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Monitoring Patenting Strategies in the Electric Vehicle Market

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Summary
Patenting activity in and around electric vehicles is analysed using the collection of patent application and publication data PATSTAT, hosted at the European Patent Office (EPO). It is shown, how particular information in the publicly available data set, namely the so-called "legal status" of patent applications, can be used to identify strategies of intellectual property protection of different companies, or to establish the intellectual property landscape of a certain technological field, in the form of a fingerprint of the considered set of patent applications [1]. Such a fingerprint analysis may help defining a company's own strategy on intellectual property protection, and improve freedom-to-operate analyses (FTO), and might also assist R&D teams in their decision making with respect to new product development.

Keywords: market, market development, research, strategy, business model

1 Introduction

Knowledge about the market that one is engaged in is important strategic information. It helps to make the right decisions at an early stage of development, e.g. with respect to marketing or product development. Patents, as a common means of protecting inventions developed by firms or individuals, are a key parameter for such market knowledge. Of course, before an invention can become an innovation, further entrepreneurial efforts are required to develop, manufacture and market it, but being acquainted with the intellectual property "landscape" in a certain market segment, as defined by the scope of protection of existing patents and the disclosure of patent (or non-patent) publications, is an important aspect of this knowledge. Since Research and Development is very costly, the development of something already known is to be avoided. And developing a product that has already been protected would lead to the necessity of paying royalties to competitors or patent trolls. Consequently, the evaluation of competitors' patenting strategies is of interest, not only to patents attorneys, but also to scientists and engineers. This can also be deduced from the fact that an increasing number of policy reports use patent data to monitor developments in particular technical or institutional fields [2].

There exists a whole field of academic research, which makes use of patent data [3, 4, 5]. Thereby, it is well-established, that the mere count of patent applications and granted patents is only a rather weak indicator of inventive and innovative activity of a firm or in a technical field [4, 6, 7]. Also, it could be considered a waste of the rich source of data, which patent applications provide: Foremost, of course, patent applications provide information on the technological content of the invention, of which in particular the technical field can be rather easily evaluated automatically. They also indicate the geographical location of the inventive process, in that they identify applicants and inventors, which can be used to reveal the organisation of the underlying research process when matched with further data on the firms and individuals [8]. And they comprise links to other applications, in the form of citations, which allows it to

track the diffusion of knowledge, or to identify particularly influential inventions [7, 8]. Last but not least, patent documents also comprise, to a certain extent, their own history, notably the application's passage through the patent office's workflow.

In this paper, the so-called "legal status" of European patent applications is used to shed light on patenting strategies, employed by different applicants, and visible in different technical field related to the development of electric vehicles. The "legal status" thereby indicates the current status of a (published) patent application and patent, e.g., whether it is still in examination, refused, granted, or opposed. Any change of it is triggered by one of a list of selected legal events and entered into the EPO's databases. Hence, it can be deduced up to which point in the patenting procedure applications proceed, and it is assumed that this allows drawing conclusions on the levels of importance attributed by a particular company to inventions in a certain technical area. Indicators may be, for example, high withdrawal rates, increased readiness to oppose a patent, or – on the other side – willingness to maintain a patent against opposition. Status or event data are used to a somewhat limited extent in several studies [9], correlating for example the value of a patent to the readiness of the patent proprietor to pay renewal fees, i.e., to maintain the patent protection [10]. Similar work than in the present study has already been carried out with respect to granting and opposition data, but with a significantly less comprehensive access to raw data [11].

The automotive industry is a particularly interesting subject for such an investigation: the increasing importance of electrical propulsion of vehicles may fundamentally change this important industrial sector. It brings about a shift in relevant technologies, e.g., the increasing importance of battery technology, or changing infrastructure requirements, e.g. for charging and refuelling. Additionally, the competition may change, with new players entering the field, stemming from non-traditionally automotive sectors and regions [12].

Of course, there are also some caveats when using statistics in general and patent statistics in particular. While it can be positively noted, that patent data are publicly available for most countries across the world, often reaching far back into the past, and no confidentiality rules forbid access to those published patent information, it also has to be kept in mind, that publication generally only takes place 18 months after the first filing. Adding that also the overall procedure takes some time, it has to be kept in mind, that consolidated data is only available after some years [2].

The paper is structured as follows: In the following section, a brief overview over the patenting process will be given and it will be explained how status data bearing information about the progression of a single application within this process can be used. It is then touched on patenting activity in the electric vehicle market and explained, how the patent applications considered in the statistical analyses are retrieved. Subsequently, results of queries of the European Patent Register database are analysed in order to exemplarily demonstrate the potential of the data sources and the query tools to carry out market or competitor's analysis. Finally, possible extensions of the applied methods are briefly discussed, extending the possible scope of analysis beyond European patent applications.

2 The (European) patenting process and legal event information

The European Patent Office (EPO) provides a single procedure for the granting of patents in the contracting states of the European Patent Convention (EPC). Hence, with a single application in English, French or German, patent protection in up to 42 countries can be applied for. This can provide significant advantages compared to applying for national patents directly at the various national patent offices. There, submission of the application in the local language, often using a local patent attorney as an intermediary is compulsory. Furthermore, the outcome of the procedure may vary from one national patent office to another. Currently, around 200000 applications are filed every year with the EPO.

2.1 The patenting procedure at the EPO

Once an application arrives at the EPO, it is important for the EPO to give applicants early certainty with respect to this application. The applicant normally receives a search report detailing related publications (prior art) to his invention within 6 months. Accompanying this is a written opinion from the examiner detailing whether the application meets the legal provisions of the European Patent Convention (EPC) such as novelty, inventive step, clarity, conciseness, disclosure of invention and so on [13].

After this, the applicant then enters into dialogue with a three-member examining division with a view to remedying defects, e.g., modifying the claims to take account of prior art or in order to clearly define the scope of protection. If the defects cannot be overcome, the applicant either withdraws or abandons the application (such that it is deemed to be withdrawn), or the examining division refuses it. If all objections can be overcome, the application proceeds to grant. As it is already implemented with respect to the search phase, there are currently efforts undertaken by the EPO to reduce the pendency of applications in the examination phase. The goal is, to reduce the average time from the start of examination to the proposal f a grant to 12 months by 2020.

Once an application is granted, third parties are given 9 months to provide grounds to oppose it. Possible outcomes of the opposition proceedings are the rejection of the opposition, the maintenance of the patent in amended form or its complete revocation. Also, a granted patent may be limited or revoked at the proprietor's request.

Any decision of a division at the EPO with respect to an application or a granted patent, e.g., to refuse a patent or to reject an opposition, may be appealed. The ultimate decision is then made by the Boards of Appeal of the EPO.

Once a European patent application has been granted, the granted patent is validated in the designated states, i.e., the member states of the EPC, for which protection has been asked. This procedure is not

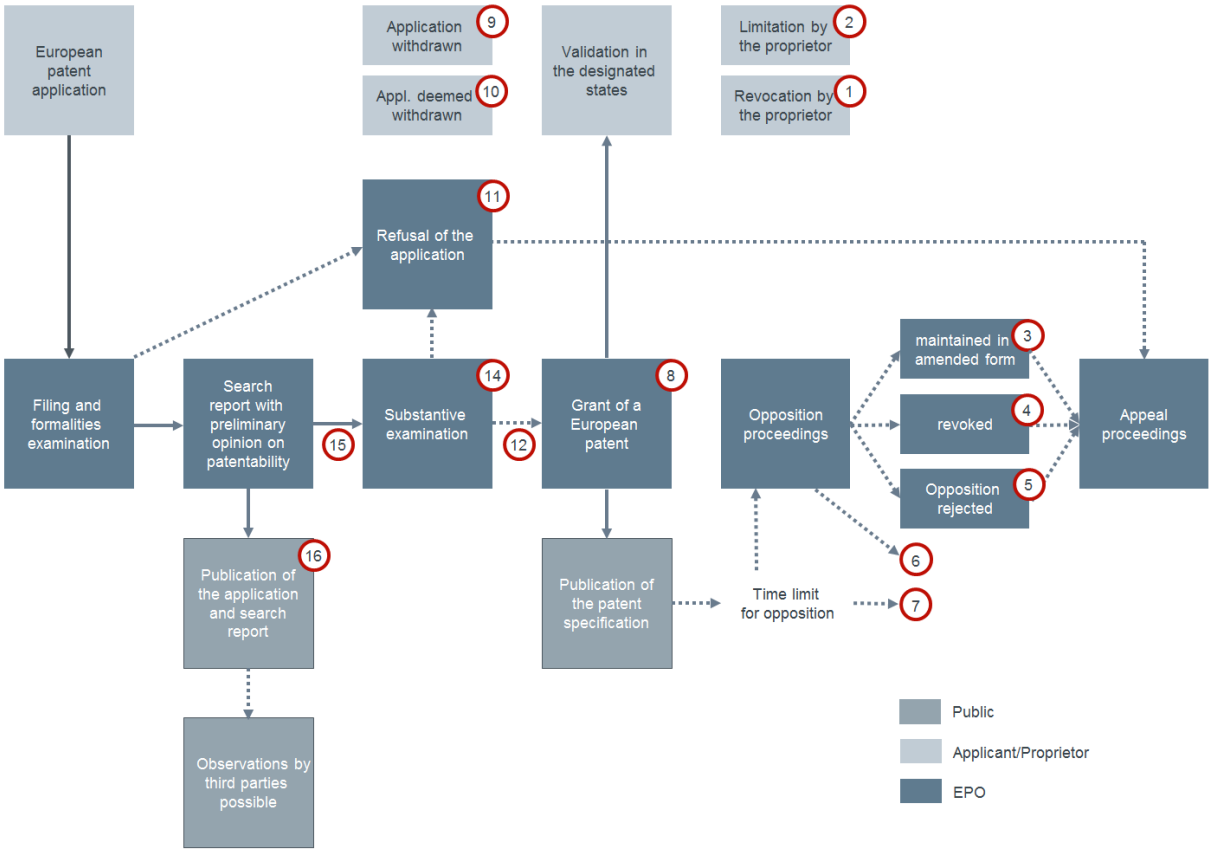

Figure 1: Important procedural steps in the European patenting procedure

administered by the EPO, but by the national patent offices, and may be linked to paying fees or filing translations. This means, too, that renewal fees, i.e., fees which have to be paid regularly in order to maintain the protection, and the duration until the patent protection ends or lapses, are governed by the national patent laws.

The most important stages of the patenting process at the EPO to obtain are summarized in Figure 1. Note, that this study mainly concentrates on European patent applications, and that the process for international applications under the Patent Cooperation Treaty (PCT), which may also be pursued with the EPO as the patenting authority, is different. Still, there are, even within the patenting process shown in Figure 1, different possibilities to file an application. For example, an application may be directly filed at the EPO, either as first filing or claiming the right of priority of an application in another country, covering the same invention, or it may be filed following the international phase under the PCT with either the EPO itself as the international searching and preliminary examining authority or one of the 21 other patent offices offering international search and preliminary examination. Those variants differ mainly in that specific internal procedures or time limits apply, but the principal steps and legal effects are the same [14, 15].

Of course, disputes about patents do not all end after a possible appeal has been settled, but may also carried out in front of (national) courts. This, however, is no longer under the influence of patenting authorities, is hence not reflected in the patent statistics data. Consequently, it cannot be considered in the course of this study.

2.2 Legal event/status data

The EPO maintains what is possibly the world's largest patent database, bringing together more than 100 million patent documents worldwide. Alongside bibliographical data, i.e. the content in terms of claims, description and figures, this comprises large sets of administrative data, much of which is originally compiled for internal purposes in order to manage their administration of patent examinations and to disseminate information. For example, in the European Patent Register several dozens of Millions of entries are stores relating to procedural data of European patent applications, the EPO worldwide legal status database INPADOC collects entries on more than 220 Million events concerning patent applications worldwide.

All this information is made publicly available, freely using Espacenet or on a subscription basis using PATSTAT [16], and among many other things allows the public to determine, up to which point in the patent granting procedure, a certain application has proceeded, for example. PATSTAT thereby is particularly useful, since it is, in fact, a sophisticated statistical analysis tool.

This study is mainly using the European Patent Register data, which contains all the publicly available procedural information on European patent applications as they pass through each stage of the granting process. Thereby, the current or latest event is entered and made available as the “legal status”. There are 18 different identifiers of those “legal status” in the European Patent Register, as documented in Table 2. Those identifiers were also added, where possible to the flow chart in Figure 1. It is to be noted, that those “legal status” identifiers only cover a subset of all the procedural actions taken by any party to the proceedings, which may trigger an entry in the European Patent Register. Most significantly, there is no identifier on the lapse of a patent at the end of the validity period or if the proprietor decides to stop paying renewal fees: This has to do with the fact, that European patent applications are validated, after grant, as national patents in the designated member states. Such information can instead be found in other parts of the European Patent Register, for example the in the event history. The latter also makes it possible to retrace the history of events, while the “legal status” only indicates the current situation, i.e., the latest of the events as shown in Table 1.

Table 1: Identifiers of "Legal Status" in the European Patent Register

Identifier	Definition
1	Patent revoked by proprietor
2	Patent limited
3	Patent maintained in amended form
4	Patent revoked
5	Opposition rejected
6	Opposition procedure closed
7	No opposition filed within time limit
8	Patent granted
9	Application withdrawn
10	Application deemed to be withdrawn
11	Application refused
12	Grant of patent intended
13	Proceedings closed following consolidation with another application
14	Examination in progress
15	Examination requested
16	Application published
17	International application published
18	Unknown

The identifiers which are most pertinent in the further course of this paper will be briefly discussed, also, to the extent that their meaning cannot always be fully understood from the definition. For example, the definitions of two identifiers apparently refer to the grant of an application, namely identifiers 12, stating that the grant of a patent is intended, and 8, stating that it has actually been carried out. However, those events are usually valid but for a limited time, most importantly, because if a granted patent is not opposed within nine months after the publication of the grant, a new event is triggered and the "legal status" identifier will change to 7, which therefore also denotes a granted patent. Similarly, identifiers 6 and 5, wherein the former usually indicates that the opposition has been withdrawn, also imply that the grant is still valid. It is further noted that some of the identifiers, namely 13, 17, or 18 are rather rare; Neither of those or 1 or 2 did turn up in the data sets evaluated for the present study.

3 Patents in electric vehicles

Vehicles with propulsion delivered at least partly by electric motors have always played a role in the history of mechanized mobility. Although the concept has found widespread use in some areas like propulsion of locomotives, it could not prevail over internal combustion engines as a propulsion concept for individual passenger cars and trucks for a long time. Increase concerns about environmental impacts of petrol-based mobility, in particular in densely populated inner cities, has changed the external conditions during the last decade, and more and more automakers are broadening their portfolio to include hybrid or purely electric propulsion concepts [17]. At the same time companies not having traditional automotive background are entering the field. Also, the rise of China as a largely important economic player in this industry along with the commitment to electric mobility brings about important changes and a lot of innovative stimulus to this technical field [12]. All of the above is ultimately also expected to significantly lower consumer prices of electric vehicles.

In terms of patents, this could be perceived at the EPO, by a substantial growth in European patent applications relating to electric propulsion of vehicles over the last one and a half decades, both in absolute numbers and related to overall application figures, as it can be observed from Figure 2. In particular the percentage, among all European patent applications filed with the EPO, of patent applications related to this field has tripled between 2001 and 2014. In view of this dynamical growth and keeping in mind the cataclysm caused in the automotive sector caused by the factors mentioned above, it is interesting to investigate, which developments can also actually be discerned from patent statistics data.

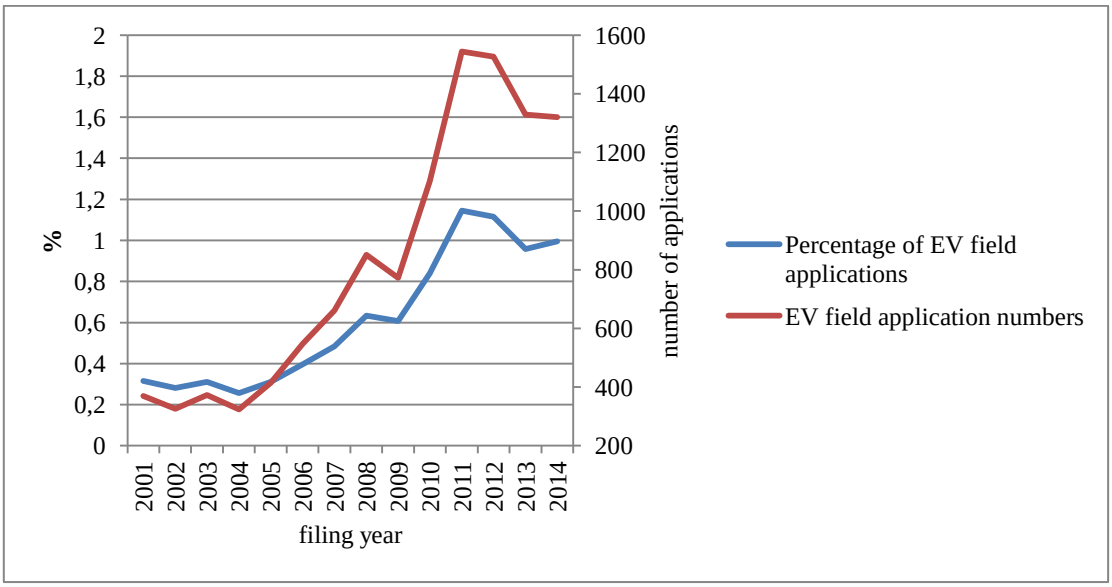

Figure 2: Development of European patent applications in the field of electric propulsion of vehicles

Thereby, at first it has to be established, how patent applications related to electric propulsion of vehicles are identified. In this paper, patent classification codes are used, which are attributed to an application at the EPO by the patent examiners entrusted with the search. Before identifying the classification codes used in this study, the general principle of patent classification will be briefly explained.

3.1 Patent classification

One of the reasons which render patent data a unique source of information with respect also to the specific area of technology it is treating, is the use of patent classification schemes. The classification codes, which are attributed to the patents, make it possible to analyse technologies at varying levels of detail. As a result, patents can be used to compare whole industrial sectors to each other, or at the other end of the scale, examine exactly which details of a particular field are growing or receding on a very specific level.

Different classification schemes exist and are maintained by respective patenting authorities. However, there are two main classification schemes used at the international level, namely the Cooperative Patent Classification (CPC) [18] scheme, which was jointly introduced by the EPO and the US Patent Office (USPTO), and is since being adopted by further patenting authorities, among others the Chinese Patent OFFICE (SIPO), and the International Patent Classification (IPC) [19] scheme, which is maintained by the World Intellectual Property Organisation (WIPO). While the CPC scheme offers a better granularity in terms of identification of relevant technological fields compared to the IPC scheme, the IPC scheme offers a wider coverage in terms of patenting authorities using it.

Since the principal part of this study is concerned with European patent applications, which are all classified in the CPC scheme, classification codes of this scheme are used to define the relevant set of data for the analysis.

3.2 Relevant classification codes for electric vehicles

In this paper, the following classification codes have been considered using the CPC scheme: B60L, B60K6/20 and B60W20. The definition of those classes is given in table. The study is thus considering most of the patent applications relating to propulsion of purely electric, hybrid and plug-in hybrid vehicles, as well as patent applications of other electric vehicle (EV) specific components including charging equipment and also some aspects of locomotives. The study is also, in part, considering patent applications relating to batteries, as long as the focus of the invention is on the integration of these batteries in the electric vehicles. Batteries in general are covered by other CPC and IPC classification codes, which are not

used for this analysis. These covered technological fields will be referred to in the rest of the article as “EV fields”.

Table 2: Definitions of the CPC symbol areas

Code	Description
B60L	Electric equipment or propulsion of electrically-propelled vehicles
B60W20	Conjoint control of vehicle subunits with control systems specially adapted for hybrid vehicles
B60K6/20	Vehicles with plural diverse prime-movers for propulsion, e.g. comprising electric motors and internal combustion engines

4 Using legal event information in statistical analyses

In the following, use cases of statistical patent data analysis using legal event identifiers are shown. Indications are given, how those data may be interpreted and what conclusions may be drawn from it for different actors in the concerned fields.

4.1 Fingerprints of exemplary applicants

Any of the Figures 3, 4, and 5 comprises what we call fingerprint information of a specific patent portfolio obtained from “legal status” identifiers. Thereby, the patent portfolio may be attributed to a certain applicant as in Figure 3, to applicants originating from certain countries as in Figure 4, or being classified in specific classification codes as in Figure 5. Each of those fingerprints is defined by two axes, the vertical axis showing the filing year of the applications and the horizontal axis giving the “legal status” identifier. It is reminded, that a single European patent application in the European Patent Register only is attributed one single identifier at a time. The colour coding of the cells in the table spanned by the application filing year and the identifier then indicates the percentage of applications filed in that particular year having reached a particular “legal status” identifier at the time the PATSTAT database snapshot was made. It should hence be reminded, that those fingerprints are likely to change with future database snapshots, the more likely the more recent filing years are concerned, for example, because granted patents may have been opposed, and a new event is only triggered once the opposition proceedings are closed, which might only happen after a database snapshot has been made.

Figure 3 shows legal status of European patent applications and granted patents related to electric vehicles for applications of three exemplary applicants – companies A, B, and C – in the EV fields. Quite different approaches to the subject of handling the patent portfolio can be observed. It can be noted, that for all companies a high percentage of applications is finally granted and not opposed, the mean value in the field of electric vehicles being around 60%. This is particularly true for applications of company A and C, a major Japanese car manufacturer and a German supplier, respectively, which reach around 80%. In particular for company A, where it is rather safe to say that applications not being classified in the EV fields still belong to the automotive sector, it is also interesting to note a significant difference when comparing the data underlying Figure 3 to all of their European patent applications (not shown in any of the figures in this paper): There, the percentage of granted patents is considerably lower, while to the same extent, the percentage of withdrawn or abandoned applications is higher. This could be interpreted as an indication that the automotive industry as such is a rather mature field, where it may be more difficult to develop new and inventive solutions, while there are more possibilities therefor in the EV fields.

It also can be observed, that applications of company A remain longer in the state of examination than those of company C. This can probably be attributed to the company’s policy or to the route chosen to obtain a European patent, e.g. direct application with the EPO or route via PCT [14, 15]. Generally, however, this effect is likely to be decreased by the efforts of the EPO to reduce the duration of the patent granting process.

Company B, a group of French car manufacturers, in contrast to both A and C, seems to be inclined to stopping the further pursuit of their applications. This, consequently, results in a comparatively high rate of files which are deemed withdrawn.

In the case of all companies taken into account for the fingerprints in Figure 3, opposition does not play a significant role. At least, the rate of opposed patents of those companies in the EV field is generally lower than the average opposition rate for all technical fields at the EPO, where around 5% of the granted patents are opposed. This may have to do with strategic decisions of the companies (and of course there competitors), valuing, e.g., licensing agreements over opposing each other's patents. As it will be seen in the following section, however, this also depends on the technical field. Also, no cases of revocation or limitation of patents by their proprietors could be observed in the data set used in this study, which is why the status identifiers 1 and 2 are omitted from all of Figures 3-5.

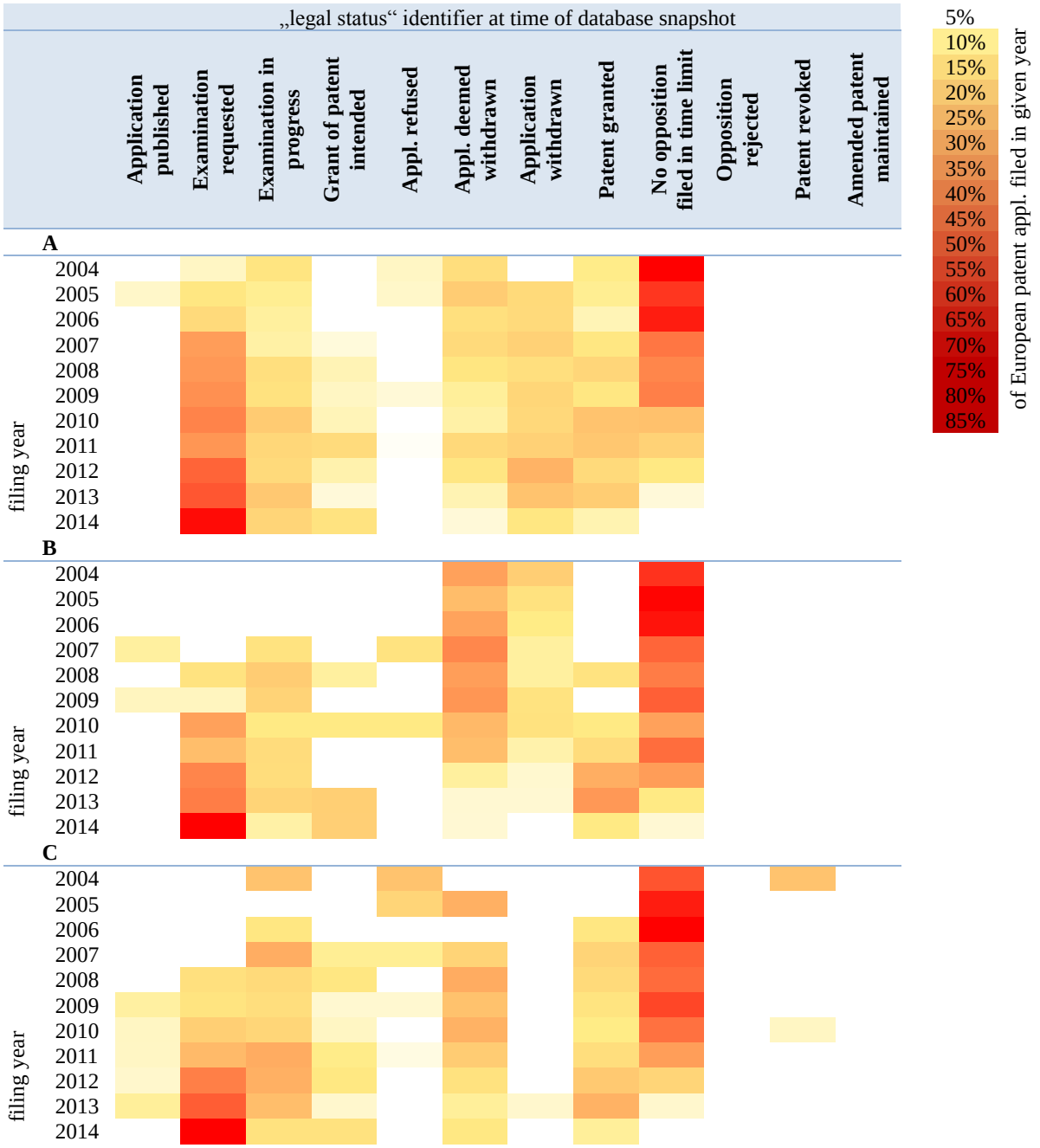

Figure 3: Fingerprint data of different major applicants

On a more general scale, it can also be interesting to consider the fingerprints of the European patent application portfolios in the EV fields on a national level, e.g., determined by the country of origin of the

first applicant. The corresponding data for applicants from Germany, Japan, and the United States of America are displayed in Figure 4. Of course, a certain bias cannot be avoided in this data, stemming for example from the organization of multi-national companies, where a European subsidy files patent applications in Europe, while the head office in Japan or the US determines the corresponding strategy. Nonetheless, some findings from the consideration of individual companies from Figure 3 can be found confirmed by Figure 4. This concerns notably the high rate of granted patents for Japanese applicants, being in the same order of magnitude as for company A, and to a bit smaller extent for German applicants, cf. the fingerprint of company B. For US applicants it is in particular the high withdrawal rate which is noteworthy.

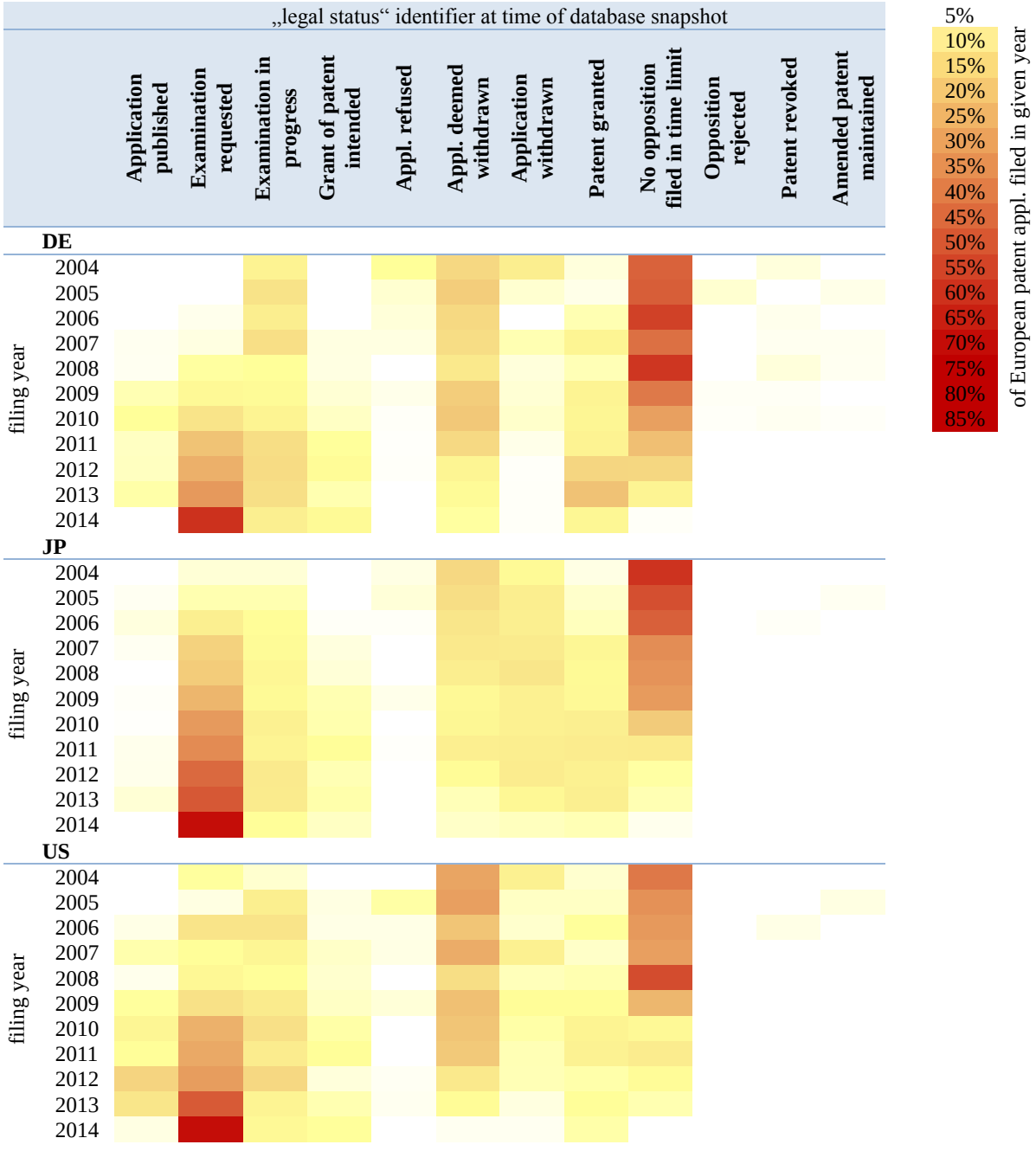

Figure 4: Status data fingerprints for applications sorted by country code of the first applicant

4.2 Comparison of different technical fields

The methodology of analysing the legal status data of applications can of course also be applied to a narrower classification code instead of distinct applicants. This may be interesting in order to assess the situation in a particular application area. Figure 5 shows a summary of legal status information of all

European patent applications in more specific fields, as characterized by a sub-range of the EV fields as defined in section above. As a first example, the field of charging equipment and stations with the CPC classification code B60L11/18 and its subordinate classification codes is considered, mainly, because this field has seen a lot of new development in the past decade, with regards to electrical and physical architecture, standardization procedures, details of charging plugs and cables, but also the integration of vehicle charging stations into the grid, billing methods and so on. As a further specialization, contactless charging, roughly defined by the classification codes B60L11/182, B60L11/1829, and B60L11/1831, was chosen. This field gets widespread attention since only rather recently, which can already be seen from the fact that there were only sufficiently many applications to create a meaningful fingerprint after 2008. As a third, and maybe comparative example, the fields with the classification code B60L5 and B60L9 were considered which collect applications with a respect to locomotives.

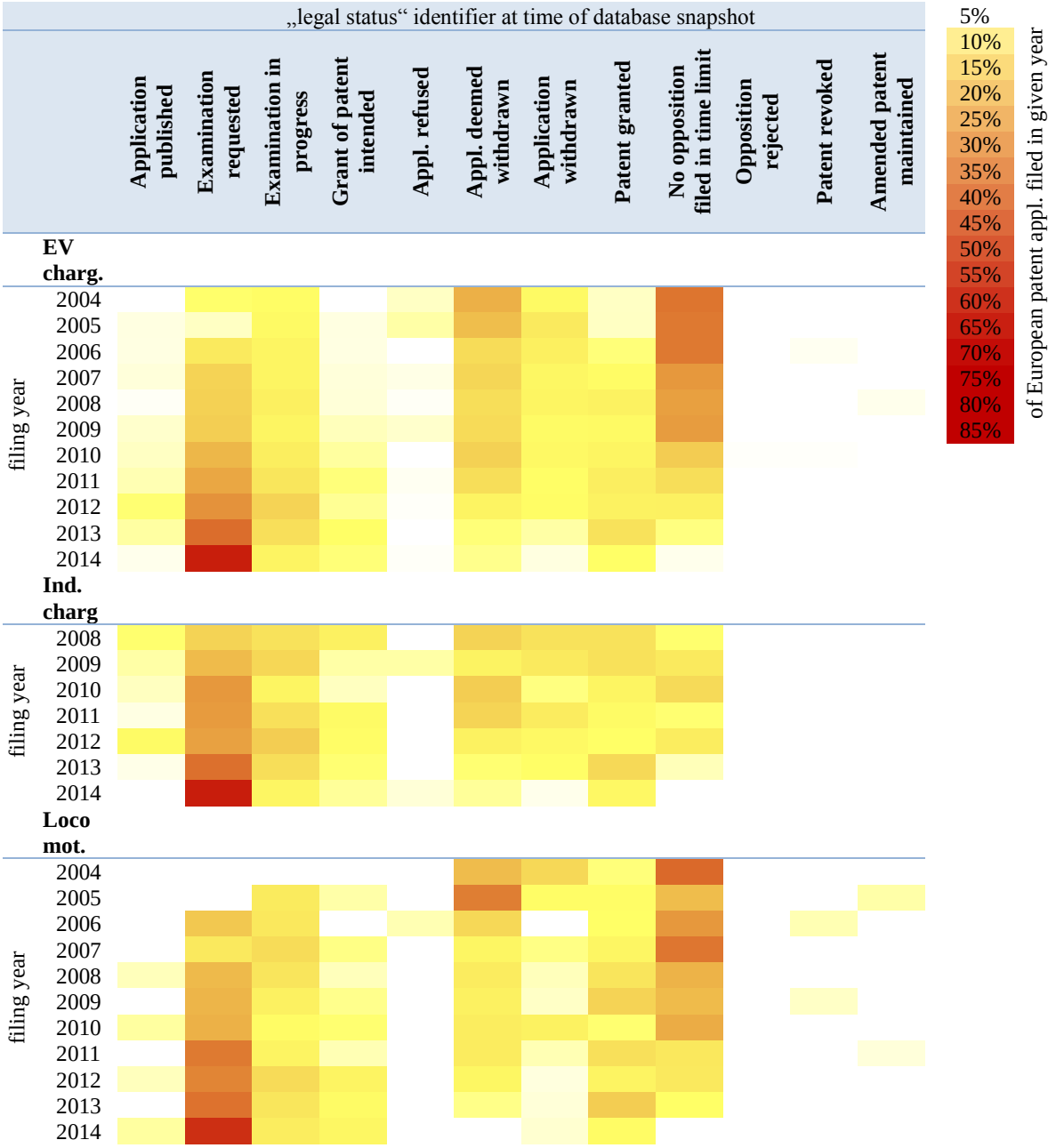

Figure 5: Status data fingerprints for applications from different technical fields within the EV fields

It is interesting to note that in particular in inductive charging the percentage of granted patents is rather low, compared to the numbers of the same years in the superordinate field of electric vehicle charging in general. This may have to do with the observation that many aspects of inductive charging are known from

other fields of applications, contactless energy transfer in general, but also for example antennas, making it not so easy after all to come up with a both new and inventive idea, which are necessary criteria to get a patent [13].

At the same time, and maybe a bit surprisingly, the fields of electric vehicle charging and the locomotive fields do not have significantly different status data fingerprints, at least with respect to withdrawn and abandoned applications and granted patents. What can be noted, however, is the higher rate of opposed and as a result revoked patents in locomotive fields. This allows some observations to be made with respect to the different structure of the respective industrial sectors and its participants.

4.3 Further use of the status identifiers and possible internationalization

Of course, the evaluation of patent data does not have to stop at preparing the above-shown fingerprints of portfolios. To the contrary, for profound freedom-to-operate analyses, this can only be a preliminary step. However, status data give valuable additional information when evaluating the portfolio of a firm or the entirety of patents in a technical field. Deepening analysis will then probably consider patents maintained after an opposition differently compared to withdrawn applications.

The data set in this study so far was restricted to European patent applications, mainly for two reasons. First, it allowed the definition of the technological field using the CPC classification scheme, which allows a more detailed analysis of the technological fields than the International Patent Classification (IPC) scheme. Second, the legal status data, which is at the centre of the present study, is available in a harmonised way only for entries in the European Patent Register.

However, it would of course give even more insight into a firm's patenting strategy or in the market structure of a certain field, if the approach could be internationalized, since it can be expected, that companies act differently on their domestic market than on another continent, and since of course also the markets differ. An obstacle to such efforts lies in the fact that status information of patents is not harmonized among different patent offices, not all existing standards are respected by all patent offices [2].

As a possible means for mitigating this obstacle, the EPO hosts, also within the PATSTAT product line, the worldwide legal event database INPADOC, which contains nearly 4000 legal event codes [20]. Harmonisation efforts are being made aiming for example at mapping the variety of legal status data used by patent offices worldwide to a consistent status list. Further comparisons, however, would go beyond the scope of this study.

5 Conclusion

The present study gives a first impression of how refined patent statistics may be used to gain a more detailed picture of how applicants in the sector of electric vehicles and different of its sub-fields treat questions related to IP and patents. It could be shown that by taking into account legal status data of patents applications and granted patents, distinguishable "fingerprints" can be created from patent portfolios belonging to a certain entity or being chosen from a certain technical field. The findings reflect the experience of patent system users with respect to different patenting structures reasonably well. It provides a helpful tool to identify main competitors in certain technical fields or fields with higher or lower potential for innovation. Hence, it can be concluded that analyses like the ones shown in this study can make a significant contribution to the successful use of patent information for businesses.

Acknowledgments

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