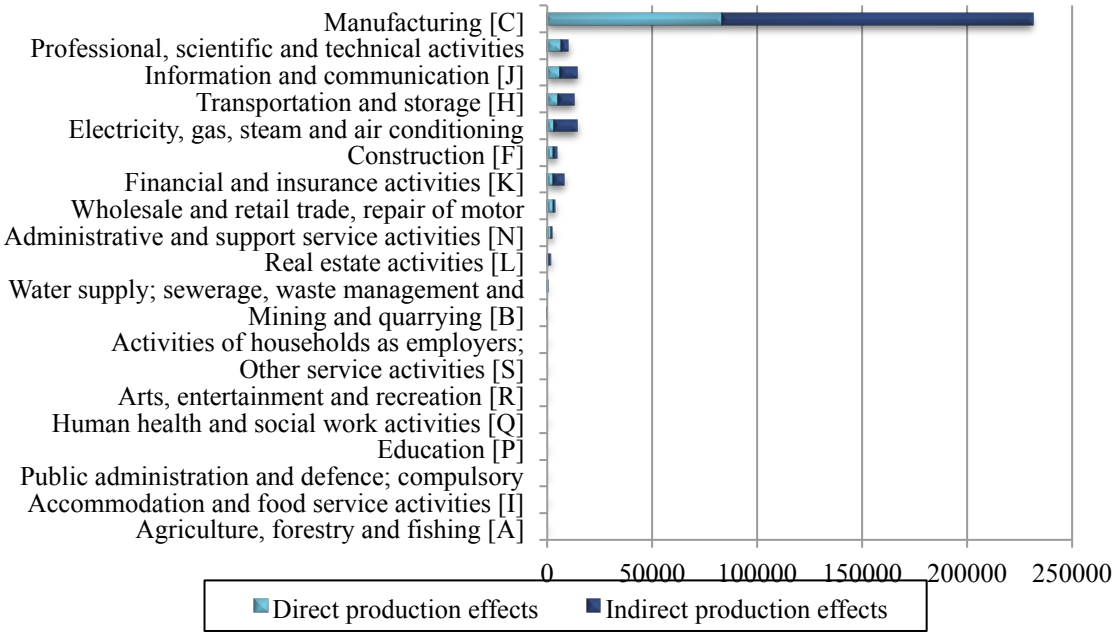
Source: EPO - PATSTAT, BvD-Orbis, Mannheim Innovation Panel (MIP), OECD – STAN, calculations of Fraunhofer ISI.

Figure 12 Direct and indirect employment effects in Germany by sub-sectors of the manufacturing sector, in thousands, 2010



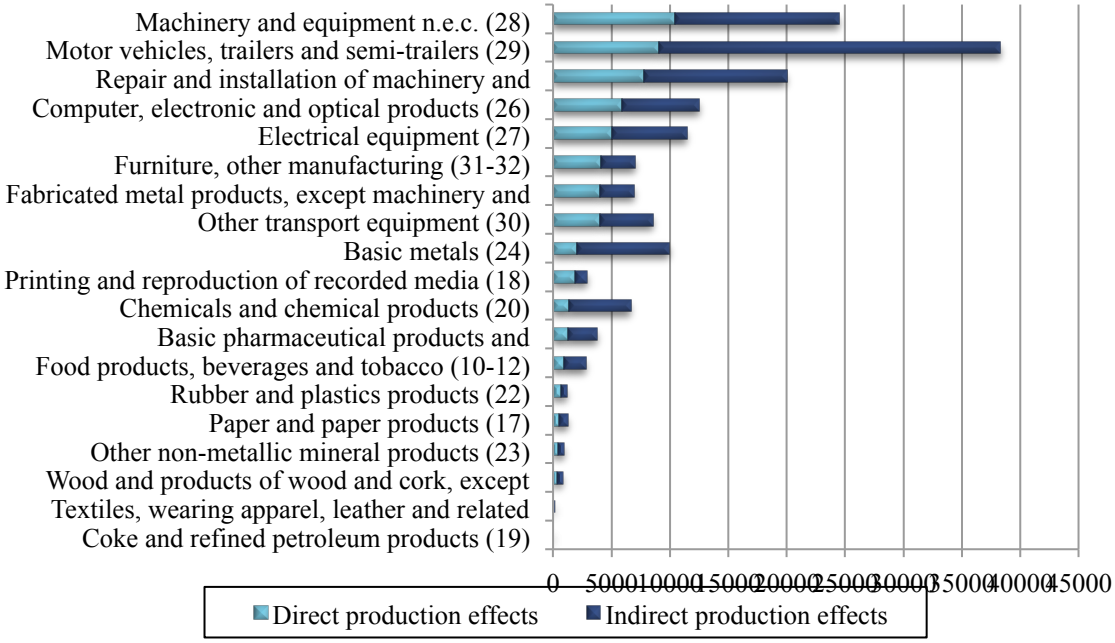
Source: EPO - PATSTAT, BvD-Orbis, Mannheim Innovation Panel (MIP), OECD – STAN, calculations of Fraunhofer ISI.

Figure 13 Direct and indirect production effects in Germany by sectors, in thousands, 2010



Source: EPO - PATSTAT, BvD-Orbis, Mannheim Innovation Panel (MIP), OECD – STAN, calculations of Fraunhofer ISI.

Figure 14 Direct and indirect production effects in Germany by sub-sectors of the manufacturing sector, in thousands, 2010



Source: EPO - PATSTAT, BvD-Orbis, Mannheim Innovation Panel (MIP), OECD – STAN, calculations of Fraunhofer ISI.

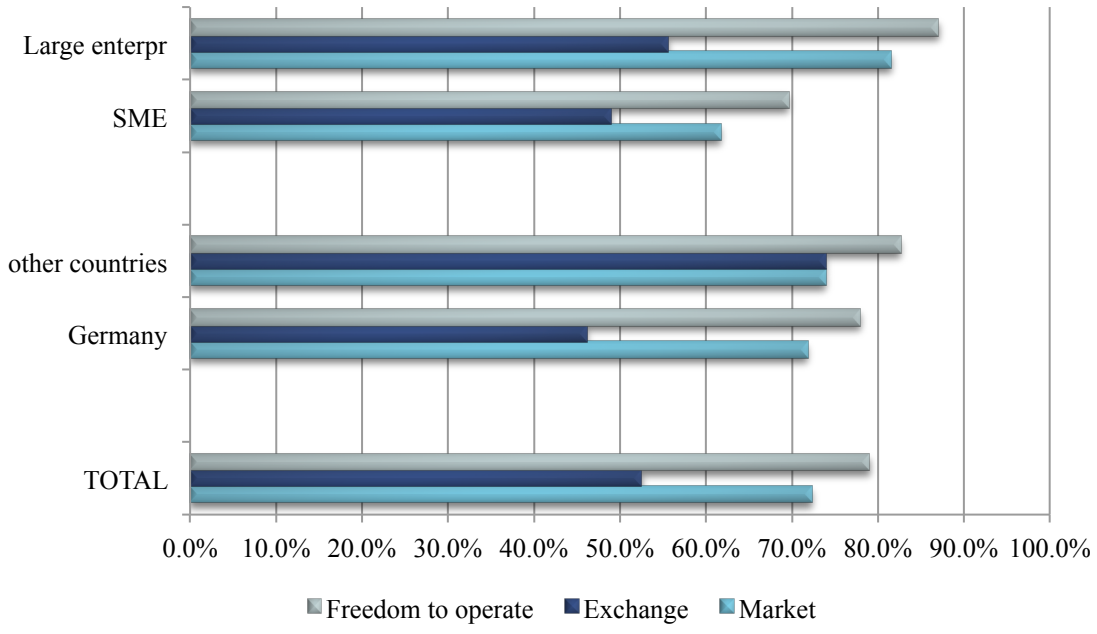
5.3 Survey results

About 78% of the surveyed companies answered that they have a lot of experience with the patent system. Approximately 88% of all companies are located in Germany, about 66% are SMEs, half of the surveyed companies have CII inventions and about a third has filed at least one CII patent in 2013.

The most important motive for filing a CII patent is to create room to maneuver, followed by market motives. Exchange motives are considered less important. For large companies, all motives are more important than for SMEs. Competition in CII markets is considered high for all surveyed groups, while large enterprises observe an even stronger intensity of competition than SMEs in the last five years.

The largest proportion of respondents with CII filings assesses the consequences of a restrictive amendment of the patent law as neutral or even low, while the influence of CII on employment and market shares is assessed higher especially by SMEs. The majority of respondents is in favor of preserving the current status quo with regard to patenting CII. A large proportion rated an abolition of the patentability of CII as inappropriate; another large share is at least ambivalent. However, also only a minority of respondents votes for an extension of patent rights for CII, such as business methods or software "as such".

Figure 15 Companies that evaluate the following reasons for patenting CII as high (2 or 3 on a scale of -3 to +3)



Source: Survey and calculations of Fraunhofer ISI.

Table 5 Share of companies with CII inventions, 2013

		Country		Size	
	Total	**Germany**	**other countries**	**<500**	**>500**
No	50,3%	53,8%	24,3%	55,9%	40,9%
Yes	49,7%	46,2%	75,7%	44,1%	59,1%

Source: Survey and calculations of Fraunhofer ISI.

Table 6 Necessity of amendments of the patent law for CII

The patent law for CII should be extended to software in general							
	Total	Germany	other countries	SME	Large enterpr.	CII pat.	no CII pat.
Yes	27,9%	27,3%	**32,0%**	27,7%	28,0%	28,0%	27,8%
No	72,1%	72,7%	68,0%	72,3%	72,0%	72,0%	72,2%
Total	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
There should be other protection mechanisms in order to improve the protection of CII							
	Total	Germany	other countries	SME	Large enterpr.	CII pat.	no CII pat.
Yes	26,1%	26,9%	21,7%	30,0%	21,0%	21,7%	30,1%
No	73,9%	73,1%	78,3%	70,0%	79,0%	78,3%	69,9%
Total	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
There should be other protection mechanisms altered in order to improve the protection of software in general							
	Total	Germany	other countries	SME	Large enterpr.	CII pat.	no CII pat.
Yes	17,6%	19,7%	5,0%	18,8%	15,8%	15,9%	19,2%
No	82,4%	80,3%	95,0%	81,2%	84,2%	84,1%	80,8%
Total	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

Source: Survey and calculations of Fraunhofer ISI.

Table 7 Evaluation of the consequences of a restrictive amendment of patent law for CII

	Total	
	General factors	Company spec. factors
Low	61,8%	64,5%
Neutral	32,4%	29,0%
High	5,9%	6,5%
Total	100,0%	100,0%

	General factors		Company spec. factors	
	Germany	other countries	Germany	other countries
Low	64,2%	52,4%	65,5%	60,9%
Neutral	30,9%	38,1%	31,0%	21,7%
High	4,9%	**9,5%**	3,6%	**17,4%**
Total	100,0%	100,0%	100,0%	100,0%

	General factors		Company spec. factors	
	SMEs	Large enterprises	SMEs	Large enterprises
Low	66,0%	57,7%	62,7%	66,1%
Neutral	28,0%	36,5%	27,5%	30,4%
High	6,0%	5,8%	**9,8%**	3,6%
Total	100,0%	100,0%	100,0%	100,0%

Source: Survey and calculations of Fraunhofer ISI.

Table 8 Appropriateness of alternatives to the current legal framework for CIII patenting

	Inappropr.	Ambivalent	Appropr.
Computer-implemented inventions should largely be excluded from patent protection	**44,1%**	31,1%	24,8%
Maintaining the Status quo: restricted patentability	7,9%	24,2%	**67,9%**
Practice as before, but reduce the duration of protection	45,5%	30,6%	23,9%
General patentability of software (similar to the U.S.) and hence extension of patent protection	46,6%	31,2%	22,2%
Patents also for software-based processes (business methods)	**55,3%**	24,1%	20,6%
Introduction of a grace period (regarding novelty)	23,4%	34,5%	**42,1%**
Immediate patent disclosure	41,9%	35,9%	22,1%
Administrative relief or assistance in patenting	14,4%	33,0%	**52,6%**
Globally uniform, binding and enforceable patent law	8,1%	14,5%	**77,4%**
Support from privately organized initiatives for the enforcement and prosecution of intellectual property rights	36,4%	33,5%	30,1%

Source: Survey and calculations of Fraunhofer ISI.

6 Summarizing Conclusions

The aim of the present study was to understand the importance and spread of computer-implemented inventions of German companies in Germany and Europe and structurally compare them with companies from other countries. For the analysis and empirical evaluation of computer-implemented inventions, three approaches have been implemented, allowing different perspectives on the issue. First, the development of computer-implemented inventions over time, the absolute numbers and the structure of the applicants in an international comparison were collected using patent databases. A compilation of the patent data with other enterprise information allowed an estimate of the size classes of enterprises and sectors that are responsible for computer-implemented inventions. A survey of patenting firms – both those who file computer-implemented inventions, as well as those that file patents in other technology fields – as well as a control group of companies without patents, provided information about needs and motivations. A legal description of the status quo, an assessment of alternative protection mechanisms for computer-implemented inventions and a legal assessment of possible changes in the patent system completed the picture.

The results show that computer-implemented inventions nowadays are in widespread use, but have also achieved great importance in a variety of sectors. These computer-implemented inventions are by no means limited to large enterprises, but also small and medium-sized companies report a large number of such patents. With well over 50,000 patent applications at the European Patent Office per year, computer-implemented inventions reach a share of about 35% of total EPO patent filings. Since about 2003, the proportion fluctuates around a third of all applications and started to grow since 2009. As regards the countries of origin of the applicants, size effects are visible for the US and Japan, where extraordinarily high shares of computer-implemented inventions compared to their shares in total patent filings are reached. In other words, computer-implemented inventions are of above-average importance to companies from these two countries. However, companies from European countries, especially Germany, also report substantial absolute numbers of computer-implemented inventions.

About 75% of computer-implemented inventions, similar to filings in other technological fields, originate in the manufacturing sector, while technical services and information and communication services do indeed play a role, but contribute significantly less than 10%. Within the manufacturing sector, it can be found that computer-implemented inventions are filed from a very broad range of sub-sectors, i.e. computer-implemented inventions play an important role in many sub-sectors. This scattered distribution is even more pronounced in Germany compared to the average of all countries. The sec-

tor computer, electronic and optical products obtained – as expected – the highest shares, followed by mechanical electrical equipment, chemicals and pharmaceuticals, as well as the automotive industry. The share of computer-implemented inventions within the sectors shows an important role of such patents also in service sectors, i.e. if companies apply for patents in those industries it is most often a computer-implemented invention.

The analysis of patent and corporate data also shows that substantial employment effects of computer-implemented inventions occur especially in the manufacturing sector. In the manufacturing sector in Germany, nearly 1 million jobs were directly or indirectly dependent on computer implemented inventions in 2010. In relation to all industries, there were even some 1.4 million jobs affected by CII. The largest employment effects in Germany – and this again underlines the great importance of computer-implemented inventions for a variety of industries – can be found in mechanical engineering and in the automotive sector and not primarily in the sector of "Computers, Electronic and optical Products". Both, in mechanical engineering as well as in the automotive sector more than 100,000 jobs were directly or indirectly dependent on computer-implemented inventions in 2010. What is not included here is the competitiveness that can only be secured by means of computer-implemented inventions in these sectors; for example, a car or a machine would be inconceivable without computer-implemented inventions – i.e. corresponding combinations of hard- and software.

The motives for the use of patents to protect computer-implemented inventions differ little from the use of patents and their importance in other technological areas. International companies have, however, found a slightly higher increase of competition and therefore assess patents and the protection of computer-implemented inventions as more significant in the recent past. The companies need patents to maintain their freedom of action or to open up markets. One of the main results of our survey is that companies are satisfied with the current legal situation and neither wish a sharpening nor a facilitation of the patentability of computer-implemented inventions.

The analytical discussion on the current case law also shows that a departure from the patentability of computer-implemented inventions would be both legally and economically more than questionable. Certainly the then existing instruments – in particular the copyright – would in no way be adequate or sufficient to protect this kind of inventions. It would thus significantly reduce the motivations and the incentive system to invest in R&D and to strive to innovate. As we were able to prove, the technological reality today means about one-third of computer-implemented inventions. A departure from the current system would lead to widespread disavowals and certainly significant structural changes in the economic system of Germany, but also in many other countries.

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Annex 1: Additional data

Table A 1 Basic distribution of the sample – Country, firm size and CII filings

Country		
	count	%
Germany	273	88,1%
Other countries	37	11,9%
Total	310	100,0%
Company size		
	count	%
<500 employees	195	62,9%
>500 employees	115	37,1%
Total	310	100,0%
CII inventions in 2013?		
	count	%
Yes	156	50,3%
No	154	49,7%
Total	310	100,0%
CII patents filed in 2013?		
	count	%
Yes	110	35,5%
No	200	64,5%
Total	310	100,0%

Source: Survey and calculations of Fraunhofer ISI.

Table A 2 General experience with patents as an instrument of IP protection

		Countries		Size (<500)		CII	
	Total	**Germany**	**other countries**	**<500**	**>500**	**Yes**	**No**
Low experience	11,7%	13,5%	2,8%	13,9%	8,8%	6,6%	15,2%
Moderate	10,3%	10,9%	5,6%	13,4%	5,3%	4,7%	13,2%
Much experience	78,0%	75,7%	**91,7%**	72,7%	**86,0%**	**88,7%**	71,6%
Total	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

Source: Survey and calculations of Fraunhofer ISI.

Table A 3 Shares of firms with CII filings in 2013

		Country		Size	
	Total	**Germany**	**other countries**	**<500**	**>500**
No	50,3%	53,8%	24,3%	55,9%	40,9%
Yes	49,7%	46,2%	75,7%	44,1%	59,1%

Source: Survey and calculations of Fraunhofer ISI.

Table A 4 Shares of companies that evaluate competition intensity and its change as high (2 or 3 on a scale of -3 to +3)

	Competition intensity		
	Domestic market	**Int. market - Europe**	**Int. market - Outside of Europe**
TOTAL	78,6%	86,0%	83,3%
Germany	81,6%	87,2%	82,4%
Other countries	68,2%	81,8%	86,4%
SME	77,3%	87,0%	80,4%
Large enterpr.	79,6%	85,2%	86,0%
	Increase of competition intensity		
	Domestic market	**Int. market - Europe**	**Int. market - Outside of Europe**
TOTAL	78,6%	86,0%	83,3%
Germany	81,6%	87,2%	82,4%
Other countries	68,2%	81,8%	86,4%
SME	77,3%	87,0%	80,4%
Large enterpr.	79,6%	85,2%	86,0%

Source: Survey and calculations of Fraunhofer ISI.