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From science to technology[1]: The value of knowledge from the business sector

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Introduction

Growing pressure related to energy, the environment, and traffic safety has renewed the call for a transition to electric mobility (e-mobility), which refers to vehicles that rely on plug-in electricity for their primary energy (Figenbaum & Kolbenstvedt, 2013). E-mobility is currently supported by technological, political and strategic decisions as a favourable approach to reduce carbon emissions and is being discussed as a driver of change in the automotive industry (Sanden, 2013). E-mobility requires development and integration of an appropriate infrastructure, which includes public charging stations and a smart grid (van Deventer et al., 2011). Specifically, electric vehicles (EVs) as its central idea should, in principle, have a bright future for accelerating technological progress. However, to address the problems of high costs and short range, continuously evolving charging technologies and a comprehensive charging infrastructure are needed (Adam, 2016). The recent focus of public funding has thus been directed more towards charging technologies. For example, the UK central government has established a new £400 million charging infrastructure fund and invested £40 million in charging R&D in 2017.

E-mobility is associated with the shift to a broader network of actors and stakeholders, which consists of existing automotive giants, a large range of start-up companies and new participants such as automotive suppliers and charging services providers (Capgemini, 2012). These new participants may help promote and introduce innovations to the market because they are more likely to commercialize radical innovation than the incumbents (Squicciarini, 2012). In addition, governments, energy providers and automakers have dramatically accelerated investment in charging infrastructure that supports commercial EV charging companies aiming to be truly global (Schwedes et al. 2013). Hence, e-mobility is a complex issue that requires the use of closely integrated networks and known partners in the innovation process. As the focal point of a currently international discourse, e-mobility is facilitated by multiple projects in a collaborative environment connecting research, innovation and education concerning transport (Tagscherer & Frietsch, 2014; Kaltenbrunner, 2017), while paying close attention to charging

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infrastructure development (e.g., the project Lindholmen Science Park places a special focus on fast charging). Advanced economies and societies are characterized as knowledge-based (Feldman & Link, 2001), and knowledge generated by the science sector is an essential source of innovation. However, different types of market failure are inherent in knowledge transfer. Even the business sector is increasingly encouraged to make a collaborative contribution (e.g., Copenhagen Electric 2014; BMVI 2014). One major issue faced in green innovation is that academic institutions are primarily driven to create new knowledge and companies primarily focus on valuable knowledge that can be leveraged for a competitive advantage in the market (Partha & David, 1994; Johnstone et al., 2010). The crucial point for blurring the boundaries between science and technology is to link universities with business by embedding scientific research in a larger societal context (Campbell et al., 2005). While research on the university-industry linkage has explored the reasons for, types of and the obstacles to collaboration between universities and businesses, companies are normally analysed using data that represent trends in more applied downstream research and product development (Fontana et al., 2006; Ponds et al., 2009; Perkmann & Walsh; 2009; Johnstone et al., 2010). These analyses focus a small amount of attention on the role of companies in representing knowledge flow trends from a more basic upstream research perspective.

Given recent calls for more ecological innovation policies and research funding that set frameworks for EV adoption and promote charging infrastructure development, such as the BMBF ICT 2020 - eNOVA2 that received 100 million euros for energy management research, there is clearly a considerable amount of ongoing work in the field of bridging research and innovation on EVs. To provide insights into the pattern and effectiveness of scientific and technological activities undertaken in the innovation process, indicators based on publications and patents have been given a central role (Okubo, 1997). The innovation process is regarded as continuous flows of interactions between academic institutions, companies and government agencies (Callaert et al., 2006); thus, understanding the interrelations and dynamics between scientific and technological fields provides guideposts for public policy or for improving performance in a rapidly evolving innovative environment. Accordingly, non-patent literature (NPL) as an indicator of interaction between science and technology has recently been the subject of some debate. As a part of backward citations reflecting closeness to scientific knowledge, NPL helps in assessing patentability, which further indicates that patents with NPL contain more complex and fundamental knowledge (Cassiman et al., 2008) and are of significantly higher quality (Branstetter, 2005). Such an indicator has the potential to provide a systematic view on science–technology interactions based on widespread and consistent availability of reliable and comprehensive patent databases (Callaert et al., 2011). Scholarly works cited by patents, especially journal references, highlight research that focuses on the extent to which technological developments are situated within the vicinity of scientific knowledge (Callaert et al., 2006; Popp, 2017; Jefferson et al., 2018), notwithstanding the questions indicating and interpreting the link or influence from science to technology (Tijssen, 2002; Michel & Bettels, 2001; Harhoff et al, 2003; Meyer et al., 2003). Furthermore, knowledge produced by the business sector, in contrast with that of academia, is partially tacit and is primarily applied in gaining and sustaining competitive advantages; it is embedded in the minds of employees, in the corporate culture and in organisational routines (Campbell et al., 2005). NPL references grant the ability to directly compare knowledge derived from different sectors

[2] The eNOVA Strategy Board for the Automobile Future is an alliance of relevant German companies from the automotive, battery, semiconductor components, and electrical engineering and materials sectors. More information can be found at https://www.strategiekreis-automobile-zukunft.de/english

from the perspective of scientific publications, which is explicit and may be accessed by the public on a global scale (Polanyi, 2012).

To better ascertain the knowledge flows between published and patented clean energy research, Popp (2017) uses citation data from both scientific articles and patents to identify valuable research and corresponding institutions pertaining to the quality of energy research. Analogously, citations are scrutinized to quantify the influence of the scientific outputs of nations on further advancements in science and on the introduction of new technologies (Patelli et al., 2017). In line with the starting point of the approaches above, this paper adds to the current discussion with the aim of measuring and comparing the influence that research performed with contributions from the business sector has on global technological development in EV charging technologies. In response to the challenge of linking the article data to patents, the present study directly uses scholarly works cited by patents rather than making the two-step query (Popp, 2017; Patelli et al., 2017). Furthermore, *Cooperative Patent Classification* (CPC) is employed instead of the conventional criteria of *International Patent Classification* (IPC) to allow EV charging technologies to be resolved in a more refined manner (Ross, Fucito & Coggins, 2013). We limit our analysis of 1,014 NPL references cited by 660 patents to articles and conference proceedings from *Lens patent corpus*[3], as these references cover scholarly works with author affiliation information that can be included in large-scale analysis. Combined with the new application of *Lens patent corpus* and *PATSTAT Global*[4], this paper extends the former work by providing more details on knowledge and technology transfer. In doing so, it measures citations to scholarly works in the global EV charging patent documents as well as patent assignments enabling broad assessment of the value of knowledge from the business sector.

Through a comparison of patents citing matched scholarly works developed by the business sector and other institutions such as universities, research laboratories and non-profit organizations from the perspective of patent citation, scope, claims, family, technology and legal status, this study aims to answer three questions pertaining to the quality of EV charging research output: 1) What information facilitates knowledge flow from science to technology? That is, are scientific papers written by authors from the business sector more likely to be cited by patents, or does other research yield a higher citation potential? Are there differences across technologies? 2) Are there any differences between the types of author contributions? Does the collaborative work capture more attention than the research done exclusively by firms? 3) How does scientific knowledge influence patent assignments and other transactions? Do patents with NPL references provided by the business sector involve more frequent transactions? Measuring the value of knowledge produced by the business sector not only contributes towards a better understanding of e-mobility but also serves the purpose of fostering more partnerships and unlocking further investments in research.

Data and methods

To answer the first two research questions in this paper–investigating whether a distinction exists in the flow of different sectors' knowledge–NPL data are extracted from EV charging

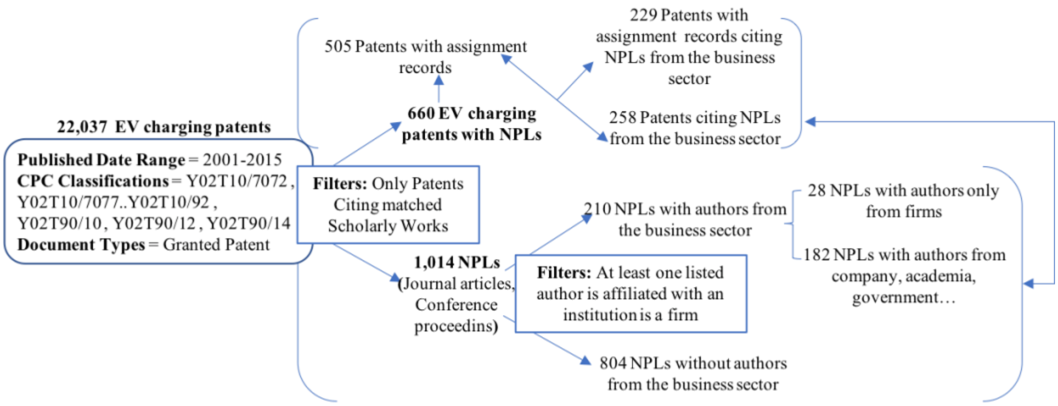
[3] The Lens began serving the scholarly citations in 2014, and by January 25, 2017, over 31 million NPL citations (resolved and unresolved with unique identifiers) were extracted from around 7.6 million patent records or 4.7 million simple patent families.

[4] PATSTAT Global contains bibliographical data relating to more than 100 million patent documents from leading industrialised and developing countries. It also includes the legal status data from more than 40 patent authorities contained in the EPO worldwide legal status database (INPADOC).

technology patent documents that are retrieved from *Lens* with CPC symbols 'Y02T90/10-169, Y02T10/7072-94, Y02T10/92, Y04S10/126, Y04S10/30, Y04S30/12' and published between 2001 and 2015 (Fig.1). Patent classifications mentioned herein cover specific charging systems or methods for batteries, ultracapacitors, supercapacitors or double-layer capacitors, charging stations as well as technologies related to EV charging that enable technologies with a potential or indirect contribution to greenhouse gas emissions mitigation. NPL data are further filtered by document types by dropping publications such as book chapter, editorials, or news items. Partial NPL references are assigned to the set of business sector publications when at least one listed author is affiliated with an institution is a firm. Moreover, authors' affiliation information is extracted and grouped as firm only and collaboration with academia to compare how firms perform in producing valuable research. Six percent of patents containing NPLs published by firms both independently and collaboratively should be considered separately and regrouped according to the contributions of authors from different sectors.

Technology transfer is explored through legal status information recorded with the *PATSTAT*, which covers the assignment data derived from the recording of patent document transfers by parties at different authorities. It maintains a complete history of claimed interests in a patent and also includes the records of other documents that affect title (e.g., certificates of name change and mergers of businesses) or are relevant to patent ownership (e.g., licensing agreements, security interests, mortgages, and liens). In this paper, we mainly take the type of assignment of assignor's interest into account, which is a transfer by an assignor of all or part of its right, title, and interest in a patent (Marco et al., 2015). This feature can be used to understand the transaction trends, and the assignments of interest in a technology area suggest leads for commercialization. However, no information about real use of the patented technology is available. Using different data sources may lead to different results (Squicciarini, 2012).

Figure 1: Dataset of EV charging patents and matched NPLs



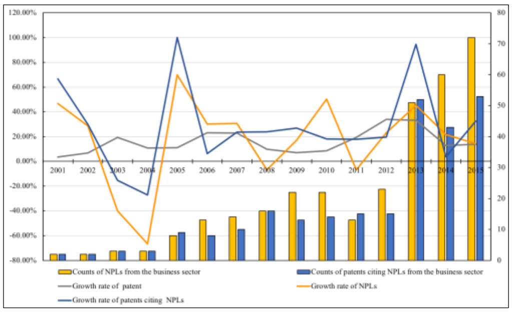
Indicators based on the existing literature, such as patent scope (Lerner, 1994), patent family size (Harhoff et al., 2003), number of claims (Tong & Davidson, 1994) and forward citations (Trajtenberg et al., 1990), are applied to capture the technological importance of the invention citing scholarly works and the possible impact on subsequent technological developments. The scope of patents is defined in terms of the number of distinct four-digit CPC subclasses listed in the patent documents, and we hypothesize that patents having broader patent scope can contribute more to technological development since a high index means that the patent covers a wide range of technology. The index is normalised according to the maximum scope value of the patents in the same cohort, with cohorts being defined according to the year of publication and group of patents. Family size is counted as the number of patent offices at which an invention has been protected by a patent, and we hypothesize that a patent applied for in more countries is more important. Patent claims determine the boundaries of the exclusive rights of a patent owner, and we hypothesize that a higher the number of claims expresses a higher expected value of the patent. Forward citation refers to the number of citations received in a five-year period after the publication of a patent, and we hypothesize that the higher citation score mirrors the technological importance of the patent for the development of subsequent technologies. NPL references are further linked to data on top assignees, frequently transferred patents and execution year for the purpose of tracing technology transfer with a knowledge base provided by different sectors. The major challenge for applying those indicators is that NPL references do not correspond directly to citing patents, which have been recorded separately, thereby resulting in a broader set of citing patents other than EV charging technologies listed in the NPL file and missing records of patent information, such as the patent family size. Due to database constraints, we combine *PatCite*, a new application of *Lens* for exploring and mapping influences of scholarly works on patents, with *Lens ID* to filter out irrelevant citing records and to match NPL references with the classification and family size of citing patents.

Results and discussion

General trends in EV charging patents and matched NPLs

The graph (Fig.2) shows changes in the number of EV charging patents and their NPLs from 2001 to 2015, which uses lines and bars to describe growth trends and counts respectively. The number of EV charging patents in the last 15 years has presented a steady growth, with the most dramatic increase in the two years from 2012 to 2013. However, continuous and sharp fluctuations are visible in the growth rates of scholarly works listed in patent documents and matched citing patents. The growth rate of NPLs shows a downward trend from 2002 and hits the lowest point in 2004 as well as a considerable increase in 2005 and 2013, meanwhile, the growth trend of citing patents is in line with similar changes. There is an upward trend in the number of NPLs from the business sector and matched citing patents, while the maximum value in 2015 is less than a hundred records.

Figure 2: Changes in the number of EV charging patents and NPLs (2001-2015)



80 percent of NPLs cited by EV charging patents were published between 1996 and 2010, particularly the papers published in 2005. the first article sorted by date was published in 1956 by authors from *Lyons Laboratorie*s, which was cited by the patent regarding battery systems filled in 2008. More than 83 percent of papers contain at least one listed author that is affiliated with universities, and those scholars have played the leading role in collaboration with authors from universities, firms and research institutes. Taking *Mie University* and *Yokohama National University* as an example, their close collaborations have accumulated 123 citations extracted from EV charging patents. *Massachusetts Institute of Technology*, *Max Planck Society* and *Oracle Corporation* are representatives in each category of author affiliations, holding a higher number of scholarly works and citing patents. NPLs from the business sector compared with others have received similar but slightly lower patent citations on average (Tab.1). The citation

frequency of firm publications is higher when the independent scholarly works are compared separately.

Table 1. Citations to NPLs

Collaboration / Counts / Group of NPLs	Independent scholarly works			Collaborative scholarly works			Total		
	Citation	NPLs	Average citation	Citation	NPLs	Average citation	Citation	NPLs	Average citation
NPLs from business sector	684	29	23.59	3,095	181	17.10	3779	210	18.08
NPLs from other sectors	1,522	78	19.51	13,916	726	19.17	15,438	804	19.35

The role of firm publications in generating applied technology

Batteries, plug-in electric vehicles and specific charging systems are the common focus points covered by patents with different kinds of NPLs (Fig.3), while certain differences in proportions according to the overall technological interest still exist. EV charging technologies are discussed in terms of electric charging stations and rail vehicles by patents citing firm publications, whereas the others explore issues that relate to information or communication technologies, energy generation and electric propulsion.

Figure 3: Main technologies covered by patents

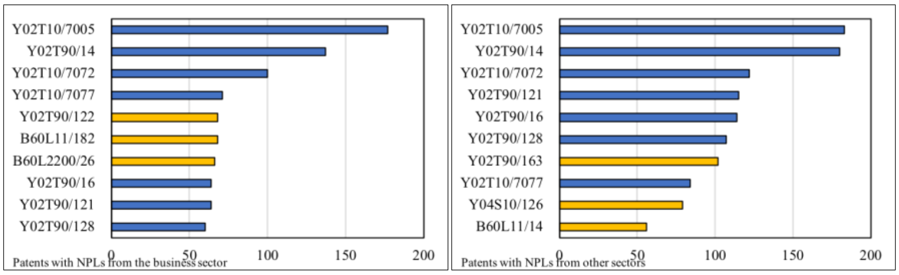


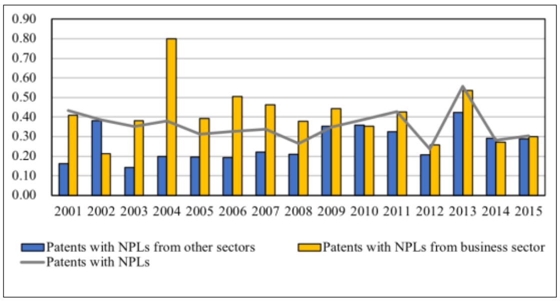
Table 2 shows the average scope index by groups of patents with different NPLs, and patents citing scholarly works published by firms have a boarder scope compared to patents citing NPLs from the others. Firms' collaborations with academia in NPLs contribute an even higher index, while the patents citing independent works from firms have no advantage over others in width.

Table 2. Average patent scope index

Group of patents/NPLs	Independent scholarly works	Collaborative scholarly works	Total
Patents with NPLs from the business sector	0.34	0.39	0.38
Patents with NPLs from others	0.34	0.30	0.31

The scope index of patents with citations to NPLs ranges from 0.24 to 0.56, which varies in a fixed width of technology coverage except the sharp decrease in 2012 and the subsequent increase in 2013. Patents citing firm publications rank above the overall patent scope index between 2003 and 2009, which report the largest index in 2004, corresponding to 0.80 as compared to 0.38 on average observed for all patents. Patents with citations to NPLs from non-business sectors conversely have reported lower indices since 2001 and only rank above the overall patent scope index in 2009.

Figure 4: Patent scope index (2001-2015)



The family size of EV charging patents mostly ranges between one and ten (Fig.5), with dispersion that varies according to the citations to NPLs. The size of 29 patents citing firm publications exceeds 40, accounting for 11.37 percent of total.

Figure 5: Distribution of family size

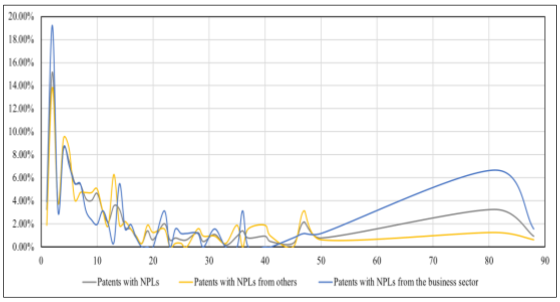


Table 3 shows the average patent family size by groups of patents with different NPLs, and patents citing scholarly works published by firms have a larger size compared to patents citing NPLs from the others. Firms' collaborations with academia in NPLs contribute a larger size on average, while the patents citing independent works from firms hold a smaller size than that of the others.

Table 3. Average patent family size

Group of patents/NPLs	Independent scholarly works	Collaborative scholarly works	Total
Patents with NPLs from the business sector	14.06	23.51	22.18
Patents with NPLs from others	16.11	16.32	16.29

Patents citing firm publications contain more claims per patent than the others despite whether there has a collaboration between authors (Tab.4), and the difference is more than ten claims on overage.

Table 4. Average patent claims

Group of patents/NPLs	Independent scholarly works	Collaborative scholarly works	Total
Patents with NPLs from the business sector	30.56	35.58	31.27
Patents with NPLs from others	22.12	21.10	21.24

Forward citation counts presented here (Tab.5) include patent equivalents – that is, patent documents protecting the same invention at several patent offices. Forward citations are counted over a period of five years after the publication date and thus the patent published between 2011 and 2015 are not compared. Patents citing firm publications have received more forward citations on average, while the patents published between 2001 and 2005 with citations to collaborative scholarly works from the business sector have been cited less than the others, showing a different pattern compared to the three indicators described above.

Table 5. Average forward citations

PY & NPLs / Group of patents	2001-2005			2006-2010		
	Independent scholarly works	Collaborative scholarly works	Total	Independent scholarly works	Collaborative scholarly works	Total
Patents with NPLs from the business sector	88.86	48.36	61.86	63.43	70.67	68.71
Patents with NPLs from others	82.25	51.20	55.47	17.43	32.50	29.55

The influence of firm publications on technology transfer

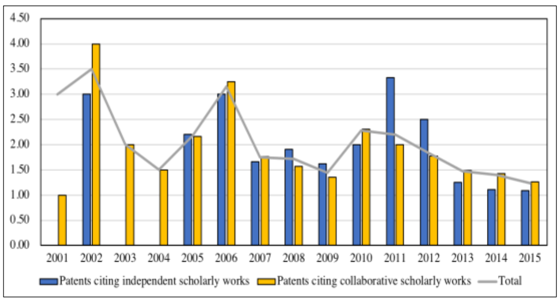
Among 2,384 records of changes in legal status of EV charging patents, assignments of interest account for 34.65% and are mainly executed in the United States, Germany, Switzerland, Australia and the Netherlands. Patents citing firm publications have less assignments by total but more on average compared to the others (Tab.6). 22 patents of total have been transacted between firms or between firms and persons more than five times, such as the assignments between *GM Global Technology Operations* and *Delphi Technologies*, or the transfers between *Genedics Company* and *Fein*. Over half of these frequently assigned patents have cited firm publications and 85 percent of them contain collaborative works.

Table 6. Legal status information of patents

Group of patents	Counts of change	Assignments	Assignments per patent
Patents with NPLs from the business sector	1,278	381	1.66
Patents with NPLs from others	1,106	445	1.61

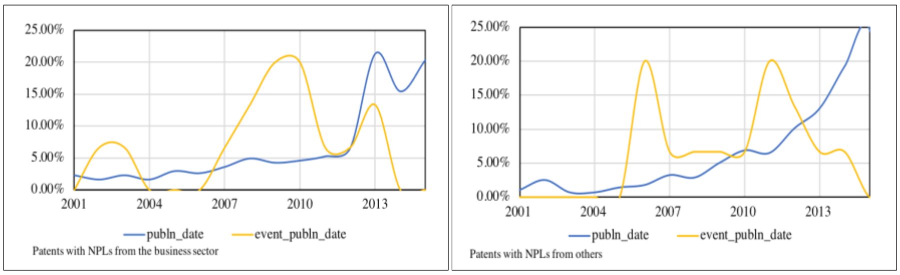
Figure 6 shows the average assignments of patents with NPLs from the business sector on a broader range, which further indicates that patents citing collaborative scholarly works are more likely to be transferred than those with citations to NPLs only affiliated with firms.

Figure 6: Average assignments of patents with NPLs from the business sector (2001-2015)



The differences arising from citations to NPLs not only exist in the number of assignments but in the time span between execution date of an event and the publication date of a patent (Fig.7). In the case of patents citing firm publications, execution date primarily ranges from 2007 to 2013, which shows a time lag of two years compared to the others. However, assignments of patents with different NPLs both frequently occur in patents published between 2012 and 2015.

Figure 7: Execution year corresponding to publication year (2001-2015)



Conclusion

Using an original data set of NPL references extracted from patent documents pertaining EV charging technologies, this paper provides new evidence on the flows of knowledge with or without a contribution from the business sector in corresponding cited scholarly works. In general, the number of EV charging patents in the last 15 years has presented a steady growth while the growth rates of scholarly works listed in patent documents and matched citing patents have conversely fluctuated to a certain extent. However, an upward trend has emerged in the number of NPLs from the business sector and matched citing patents. 80 percent of NPLs cited by EV charging patents were published between 1996 and 2010, and universities still occupy the main locus of knowledge production. NPLs from the business sector compared with others have received lower patent citations on average, while the frequency is higher when the independent scholarly works are compared separately. Batteries, plug-in electric vehicles and specific charging systems are the focal points of patented technologies. Patents citing firm publications have a special focus on technologies relating to stations and rail vehicles, while the others have explored issues of information or communication technologies, energy generation and electric propulsion.

To capture the technological importance of the invention citing scholarly works and the possible impact on subsequent technological developments, indicators like patent scope, patent family size, number of claims and forward citations are further applied. Patents citing scholarly works published by firms have a boarder scope compared to patents citing NPLs from the others, and firms' collaborations with academia in NPLs contribute an even higher index. Specifically, patents citing firm publications rank above the overall patent scope index except the year 2002 and 2010, however the others conversely have reported lower indices since 2001. The family size of EV charging patents mainly shifts between one and ten, with dispersion that varies according to the type of NPLs. For instance, 29 patents citing firm publications that exceeds 40 in size, accounting for 11.37 percent of total. Patents citing firm publications, particularly the one with citations to collaborative works, have a larger family size and contain more claims on average. This numerical advantage also exists in the comparison of forward citations, while the patents published between 2001 and 2005 with citations to collaborative scholarly works from the business sector have been cited less than the others.

Technology transfer is explored through legal status information and compared based on the assignment of assignor's interest, which accounts for 34.65% of total counts of changes. These transactions have been mainly executed in the United States, Germany, Switzerland, Australia and the Netherlands since 2001. Patents citing firm publications have less assignments by total but more on average, and patents citing collaborative works are more likely to be transferred. In addition, assignments frequently occur in patents published between 2012 and 2015, whereas the execution date of patents citing firm publications shows a time lag of two years compared to the others.

Firm publications cited by patents in the field of EV charging, especially in collaborating with academia, have exercised certain influences both on generating applied technologies and technology transfer. That is, patents with citations to NPLs from the business sector tend to cover a wider range of technologies and to be applied for in more countries. Meanwhile, they have been assigned a higher expected value and to be more technological importance in comparison with patents citing scientific research performed by other sectors. Although the real use of the patented technology in the market is unknown, the patents citing firm publications have aroused a particular interest in assignees.

This paper only presents the findings in one technological field and the discussion on the use of NPLs in exploring interactions between science and technology remains inconclusive. However, the results mentioned above have indicated that differences in patents are notable corresponding to citations to different NPLs. The findings would be compared on a broader range of technologies and NPLs are expected to be applied in developing novel indicators in a further study.

References

Adam, M. (2016). Electromobility—The Current State. In Accelerating E-Mobility in Germany (pp. 1-13). Springer, Cham.

Aksnes, D. W., & Sivertsen, G. (2004). The effect of highly cited papers on national citation indicators. Scientometrics, 59(2), 213-224.

BMVI—Elektromobilitat Model Region Bremen/Oldenburg. (2014). Retrieved from http://www.bmvi.de/SharedDocs/DE/Artikel/UI/modellregion-bremen oldenburg.html?nn=36210.

Branstetter, L. (2005). Exploring the link between academic science and industrial innovation. Annales d'Economie et de Statistique, 119-142.

Callaert, J., Grouwels, J., & Van Looy, B. (2011). Delineating the scientific footprint in technology: Identifying scientific publications within non-patent references. Scientometrics, 91(2), 383-398.

Callaert, J., Van Looy, B., Verbeek, A., Debackere, K., & Thijs, B. (2006). Traces of prior art: An analysis of non-patent references found in patent documents. Scientometrics, 69(1), 3-20.

Campbell, D. F., & Guttel, W. H. (2005). Knowledge production of firms: research networks and the" scientification" of business R&D. International Journal of Technology Management, 31(1-2), 152-175.

Capgemini. (2012). Managing the Change to E-Mobility. Retrieved from: http://www.capgemini. com/resource-file-access/resource/pdf/Managing_the_Change_to_E-Mobility___Capgemini_

Cassiman, B., R. Veugelers, and M. Zuniga (2008). In search of performance effects of (in)direct industry science links. Industry and Corporate Change 17 (4): 611–646. http://ideas.repec.org/a/oup/indcch/v17y2008i4p611-646.html

Copenhagen Electric. (2014). The regional EV secretariat. Retrieved from http://www.cphelectric.dk/.

Feldman, M. P., & Link, A. N. (Eds.). (2001). Innovation policy in the knowledge-based economy (Vol. 23). Springer Science & Business Media.

Figenbaum, E., & Kolbenstvedt, M. (2013). Electromobility in Norway-experiences and opportunities with Electric Vehicles (No. 1281/2013).

Fontana, R., Geuna, A., & Matt, M. (2006). Factors affecting university–industry R&D projects: The importance of searching, screening and signalling. Research policy, 35(2), 309-323.

Harhoff, D., Scherer, F.M., and Vopel, K. (2003). "Citations, family size, opposition and the value of patent rights", Research Policy, 32 (8), 1343-1363.

Jefferson, O. A., Jaffe, A., Ashton, D., Warren, B., Koellhofer, D., Dulleck, U., ... & Bilder, G. (2018). Mapping the global influence of published research on industry and innovation. Nature biotechnology, 36(1), 31.

Johnstone, N., Haščič, I., Popp, D., 2010. Renewable energy policies and technological innovation: evidence based on patent counts. Environ. Resour. Econ. 45 (1), 133–155.

Kaltenbrunner, W. (2017). Situated Knowledge Production, International Impact: Changing Publishing Practices in a German Engineering Department. Minerva, 1-21.

Lerner, J. (1994), "The Importance of Patent Scope: An Empirical Analysis", RAND Journal of Economics, 25(2): 319-333.

Marco, A. C., Myers, A. F., Graham, S. J., D'Agostino, P. A., & Apple, K. (2015). The USPTO patent assignment dataset: Descriptions and analysis.

Meyer, M., Sinilainen, T., and Utecht, J.T. (2003). "Towards hybrid Triple Helix indicators: A study of university-related patents and a survey of academic inventors," Scientometrics, 58 (2), 321-350.

Michel, J., and Bettels, B. (2001). "Patent citation analysis: A closer look at the basic input data from patent search reports", Scientometrics, 51, 185-201.

Okubo, Y. (1997). Bibliometric indicators and analysis of research systems.

Partha, D., & David, P. A. (1994). Toward a new economics of science. Research policy, 23(5), 487-521.

Patelli, A., Cimini, G., Pugliese, E., & Gabrielli, A. (2017). The scientific influence of nations on global scientific and technological development. Journal of Informetrics, 11(4), 1229-1237.

Perkmann, M., & Walsh, K. (2009). The two faces of collaboration: impacts of university-industry relations on public research. Industrial and Corporate Change, 18(6), 1033-1065.

Polanyi, M. (2012). Personal knowledge. Routledge.

Ponds, R., Oort, F. V., & Frenken, K. (2009). Innovation, spillovers and university–industry collaboration: an extended knowledge production function approach. Journal of Economic Geography, 10(2), 231-255.

Popp, D. (2017). From science to technology: The value of knowledge from different energy research institutions. Research Policy, 46(9), 1580-1594.

Ross P., Fucito P. & Coggins W. (2013). USPTO and EPO Announce Launch of Cooperative Patent Classification System. Washington: USPTO Press.

Sanden, B. (2013). Systems perspectives on electromobility 2013, Chalmers University of Technology. ISBN 978-91-980973-1-3.

Schwedes, O., Kettner, S., & Tiedtke, B. (2013). E-mobility in Germany: White hope for a sustainable development or Fig leaf for particular interests? Environmental Science & Policy, 30, 72–80. Retrieved from http://linkinghub.elsevier.com/retrieve/pii/ S1462901112001839.

Squicciarini, M. "Measuring patent quality and radicalness: new indicators." 4th IPTS Workshop on “The Output of R&D activities: Harnessing the Power of Patents Data”. Sevilla. 2012.

Tagscherer, U., & Frietsch, R. (2014). E-mobility in China: Chance or daydream? (No. 40). Fraunhofer ISI Discussion Papers Innovation Systems and Policy Analysis.

Tijssen, R.J.W. (2002). "Science dependence of technologies: Evidence from inventors and their inventions", Research Policy, 31 (4), 509-526.

Tong, X and J. Davidson (1994), “Measuring national technological performance with patent claims data”, Research Policy, 23: 133-141.

Trajtenberg, M. (1990), “A Penny for Your Quotes: Patent Citations and the Value of Innovation”, RAND Journal of Economics, 21 (1): 172-187.

van Deventer, P. et al. (2011). Governing the transition to e-mobility: small steps towards a giant leap. Retrieved from http://www.nsob.nl/EN/wp-content/uploads/2010/06/e-mobility-webversie.pdf.