IMPACT: International Journal of Research in Engineering and Technology
ISSN (P): 2347–4599; ISSN (E): 2321–8843
Vol. 11, Issue 1, Jun 2023, 7–17

SYSTEMATIC REVIEW OF THE INTERNATIONAL LITERATURE ON UNIVERSITY PATENT QUALITY INDICATORS

Leonidio, U.C[1,2], Pereira, J.C[2], Souza, C.G[1], Cardoso, D.O[3]

[1]*Research Scholar, Federal Center for Technological Education Celso Suckow da Fonseca, Rio de Janeiro, Brazil*

[2]*Research Scholar, Catholic University of Petrópolis, Petropolis, RJ, Brazil*

[3]*Research Scholar, Smart Cities Research Center, Polytechnic Institute of Tomar, Portugal*

Received: 06 Jan 2023 **Accepted: 15 Jan 2023** **Published: 31 Jan 2023**

ABSTRACT

This study proposes to carry out a systematic review of the international scientific production on quality indicators and metrics of patents related to universities between the years of 1945 and 2018. The database consulted was the Social Sciences Citation Index (Web of Science). The results indicate that 88% of the studies are of a quantitative nature, and the most used metric to evaluate the quality of patents is the subsequent citation of patents. Others metrics were indicated, such as a) The relative Citation Index (RCI), b) Scientific productivity of the inventor, c) Previous patent citation, d) Number of patents accepted, e) Number of patent applications, f) Renewal of patents, g) Patent portfolio. And there are still studies that propose the creation of a patent quality index trying to facilitate the measure of patent quality. It is observed that there are works with an approach to innovation and the triple helix, which means, the union of the university with government and industry, with indicators of commercialization metrics to evaluate the quality of patents in universities.

KEYWORDS: *Patent Quality, Performance, Innovation.*

I. INTRODUCTION

The universities have an important role in the dynamics of forming knowledge and the process of technologic innovation. It is so meaningful that since 1970, governments around the world have been releasing countless initiatives, with the goal of approximate colleges and the industry (MOWERY and SAMPAT, 2005). It highlights still, that the knowledge produced by universities may result in marketable processes and products, benefiting society and the industry. And the publication of scientific articles, patents deposits, in such a way, that they serve as protection from discovery to the application, divulgation and diffusion of knowledge, given through the transference of technology from universities to companies. Once the innovative process has as its ultimate aim, the positive exploration of this knowledge, either in an economic approach or using encouragement and improvement of the quality of the research (CARO, LUCIA and GARCIA, 2003, HAASE, ARAÚJO and DIAS, 2005, BARBASTEFANO, SOUZA and ARAÚJO, 2010, PERUCHI e MUELLER, 2014, CATIVELLI and LUCAS, 2016)

Universities contribute the economic growth. Not only through teaching and research, but also through engagement and collaboration outside the university environment one way to measure the economic effects of these activities is to examine patent data. Over the last years, it has been seen an increase in the use of patent metrics to evaluate the innovation and performance of research, and in the last instance, patent quality. (OECD, 2018) There is an impact caused by patents originated in universities, as in the adhesion of stimulus through teaching activities and oriented research towards innovations and the repercussions for licensing and funding of colleges. (CARO, LUCIA and GRACIA, 2003; HAASE, ARAUJO and DIAS, 2005).

The innovation is considered a primordial factor in the development of organizations, which can occur in any sector of economy. Including government services such as health and education an innovation is a continuous process, which only occurs when there is the presence of an idea, followed by implementation and results. (OECD, 2015; DALLACORTE and JACOSKI 2016)

Technological innovation is the incorporation of this conception, it is the conception of new technological knowledge, whither a new product or a manufacturing process, as well as the attachment of new functionalities or features, and that implies incremental improvements with gains of productivity and quality to the productive activities, resulting in greater market competitiveness. It is the invention being affectively applied in practice, in another words, it is the introduction of new products on the market, or alterations in known products, from on advance in technological knowledge. According to WIPO (2017), invention can be considered as a new solution to a specific technological field. The innovation can be referred to products and productive processes, the implementation of a product (material assets or services) being new or significantly improved, an existing process, a new marketing method, a new organizational method in business practices, workplace organization or external relations that changes the operational relations that changes the operational way. It perceives that invention is characterized by ¨conceiving¨ and innovations by using¨. (OCDE, 2015, OECD, 2018)

Since the 1950´s, the researchers have discussed the connection between invention, innovation and patents. Maclaurin (1953), Schmookler (1960, 1966, 1975) Where (1) patents and innovations are interrelated within inventions, because (2) there are innovations in use arising from inventions; (3) There are patents arising from inventions both unused and in use, which (4) relate to innovations as shown in figure 1 below

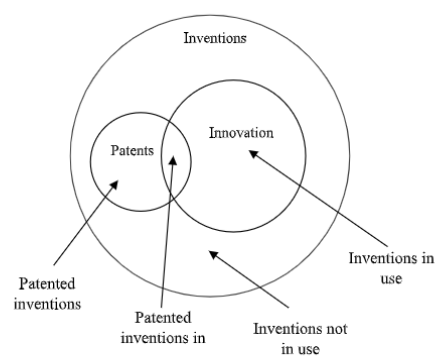

Figure 1: Interconnection between patenting, invention and innovation Adopted from Basberg (1987).

The data from universities deposits of patent can rive important trends, in this important innovative process and also relating to patenting activity. Highlighting the role of colleges as an intermediate outcome of innovation activity in some specific segments and also the university industry partnership the analysis of these data contributes, albeit marginally, to a deeper understanding of the Brazilian university in the national innovation system. ¨ (POVOA, 2006, p3;

OECD, 2018)

It should be noted that universities can present an attractive work environment for researches, professors and those in transposing research results to the market demand and as a response to the market demand and as an ¨Additional instrument for the evaluation of research results in the academic environment that, depending on the scientific orientation of the respective areas, it facilitates clarification on the effective market value of the scientific output ¨Thus, it becomes relevant to know the number of commercializes patents, indicating ¨The scientific competence and the knowledge or technology advantage of universities.¨, besides the addition to indicating the quality of research and commercialized patents. (HAASE, DIAS and ARAUJO, 2005)

The trilateral interaction between university, industry and government is the key to innovation and growth in a knowledge- based economy, proposed as the ¨Triple helix¨ (ETZKOWITZ and LEYDESDORFF, 2000, ETZKOWITZ, 2008). And the production of marketable innovations, as results of academic research, has also become a reality in several countries, and ¨More and more governments invest in universities as producers of innovation. ¨ As pointed out by Perucchi and Mueller (2014).

According to the OECD (2015, 2018) and the Frascati Manual (2015) a patent is a property right over in invention, granted by national patent offices. A patent gives it holder a limited – duration monopoly over the exploitation of the patented invention in return for disclosure, with the aim of allowing a wider social use of the discovery. Increasingly, patent statistics are used in various ways by technology students as indicators of the outcome of invention activities, because the number of patents granted to a particular company, institution or country may reflect its technological dynamism. Examination of patented technologies can give some indication of the direction of technological change and is probably the most used. Scientific Liberatore on the determinants and impacts of innovative activity increasingly uses patent data at the aggregation (national scale) or company level, due to the close relationship between patents and innovation output, which is widely recognized. Patent data also make it possible to identify changes in the structure and evolution of inventive activity in countries, industries, companies and technology, by mapping changes in technological depend, it´s diffusion and deepness.

However, there may be some problems with just using patents as indicators: (1) Many innovations do not correspond to patented inventions; (2) Many patents correspond to inventions of almost zero technological and economic value; although many others never result in innovation, which represents an express challenge between commercial value and technological impact, requiring a proposal for evaluating the quality of patents that assesses the invention - innovation relationship (BOEING and MUELLER, 2016)

It is observed that research on the quality of patents can be a relevant contribution to improving the invention-innovation relationship. Furthermore, developing ways to assess their quality can enhance the results of academic research. Thus, the reflection and question are highlighted: What are the patent quality indicators for universities and their potential for generating technological innovation according to the databases of Web of Science? Therefore, the proposal is to present a systematic review of the literature on the evaluation indicators of the quality of patents produced by universities based on the databases of Web of Science. In an in-depth analysis, what are the features in which Patent Indicators have been implemented? This objective helps researchers learn about the usefulness of Patent Indicators. Systematic reviews may assist researchers in pinpointing future trends in the field.

It is considered as specific objects of this paper: 1) Map the articles that approach the subject quality of patents in universities; 2) Identify the articles that present metrics to measure the quality of university patents; 3) Organize and indicate all these metrics; 4) Indicate the methods used to develop research in the national environment, in order to serve as a theoretical and practical framework for improving the evaluative and innovative capacity of universities and their research.

II. REVIEW OF THE LITERATURE AND METHODS

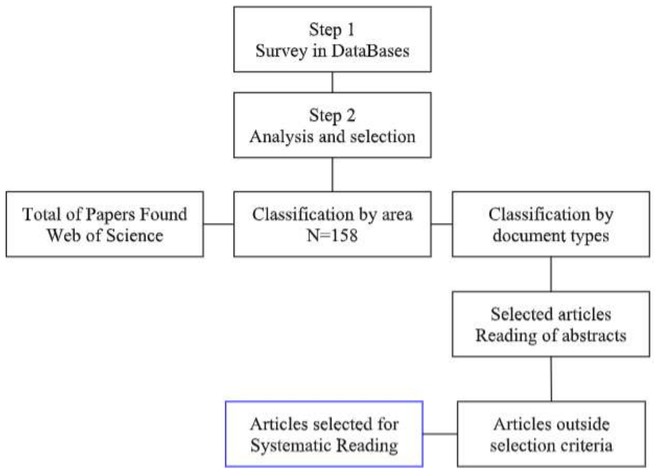

Figure 2: Article survey and selection process.

III. SYSTEMATIC REVIEW, DATA ANALYSIS AND RESULTS

In order to present the results in the review, two moments of analysis were established: The first one is intended to highlight the general characteristics of the productions: Name of the work, name of the authors, name of the journal (source), year of publication, total of quotes. In the second moment, the articles' contribution to understanding the purpose of this review are listed, highlighting the patent quality metrics, the research methods used and the contributions of each article.

The survey made it possible to access 298 papers in the Web of Sciences database. After delimitation and categorization in the following areas with the respective quantities: Management (N=72); Economics (N=41); Education Educational Research (N=23); Information Science Library Science (N=23); Business (N=19); Computer Science Interdisciplinary Applications (N=17); Operations Research Management Science (N=11); Computer Science Information Systems (N=9); Education Scientific Disciplines (N=7); Business Finance (N=5); Public Administration (N=4); Law (N=2) resulted in 158 articles; Selecting only articles and reviews, we reached the number of 120 works. With the reading of the abstracts and application of the inclusion and exclusion criteria, 95 were excluded and 25 articles were chosen to compose the analysis of this review. The main reasons for exclusion were: (a) distancing from the thematic focus of this review, as studies were found that dealt with issues related to Universities, but unrelated to the quality of research, specifically patents; (b) articles that addressed data related to the number of patents, without considering their quality or even dealing with geographic and demographic issues, unrelated to the focus of the study.

Referring to the 25 chosen articles, Figure 3 presents an evolution over time of the publications, showing a trend of increasing publications over time, with an average of 2.166 articles per year, where the year 2017 peaks in publications, with 5 articles.

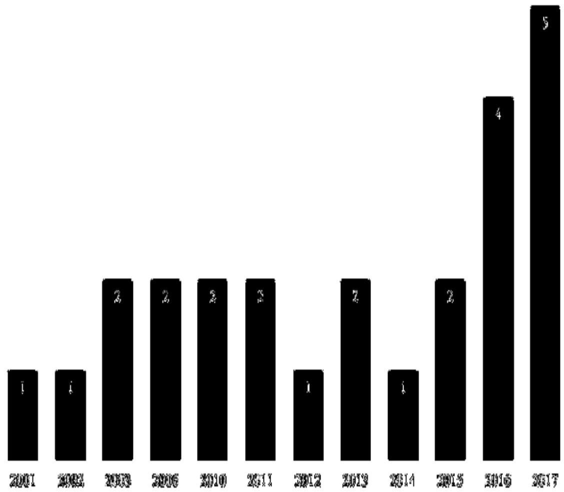

Figure 2: Number of articles published per year.

Table 1 presents a systematization of the information regarding (1) title of the paper, (2) authors, (3) journal, (4) year of publication and (5) number of citations. It was observed that the publications on the theme of the study began after the year 2001, with a greater concentration from the year 2010, with 20 published articles, that is, 77% of the publications occurred after the year 2010. However, most of them refer to previous works, which represent 61.6% of the total citations received. It is notable that some journals have a preponderance in relation to the theme, as is the case of the journal Research Policy, which has 7 publications, and the Journal of Technology Transfer, which has 2 publications, representing 38% of the total number of selected articles. These publications still have 51% of the total number of citations received.

The journal Research Policy (192, 159, 54, 27, 22, 9, 8) has 42.1% of the citations received, Technovation (122) received 12% and the International Journal of Industrial Organization (101) received 10% of the citations.

The most prominent authors are Mowery, DC; Ziedonis, AA, receiving 28.8% of the citations, Owen-Smith, J; Powell, WW, with 15.6% and Rasmussen, E; Moen, O; Gulbrandsen, M, with 12% of the citations. It is worth pointing out the work of the authors Fini, Riccardo; Lacetera, Nicola; Shane, Scott, from the year 2017 and received 54 citations, which represents 5.3% of the citations, which indicates great potential for contribution to the literature.

Table 2: Summary of the Result of the Selection of Articles

Title	Authors	Source	PY	TC
Academic patent quality and quantity before and after the Bayh-Dole act in the United States	Mowery, DC; Ziedonis, AA	Research Policy	2002	192
The expanding role of university patenting in the life sciences: assessing the importance of experience and connectivity	Owen-Smith, J; Powell, WW	Research Policy	2003	159
Initiatives to promote commercialization of university knowledge	Rasmussen, E; Moen, O; Gulbrandsen, M	Technovation	2006	122
Changes in university patent quality after the Bayh-Dole act: a re-examination	Sampat, BN; Mowery, DC; Ziedonis, AA	International Journal of Industrial Organization	2003	101
Reinventing public R&D: patent policy and the commercialisation of national laboratory technologies	Jaffe, AB; Lerner, J	Rand Journal of Economics	2001	70
Inside or outside the IP system? Business creation in academia	Fini, R; Lacetera, N; Shane, S	Research Policy	2010	54
University research, intellectual property rights and european innovation systems	Verspagen, B	Journal of Economic Surveys	2006	51
A Dynamic Network Measure of Technological Change	Funk, RJ.; Owen-Smith, J	Management Science	2017	32
R&D productivity and the organization of cluster policy: an empirical evaluation of the Industrial Cluster Project in Japan	Nishimura, J; Okamuro, H	Journal of Technology Transfer	2011	31
The Effects of Academic Incubators on University Innovation	Kolympiris, C; Klein, PG.	Strategic Entrepreneurship Journal	2017	28
To Own, or not to Own? A multilevel analysis of intellectual property right policies' on academic entrepreneurship	Halilem, N; Amara, N; Olmos-Penuela, J; Mohiuddin, M	Research Policy	2017	27
Patent quality and ownership: An analysis of UK faculty patenting	Sterzi, V	Research Policy	2013	22
The Effects Of Gender On The Quality Of University Patents And Public Research Centres In Andalusia: Is It Better With A Female Presence?	Toribio, R; Puentes, C	Economics & Sociology	2016	21
Collaborative networks and patent production in Andean Community of Nations universities (UCANS), 2005-2015	Aguero A, Carlos E	Revista Espanola de Documentacion Cientifica	2017	13
Patent strategy in Chinese universities: a comparative perspective	Luan, C; Zhou, C; Liu, A	Scientometrics	2010	13
Chinese university patents: quantity, quality, and the role of subsidy programs	Fisch, C O.; Block, J H.; Sandner, P G.	Journal of Technology Transfer	2016	12
A context-aware researcher recommendation system for university-industry collaboration on R&D projects	Wang, Q; Ma, J; Liao, X; Du, W	Decision Support Systems	2017	10
The Stakes in Bayh-Dole: Public Values Beyond the Pace of Innovation	Valdivia, W D.	Minerva	2011	10
Co-owner relationships conducive to high quality joint patents	Briggs, K	Research Policy	2015	9
Spatial patterns of innovation activities in France: market's role versus public research efforts	Corsatea, T D; Jayet, H	Annals of Regional Science	2014	9
Follow the (Industry) Money - The Impact of Science Networks and Industry-to-University Contracts on Academic Patenting in Nanotechnology and Biotechnology	Beaudry, C; Kananian, R	Industry and Innovation	2013	9
Differences in science based innovation by technology life cycles: the case of solar cell technology	Motohashi, K; Tomozawa, T	International Journal of Technology Management	2016	8
Spatial differences in the quality of university patenting: Do regions matter?	Acosta, M; Coronado, D; A Martinez, M.	Research Policy	2012	8
What is the causal effect of R&D on patenting activity in a professor's privilege country? Evidence from Sweden	Ejermo, O; Kallstrom, J	Small Business Economics	2016	6
The role of universities in the national innovation systems of China and the East Asian NIEs: An exploratory analysis of publications and patenting data	Singh, A; Wong, P-K; Ho, Y-P	Asian Journal of Technology Innovation	2015	3

Min Max

Table 3 presents a list of articles that presented contributions related to the theme "patent quality metrics", and the methods used with the intention of fulfilling the objective of the research. Of the 25 analyzed, it was possible to identify quality metrics in 22 articles, that is, 88% of the selected articles presented some type of metric for evaluating patent quality. As for the metrics indicated by the articles, the majority use the "forward citation" (17) metric to evaluate patent quality, i.e. 82.5% of the total number of articles selected for reading. There are other indications, such as a) Relative Citation Index (RCI), b) Scientific productivity of the inventor, c) Backward patent citation, d) Granted Patent, e) Patent applications, f) Patent renewals, g) Patent portfolio. There are also authors (MOTOHASHI et al, 2016) who propose the creation of a patent quality index to try to facilitate the measurement of patent quality.

Table 3: Patent Indicators and Metrics Indicated in the Papers

Authors , PY	Patent Quality Indicators
Wang, Q; Ma, J; Liao, X; Du, W , 2017	Forward citations , Backward citations
Halilem, N ; Amara, N; Olmos-Penuela, Ja; Mohiuddin, M , 2017	Number of spin-off companies
Kolympiris, Christos; Klein, Peter G. , 2017	Forward citations
Funk, R.J. ; Owen-Smith, J , 2017	Forward citations
Fisch, C O.; Block, J H.; Sandner, P G. , 2016	Forward citations
Motohashi, K ; Tomozawa, T , 2016	Forward citations
Ejermo, O ; Kallstrom, J , 2016	Forward citations
Briggs, K , 2015	Forward citations
Singh, A ; Wong, P -K ; Ho, Y -P , 2015	Forward citations ,The Relative Citation Index (RCI)
Corsatea, T D ; Jayet, H , 2014	Science linkage
Beaudry, C; Kananian, R , 2013	Forward citations and Patent application
Sterzi, V , 2013	Forward citations, Backward citations, Patent application and Patent Granted
Acosta, M; Coronado, D; A Martinez, M. , 2012	Forward citations
Nishimura, J; Okamuro, H , 2011	Forward citations and Patent application
Fini, R; Lacetera, N; Shane, S , 2010	Science linkage
Luan, C; Zhou, C; Liu, A , 2010	Patent H-index
Verspagen, B , 2006	Forward citations and Publications
Rasmussen, E; Moen, O; Gulbrandsen, M , 2006	Commercialization
Sampat, BN; Mowery, DC; Ziedonis, AA , 2003	Forward citations, Backward citations, Patent application and Patent Granted
Owen-Smith, J; Powell, WW , 2003	Forward citations, Patent Portfolio
Mowery, DC; Ziedonis, AA , 2002	Forward citations
Jaffe, AB; Lerner, J , 2001	Forward citations, Patent Portfolio

IV. CONCLUSIONS

Considering the research question of this work about what are the quality indicators of patents used by Universities and their potential to generate technological innovation according to the databases of Web of Science journals, with the proposal to present a systematic review of the literature of indicators for evaluating the quality of patents produced by universities, it was found that the most used indicator by the authors of the selected articles is the subsequent citation of patents (JAFFE and LENNER, 2001; MOWERY and ZIEDONIS, 2002, OWNER-SMITH and POWELL, 2003 , SAMPAT et al, 2003; RASMUSSEN et al, 2006 , VERPAGEN, 2006; NISHIMURA and OKAMURO, 2010; ACOSTA et al, 2012; STERZI, 2013; BEAUDRY and KANANIAN, 2013; SINGH et al, 2015; BRIGGS, 2015; EJERMO and KALLSTROM, 2016; MOTOHASHI and TOMOZAWA, 2016; FISCH et al, 2016; KOLYMPIRIS and KLEIN, 2017; WANG et al, 2017). Although this metric is not considered the only and definitive one, also because other metrics are indicated, such as The Relative Citation Index (RCI), Inventor scientific productivity, Previous patent citation, Number of accepted patents, Number of patent applications, Renewal of patents, Patent Portfolio, and even proposals for the creation of a patent indicator (MOTOHASHI et al, 2016), it must be considered that it is a relevant indicator and to be considered as a metric for assessing the quality of patents. As a research environment, universities have some peculiarities, highlighting indications of the inventor's scientific productivity (STERZI, 2013), such as metrics for evaluating the quality of patents, as well as the Correlation between the number of patents and published articles (CORSATEA and JAYET, 2014). It is also worth highlighting the concern with innovation and the Triple Helix, in the union of the University with the Government and Industry, with indications of commercialization metrics (RASMUSSEN and GULBRANDSEN, 2006), formal commercialization and spin off (HALILEM et al, 2017). As an indication for future studies, it is worth evaluating the visitation in other bases to provide new knowledge and expand the possibility of new indicators. Additionally, the analysis of indicators applied in the market to be adapted in universities can be evaluated.

V. ACKNOWLEDGEMENTS

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES)

VI. REFERENCES

1. *Abbas, A., Zhang, L., & Khan, S. U. (2014). A literature review on the state-of-the-art in patent analysis. World Patent Information, 37, 3–13. https://doi.org/10.1016/j.wpi.2013.12.006*
2. *Azagra Caro, J. M., Fernández de Lucio, I., & Gutiérrez Gracia, A. (2003). University patents: output and input indicators of what? Research Evaluation, 12(1), 5–16. https://doi.org/10.3152/147154403781776744*
3. *BARBASTEFANO, R. G., SOUZA, C. G. e ARAÚJO, F.O. (2010). Interação universidade-empresa: Análise de Padrões de Depósitos Conjuntos e Desafios ao Patenteamento Universitário No Brasil. XXX Encontro Nacional De Engenharia De Produção Maturidade e desafios da Engenharia de Produção: competitividade das empresas, condições de trabalho, meio ambiente. São Carlos, SP, Brasil, 12 - 15 de outubro de 2010.*
4. *Basberg, B. L. (1987). Patents and the measurement of technological change: A survey of the literature. Research Policy, 16(2–4), 131–141. https://doi.org/10.1016/0048-7333(87)90027-8*
5. *Beaudry, C., & Kananian, R. (2013). Follow the (Industry) Money – The Impact of Science Networks and Industry-to-University Contracts on Academic Patenting in Nanotechnology and Biotechnology. Industry &Amp; Innovation, 20(3), 241–260. https://doi.org/10.1080/13662716.2013.791125*
6. *Boeing, P., & Mueller, E. (2016). Measuring patent quality in cross-country comparison. Economics Letters, 149, 145–147. https://doi.org/10.1016/j.econlet.2016.10.039*
7. *Briggs, K. (2015). Co-owner relationships conducive to high quality joint patents. Research Policy, 44(8), 1566–1573. https://doi.org/10.1016/j.respol.2015.05.011*
8. *Cativelli, A. S., & Lucas, E. D. O. (2016). Patentes universitárias brasileiras: perfil dos inventores e produção por área do conhecimento. Encontros Bibli: Revista Eletrônica De Biblioteconomia E Ciência Da Informação, 21(47), 67. https://doi.org/10.5007/1518-2924.2016v21n47p67*
9. *Dallacorte, C., & Jacoski, C. A. (2016). Avaliação do desenvolvimento econômico e ligação com patentes: estudo de caso para mensurar inovação em municípios. Ágora : Revista De Divulgação Científica, 21(1), 64–83. https://doi.org/10.24302/agora.v21i1.1103*
10. *Dang, J., & Motohashi, K. (2015). Patent statistics: A good indicator for innovation in China? Patent subsidy program impacts on patent quality. China Economic Review, 35, 137–155.*

https://doi.org/10.1016/j.chieco.2015.03.012

11. *Ejermo, O., & Källström, J. (2016). What is the causal effect of R&D on patenting activity in a "professor's privilege" country? Evidence from Sweden. Small Business Economics, 47(3), 677–694. https://doi.org/10.1007/s11187-016-9752-7*
12. *Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university–industry–government relations. Research Policy, 29(2), 109–123. https://doi.org/10.1016/s0048-7333(99)00055-4*
13. *Fini, R., Lacetera, N., & Shane, S. (2010). Inside or outside the IP system? Business creation in academia. Research Policy, 39(8), 1060–1069. https://doi.org/10.1016/j.respol.2010.05.014*
14. *Fisch, C. O., Block, J. H., & Sandner, P. G. (2014). Chinese university patents: quantity, quality, and the role of subsidy programs. The Journal of Technology Transfer, 41(1), 60–84. https://doi.org/10.1007/s10961-014-9383-6*
15. *Fisch, C. O., Hassel, T. M., Sandner, P. G., & Block, J. H. (2014). University patenting: a comparison of 300 leading universities worldwide. The Journal of Technology Transfer, 40(2), 318–345. https://doi.org/10.1007/s10961-014-9355-x*
16. *Funk, R. J., & Owen-Smith, J. (2017). A Dynamic Network Measure of Technological Change. Management Science, 63(3), 791–817. https://doi.org/10.1287/mnsc.2015.2366*
17. *Haase, H., Araújo, E. C. D., & Dias, J. (2009). Inovações Vistas pelas Patentes: exigências frente às novas funções das universidade. Revista Brasileira De Inovação, 4(2), 329. https://doi.org/10.20396/rbi.v4i2.8648916*
18. *Halilem, N., Amara, N., Olmos-Peñuela, J., & Mohiuddin, M. (2017). "To Own, or not to Own?" A multilevel analysis of intellectual property right policies' on academic entrepreneurship. Research Policy, 46(8), 1479–1489. https://doi.org/10.1016/j.respol.2017.07.002*
19. *Henderson, R., Jaffe, A. B., & Trajtenberg, M. (1998). Universities as a Source of Commercial Technology: A Detailed Analysis of University Patenting, 1965–1988. Review of Economics and Statistics, 80(1), 119–127. https://doi.org/10.1162/003465398557221*
20. *Jaffe, A. B., & Lerner, J. (2001). Reinventing Public R&D: Patent Policy and the Commercialization of National Laboratory Technologies. The RAND Journal of Economics, 32(1), 167. https://doi.org/10.2307/2696403*
21. *Katila, R. (2000). Using patent data to measure innovation performance. International Journal of Business Performance Management, 2(1/2/3), 180. https://doi.org/10.1504/ijbpm.2000.000072*
22. *Kolympiris, C., & Klein, P. G. (2017). The Effects of Academic Incubators on University Innovation. Strategic Entrepreneurship Journal, 11(2), 145–170. https://doi.org/10.1002/sej.1242*
23. *Lanjouw, J. O., & Schankerman, M. (2004). Patent Quality and Research Productivity: Measuring Innovation with Multiple Indicators. The Economic Journal, 114(495), 441–465. https://doi.org/10.1111/j.1468-0297.2004.00216.x*
24. *Luan, C., Zhou, C., & Liu, A. (2010). Patent strategy in Chinese universities: a comparative perspective.*

Scientometrics, 84(1), 53–63. https://doi.org/10.1007/s11192-010-0194-8

25. *Motohashi, K., & Tomozawa, T. (2016). Differences in science based innovation by technology life cycles: the case of solar cell technology. International Journal of Technology Management, 72(1/2/3), 5. https://doi.org/10.1504/ijtm.2016.080539*
26. *Mowery, D. C., & Sampat, B. N. (2006). Universities in National Innovation Systems. Oxford Handbooks Online. https://doi.org/10.1093/oxfordhb/9780199286805.003.0008*
27. *Mowery, D. C., & Ziedonis, A. A. (2002). Academic patent quality and quantity before and after the Bayh–Dole act in the United States. Research Policy, 31(3), 399–418. https://doi.org/10.1016/s0048-7333(01)00116-0*
28. *Mueller, S. P. M., & Perucchi, V. (2014). Universidades e a produção de patentes: tópicos de interesse para o estudioso da informação tecnológica. Perspectivas Em Ciência Da Informação, 19(2), 15–36. https://doi.org/10.1590/1981-5344/1828*
29. *Nishimura, J., & Okamuro, H. (2010). R&D productivity and the organization of cluster policy: an empirical evaluation of the Industrial Cluster Project in Japan. The Journal of Technology Transfer, 36(2), 117–144. https://doi.org/10.1007/s10961-009-9148-9*
30. *OECD (2015). Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development, The Measurement of Scientific, Technological and Innovation Activities, OECD Publishing, Paris, https://doi.org/10.1787/9789264239012-en.*
31. *OECD/Eurostat (2018). Oslo Manual 2018: Guidelines for Collecting, Reporting and Using Data on Innovation, 4th Edition, The Measurement of Scientific, Technological and Innovation Activities, OECD Publishing, Paris/Eurostat, Luxembourg, https://doi.org/10.1787/9789264304604-en.*
32. *Owen-Smith, J., & Powell, W. W. (2003). The expanding role of university patenting in the life sciences: assessing the importance of experience and connectivity. Research Policy, 32(9), 1695–1711. https://doi.org/10.1016/s0048-7333(03)00045-3*
33. *Póvoa, L. M. C. (2005). DEPÓSITOS DE PATENTES DE UNIVERSIDADES BRASILEIRAS (1979 - 2004). Research Papers in Economics. https://EconPapers.repec.org/RePEc:cdp:diam06:006*
34. *Prud'homme, D., & Taolue, Z. (2016). Evaluation of China's Intellectual Property Regime for Innovation: Summary Report. Social Science Research Network. https://papers.ssrn.com/sol3/Delivery.cfm/SSRN_ID3118079_code1947926.pdf?abstractid=3118079&mirid=1*
35. *Rasmussen, E., Moen, Y., & Gulbrandsen, M. (2006) Initiatives to promote commercialization of university knowledge Technovation 26(4), 518–533. https://doi.org/10.1016/j.technovation.2004.11.005*
36. *Sampat, B. N., Mowery, D. C., & Ziedonis, A. A. (2003). Changes in university patent quality after the Bayh–Dole act: a re-examination. International Journal of Industrial Organization, 21(9), 1371–1390. https://doi.org/10.1016/s0167-7187(03)00087-0*
37. *Singh, A., Wong, P. K., & Ho, Y. P. (2015). The role of universities in the national innovation systems of China*

and the East Asian NIEs: An exploratory analysis of publications and patenting data. Asian Journal of Technology Innovation, 23(2), 140–156. https://doi.org/10.1080/19761597.2015.1074515

38. *Stek, P. E., & van Geenhuizen, M. S. (2014). Measuring the dynamics of an innovation system using patent data: a case study of South Korea, 2001–2010. Quality &Amp; Quantity, 49(4), 1325–1343. https://doi.org/10.1007/s11135-014-0045-4*

39. *Sterzi, V. (2013). Patent quality and ownership: an analysis of UK Faculty patenting. Le Centre Pour La Communication Scientifique Directe - HAL - Inria.*

40. *Strand, I., Ivanova, I., & Leydesdorff, L. (2016). Decomposing the Triple-Helix synergy into the regional innovation systems of Norway: firm data and patent networks. Quality &Amp; Quantity, 51(3), 963–988. https://doi.org/10.1007/s11135-016-0344-z*

41. *Thompson, M. J. (2016). Measuring patent quality: A claim and search report approach. World Patent Information, 45, 47–54. https://doi.org/10.1016/j.wpi.2016.03.003*

42. *Valdivia, W. D. (2011). The Stakes in Bayh-Dole: Public Values Beyond the Pace of Innovation. Minerva, 49(1), 25–46. https://doi.org/10.1007/s11024-011-9162-6*

43. *Verspagen, B. (2006). UNIVERSITY RESEARCH, INTELLECTUAL PROPERTY RIGHTS AND EUROPEAN INNOVATION SYSTEMS. Journal of Economic Surveys, 20(4), 607–632. https://doi.org/10.1111/j.1467-6419.2006.00261.x*

44. *Wang, Q., Ma, J., Liao, X., & Du, W. (2017). A context-aware researcher recommendation system for university-industry collaboration on R&D projects. Decision Support Systems, 103, 46–57. https://doi.org/10.1016/j.dss.2017.09.001*