International Journal of Technical Research and Applications e-ISSN: 2320-8163,
www.ijtra.com Volume-2, Special Issue 4 (July-Aug 2014), PP. 08-12

DETERMINANTS OF PATENT VALUE IN US AND JAPANESE UNIVERSITY PATENTS

Kallaya Tantiyaswasdikul
Graduate School of Policy Science
Ritsumeikan University
Kyoto, Japan

***Abstract*— This study investigates the determinants of patent value in US and Japanese university patents. Four broad value determinants including the technical background of patents, the distance of technology from the application date to present, the breadth or scope of patent protection, and the technology classification are considered. The key variables are the number of forward citations as a dependent variable and independent variables composed of the number of backward citations, years, claims, and IPC classes. A comparison analysis using zero-inflated negative binomial regression between US and Japanese university patents has been proved based on the notion of the determinants of patent value. The results reveal that both the US and Japanese university patents share common determinants of value. Older patents receive more citations than younger patents. Backward citations and claims have positive and significant impact on the patent value; however, IPC classes reflect no impact on the value of patents.**

***Index Terms*— Japanese university patents, patent value, university patents, US university patents.**

I. INTRODUCTION

Radical changes have been observed in the academic patenting behavior over the past 30 years since the enactment of the Bayh-Dole Act in the US in 1980 that allows universities to retain their rights in any inventions deriving from public-funded research. For Japan, these changes have impacted the Japanese university patenting due to the emulation of the Act in 1999. Japan has adopted a Bayh-Dole Act-like model to enhance the effectiveness of university-industry technology transfer. As a consequence of this change, a higher propensity to patent academic inventions has been observed by Motohashi and Muramatsu [1]. At the same time, scholars and policymakers have underlined the crucial role played by industry–university partnerships in the knowledge society as discussed by Etzkowitz [2], Jaffe [3], Mansfield [4], [5], Mansfield and Lee [6], and Meyer [7].

Although recent studies of Guellec and van Pottelsberghe de la Potterie [8], Mansfield [5], McMillan et al. [9], and Narin et al. [10] clearly illustrate the significant contribution of public research (performed in universities and public laboratories) to the innovation performances of the business sector, mainly through knowledge spillovers, the rapid increase in academic patenting has provoked new debates about the quality of these patents. Do they herald a surge in academic inventions, or do they merely reflect a higher propensity to patent inventions of lower quality?

This study intends to contribute to this debate. It aims to investigate the value of academic patents and compare their value determinants in US and Japanese university patents, as well as Japanese university patents with different assignees. In order to determine the value of patents, various measures have been developed. All of these measures can be derived from patent data directly. I consider four broad value determinants including the technical background of patents, the distance of technology from the application date to present, the breadth or scope of patent protection, and the technology classification. The key variables are the number of forward citations as a dependent variable and independent variables composed of the number of backward citations, years, claims, and international patent classification (IPC) classes.

In this study, a comparison analysis using zero-inflated negative binomial (ZINB) regression between US and Japanese university patents has been proved based on the notion of the determinants of patent value. Additionally, I provide detailed analyses of Japanese university patents with different institutional-type settings, including university assignee and university co-assignee or university-industry collaboration (UIC) patents. The results reveal that both the US and Japanese university patents share common determinants of value. More precisely, in the case of Japanese university patents, the evidence suggests that the breadth of patent protection (claims) significantly affects valuations, but there is a difference in terms of the nature of patents between university assignee and UIC patents. The remainder of this article is structured as follows: The summary of the determinants of patent value is presented in section 2. Section 3 explains the methods of this study. Section 4 provides data collection and data set, while Section 5 presents the empirical analysis and findings. The last section gives conclusions.

II. DETERMINANTS OF PATENT VALUE

According to the study of Stevens and Burley [11], it is known that on average only one to three patents out of 100 yield significant financial return. This skewed distribution of patent value has been at the origin of a small but growing stream of economic research that attempts to identify the determinants of patent value as discussed by Griliches [12], Griliches et al. [13], Pakes [14], Pakes and Schankerman [15], Sapsalis et al. [16], Scherer [17], and Scherer and Harhoff [18].

Regarding the skew distribution of patent value, additional information that correlated with the value of patent rights has been employed to estimate the valuation. Various indicators have been used as variables to determine patent value in the economic literature on the measurement of the value of patents, such as the number of times the patent is cited (forward citations), or the length of its renewal, or the number of countries where it is taken (patent family size), or the breadth or scope of patent protection (patent claims).

Pakes [14], Pakes and Schankerman [15], and Schankerman and Pakes [19] were the first to develop and estimate models in which the observed renewal decisions are used to estimate the distribution of patent values. Trajtenberg [20] computed a measure of social returns to the computer-tomography scanner industry and relates that measure to citation indicators. Lerner [21] examined the impact of patent scope on the market value of biotechnology firms and developed a proxy for the breadth of patent protection to

determine the valuation. Putnam [22] integrated application data into the analysis of the value of patent.

Harhoff et al. [23] estimated patent value using a broad set of indicators, which are composed of the number of citation received from subsequent applications, the number of references to prior patents (backward citations), the number of references made to the non-patent literature, the outcome of opposition proceedings, the patent family size, and the number of different four-digit IPC classifications. They found significant correlations between patent value and citations received from subsequent patents as well as backward citations. They also found that the observed outcomes of opposition cases and the measure of international patent families are particularly valuable.

Sapsalis et al. [16] compared corporate and academic patents to assess whether they have similar value distributions and share common determinants of value. To evaluate the value determinants of patents, they used the number of non-patent citations, backward citations, co-assignees, and members in the patent family as indicators. They found that the value distribution of academic patents is very close to that for corporate patents and the determinants of patent value are broadly similar for the two sectors. Backward citations, non-patent citations, and the number of inventors and co-assignees all affect the value of both academic and corporate patents.

Guellec and van Pottelsberghe de la Potterie [24] observed the probability of getting a patent granted to approximate the value of a patent. They used the indicators of the patenting strategy, the domestic and international R&D collaboration, the technological diversity (the number of IPC classes), and the mix of designed states for protection (the patent family size) to determine the value of patents. They found that the strategic decision provides the useful information about the grant probability, while the technical diversity has a negative impact on the probability of grant, and the link between patent value and family size is ambiguity.

The type and number of explanatory variables that have been used as determinants of patent value vary widely across studies. The most frequently used determinants are the number of forward citations (when it is not used as a dependent variable), the number of backward citations, and the geographical scope for protection (the number of countries in the patent family). Other variables rely on the concepts of opposition procedures, renewal data, application scope (the number of claims), and non-patent citations.

III. METHODOLOGY

This study examines the determinants of patent value in US and Japanese university patents using panel data from the United States Patent and Trademark Office (USTPO). For this purpose, multiple regression through zero-inflated negative binomial (ZINB) regression was employed. In most patent applications, the value of the forward citation, which is used as the response variable, is zero in a large number of patents. This fact may make it difficult to successfully apply linear regression to the data. Thus, this study is based on a logistic model, wherein patents whose forward citation is equal to or beyond a certain threshold can be differentiated from others. ZINB models, which are robust against over-dispersion caused by a large number of zero counts, are used in bibliometric studies, including patent analyses as presented by Foltz et al. [25], Lee et al. [26], Tang and Shapira [27], and Yoshikane [28].

ZINB regression with the response variable is the number of forward citations was employed. This is the most commonly used proxy for the value of patents. For the explanatory variables, I develop four broad value determinants to determine patent value as follows: (1) the technical background of a patent (measured by the number of backward citations); (2) the distance of technology from the application date to present (measured by the year filed of patents); (3) the breadth or scope of patent protection (measured by the number of claims); (4) the technology classification (measure by the number of IPC classes).

Despite the heterogeneity of previous studies, some similarities emerge. The most important is probably the fact that the number of forward patent citations is closely associated with the value of a patent; all studies using forward patent citations reach this conclusion as discussed by Sapsalis et al. [16]. Thus, I use forward citations represent patent value and estimate their value determinant through four independent variables including backward citations, years, IPC classes, and claims.

Future citations received by a patent (forward citations) are one indication that an innovation has contributed to the development of subsequent inventions. For this reason, citations have been used as a measure of the value of an invention as explored by Trajtenberg [20]. An inventor must cite all related prior US patents in the patent application. A patent examiner who is an expert in the field is responsible for insuring that all appropriate patents have been cited. Like claims, the citations in the patent document help to define the property rights of the patentee as examined by Lanjouw and Schankerman [29].

The number of claims is another, underutilized, indicator of the *bits of informatio*n contained in a patent, and therefore of its value. Supporting evidence for the relationship between claims and value is found in the fact that claims are positively correlated with forward and backward citations as investigated by Lanjouw and Schankerman [30]. Tong and Frame [31] suggested that patent claims might be a better indicator of technological effort than straight patent counts. Certainly, claims correlate better with other technology-related indicators than patent counts.

For technology classification, the use of classifications helps to expedite prior art searches, and helps avoid possible ambiguity that may be present in other keyword search fields as discussed by Harris et al. [32]. The IPC system divides technology into eight discrete sections, including section A: Human necessity; section B: Performing operations, Transporting; section C: Chemistry, Metallurgy; section D: Textiles, Paper; section E: Fixed constructions; section F: Mechanical engineering, Lighting, Heating, Weapons, Blasting; section G: Physics, and section H: Electricity.

The IPC is a technology-based classification system with approximately 70,000 subdivisions. According to Adams [33] and Tantiyaswasdikul [34], in practice, there are few inventions that can be classified into one particular technology; most of the innovations include hybrid elements and patents may be assigned to more than one subclass. Like Lerner [21] and Tantiyaswasdikul [34], I use the set of all 4-digit IPC subclasses to which each patent was assigned for this analysis.

IV. Data Collection and Data Set

This study focuses on the analysis of the determinants of patent value by providing a comparison between US and Japanese university patents. Additionally, the study also investigates in detail Japanese university patents with different institutional types of assignees. Since the Japan UIC policy initiatives that have been implemented since 1998 and the number of Japanese university patents owned by universities are limited by institutional and regulatory disincentives, the data in this analysis cover the period after the enactment of UIC policies from 1998 to 2008. For Japan, the data set consists of all Japanese national university-granted *US Utility Patents* that were applied from 1998 to 2008. For the US, the data set is composed of a 5% random sample of the US university-granted *US Utility Patents* that were applied between 1998 and 2008.

I employ ZINB regression where the dependent variable is the number of forward citations. The explanatory variables include the number of IPC classes, the number of claims, the number of years filed, and the number of backward citations. Table I presents the descriptive statistics of variables of US and Japanese university patents and Table II presents the descriptive statistics of variables of Japanese university assignee and UIC patents.

TABLE I. Descriptive Statistic of Variables of US and Japanese University Patents

Variables	Descriptive statistic				
	Obs.	***Mean***	***Std. Dev.***	***Max***	***Min***
US university patents Forward citations	1,755	1.98	4.36	40	0
IPC classes	1,755	1.68	0.98	9	1
Claims	1,755	20.61	16.56	127	1
Years	1,755	9.18	3.19	15	5
Backward citations	1,755	11.99	15.60	98	0
JP university patents Forward citations	1,779	0.98	2.85	46	0
IPC classes	1,779	1.51	0.84	7	1
Claims	1,779	11.56	7.88	100	0
Years	1,779	7.50	2.52	15	5
Backward citations	1,779	5.41	6.05	123	0

Note: All data were obtained from the online records system of USPTO website; http://www.uspto.gov/patents/process/search/ (Update 20 November 2013).

The count number of US university patents is 1,755 and the count number of Japanese university patents is 1,779, respectively. Additionally, in the case of Japan, the patents were classified according to assignees and institution type. Specifically, the patents were divided into university assignee patents and university co-assignee or UIC patents. The number of university assignee patents is 916, while the number of UIC patents is 863.

TABLE II. Descriptive Statistic of Variables of Japanese University Assignee and UIC Patents

Variables	Descriptive statistic				
	Obs.	***Mean***	***Std. Dev.***	***Max***	***Min***
US university patents Forward citations	916	1.17	3.04	38	0
IPC classes	916	1.59	0.88	7	1
Claims	916	11.05	7.59	57	0
Years	916	8.31	2.86	15	5
Backward citations	916	4.95	6.64	123	0
JP university patents Forward citations	863	0.78	2.63	46	0
IPC classes	863	1.42	0.78	6	1
Claims	863	12.09	8.15	100	1
Years	863	6.65	1.73	15	5
Backward citations	863	5.90	5.32	36	0

Note: All data were obtained from the online records system of USPTO website; http://www.uspto.gov/patents/process/search/ (Update 20 November 2013).

V. Empirical Analysis and Findings

The results of ZINB regression analyses are presented in Tables III and IV. The results reveal that patent values for US and Japanese university patents seem to react to almost similar determinants. Older patents receive more citations than younger patents. Backward citations have positive and significant impact on the number of forward citations. Claims have positive impact to patent value; however, it reveals significance only on US university patents. IPC classes have no impact on the number of forward citations, as demonstrated in Table III.

However, the result of Japanese university patents in Table III is an aggregate number of patents that combine both the university assignee and UIC patents. To investigate why the measure of claims has no impact on Japanese university patents, while this factor has a positive and significant impact on US university patents, a detailed analysis of determinants of patent value in Japanese university patents was created. Table IV provides the results of a comparison analysis between Japanese university assignee and UIC patents.

We can observe almost similar results as the comparison of value determinants between US and Japanese university patents in Table III, except that the impact of claims on the patent value is different between university assignee and UIC patents. In the case of university assignee patents, the number of claims has a significantly positive impact on patent value but the number of claims has no impact on patent value in the case of UIC patents.

TABLE III. Regression Coefficients for Response Variable: Number of Forward Citations for US and Japanese University Patents

Variables	Regression Coefficients	
	US University patents	***JP university patents***
IPC classes	-0.005 (0.034)	-0.071 (0.043)
Claims	0.007*** (0.002)	0.005 (0.004)
Years	0.135*** (0.013)	0.159*** (0.013)
Backward citations	0.011*** (0.002)	0.018*** (0.006)
Obs.	1755	1779
Constant	-0.315	-0.453
Log likelihood	-1812.669	-1186.419
LR chi 2(4)	178.11	146.47

Note: ***represent statistical significance at the 1% level; standard errors in parentheses.

TABLE IV. Regression Coefficients for Response Variable: Number of Forward Citations for Japanese University Assignee and UIC Patents

Variables	Regression Coefficients	
	University assignee patents	***UIC patents***
IPC classes	-0.049 (0.054)	-0.083 (0.073)
Claims	0.011* (0.006)	-0.003 (0.005)
Years	0.134*** (0.019)	0.213*** (0.023)
Backward citations	0.013* (0.007)	0.023* (0.010)
Obs.	916	863
Constant	-0.301	-0.773
Log likelihood	-685.6705	-494.8158
LR chi 2(4)	58.15	86.30

Note: ***, * represent statistical significance at the 1% and 10% levels; standard errors in parentheses.

It is interesting that when analysis is performed separately between Japanese university assignee and UIC patents, we can observe the result of the impact of claims on the patent value in the case of university assignee patents, which show the

similarity to the US university patents, which show positive significance. On the other hand, this is opposite to the case of UIC patents, when the number of claims has no impact to patents' value.

The results of this analysis correspond to the existing study of Harhoff et al. [23], Lanjouw and Schankerman [30], and Tantiyaswasdikul [34] where a number of indicators are significantly correlated with patent value. The measure for references to the patent literature or backward citations carries significant positive coefficients to patent value, similar to the evidence in the study of Harhoff et al. [23]. Likewise, the number of years filed has significantly positive impact to patent value.

The claims number is a particularly good predictor of patent value when it reveals a positive correlation with the increased number of forward citations. Supporting evidence for the relationship between claims and value is found in the fact that claims are positively correlated with forward citations in the study of Lanjouw and Schankerman [30] and Tantiyaswasdikul [34].

Contrary to the previous results of Lerner [21], I find that the number of four-digit IPC classifications has a negative impact on the patent value. However, the relationship between the indicator of IPC class and patent value is ambiguous since Harhoff et al. [23] found that the number of four-digit IPC classifications does not have any explanatory power. The ambiguity of IPC class as a variable in the study of patent value is found in the analysis of Guellec and van Pottelsberghe de la Potterie [24] when the technical diversity has a negative impact on the probability of patent grant. The higher the number of IPC classes listed in an application, the lower the chance to get a grant. The explanation is due to the fact that it is possible that a high number of classes may reflect not only the technological diversity of the invention, but also the perplexity of the examiner facing a somewhat unclear technology as discussed by Guellec and van Pottelsberghe de la Potterie [24].

The explanation of the relationship of the breadth of patent protection and patent value can be explained regarding the links between an innovation and its technological *antecedents* and *descendants*. For claims, the number of claims in an existing patent has some relation to the technological innovation of previous patents. According to Tong and Frame [31], patents do not measure fundamental units of inventiveness. This privilege lies in the domain of patent claims. Thus, an inventor's invention is embodied in his or her claims.

A new invention based on the existing notion will have a few claims since the knowledge of that invention relates to the antecedent technology. In contrast, for the new discovery, the number of claims tends to be excessive. For the explanation of the different impact of claims on university assignee and UIC patents consider the following. In the case of UIC patents, when the number of claims increases the number of forward citations decreases. In general, when the number of claims increases the value of patents decreases.

Since UIC patents are the results of the collaborative research between university and industry that have commercialization purposes, the number of claims can cause difficulty of accessibility of invention in the future. Thus, a small number of claims is better for the broader targets. In contrast, in the case of university assignee patents, when the number of claims increases the number of forward citations also increases. This result corresponds to the existing study of Lanjouw and Schankerman [30] and Tantiyaswasdikul [34] when the number of claims reflects the value of patents. Important inventions gain many citations received. Moreover, the number of claims reflects freshness that means new inventions provide some incentives to researchers and the researcher would like to catch up new technology. Considering this point when the number of claims increases, the number of forward citations also increases.

For IPC classes representing the technology fields, according to Lerner [21], the number of IPC classes has a positive impact on the number of forward citations. This is understandable since a patent that falls into many technology fields provides many possibilities for researchers in many areas to cite. In this case, the number of IPC classes indicates the quantity aspect. However, in this result, when the number of IPC classes decreases, the number of forward citations increases, so the number of IPC classes indicates the quality aspect. This result corresponds to the existing study of Tantiyaswasdikul [34]. The explanation is that it is possible that a high number of classes may reflect not only the technological diversity of the invention, but also the perplexity of the unclear technology as discussed by Guellec and van Pottelsberghe de la Potterie [24].

The measure for references to the patent literature or backward citations carries significant positive coefficients to patent value similar to the evidence in the study of Harhoff et al. [23]. This evidence reflects the relationship between technological antecedents and descendants or backward and forward citations of innovation when an invention based on an existing technology represents the important innovation as discussed by Trajtenberg et al. [35].

VI. Conclusion

This study has been an attempt to use information from patent applications to determine patent value. The analysis of these data has been quite promising. Clear evidence of the significant correlation between the provided indicators and patent value has been observed. The results reveal that patent value for US and Japanese universities seems to react to almost similar determinants. Older patents receive more citations than younger patents. Backward citations and claims have positive and significant impact on the patent value; however, IPC classes reflect no impact on the value of patents. Moreover, regarding the breadth of patent protection in terms of claims, the results reveal the difference between Japanese university assignee and UIC patents. In the case of university assignee patents, the number of claims has a significantly positive impact on patent value but the number of claims has no impact on patent value in the case of UIC patents.

In light of the findings of this study, considering the information derived from patent data is important since it provides not only the technological antecedents and descendants of innovation, but also the determinant of patent value. Information on the value of a patent is contained not only in forward citations as recognized in previous studies, but also in other variables such as the technical background of patents and the breadth or scope of patent protection.

Acknowledgment

I would like to express my gratitude and appreciation to Professor Oda Hisaya, Graduate School of Policy Science, Ritsumeikan University for his support and encouragement.

REFERENCES

[1] K. Motohashi and S. Muramatsu, "Examining the university-industry collaboration policy in Japan: Patent analysis," Technology in Society, vol. 34(2), pp.149–162, 2012.

[2] H. Etzkowitz, "The norms of entrepreneurial science: Cognitive effects of the new university-industry linkages," Research Policy, vol. 27(8), pp. 823–833, 1998.

[3] A.B. Jaffe, "Real effects of academic research," The American Economic Review, vol. 79(5), pp. 957–970, 1989.

[4] E. Mansfield, "Academic research and industrial innovation," Research Policy, vol. 20(1), pp. 1–12, 1991.

[5] E. Mansfield, "Academic research and industrial innovation: An update of empirical findings," Research Policy, vol. 26(7), pp. 733–776, 1998.

[6] E. Mansfield and J.Y. Lee, "The modern university: Contributor to industrial innovation and recipient of industrial R&D support," Research Policy, vol. 25(7), pp. 1047–1058, 1996.

[7] M. Meyer, "Academic entrepreneurs or entrepreneurial academics? Research-based ventures and public support mechanisms," R&D Management, vol. 33(2), pp. 107–115, 2003.

[8] D. Guellec and B. Van Pottelsberghe De La Potterie, "From R&D to productivity growth: Do the institutional settings and the source of funds of R&D matter?," Oxford Bulletin of Economics and Statistics, vol. 66(3), pp. 353–378, 2004.

[9] G.S. Mcmilan, F. Narin, and D.L. Deeds, "An analysis of the critical role of public science in innovation: The case of biotechnology," Research Policy, vol. 29(1), pp. 1–8, 2000.

[10] F. Narin, K.S. Hamilton, and D. Olivastro, "The increasing linkage between US technology and public science," Research Policy, vol. 26(3), pp. 317–330, 1997.

[11] G.A. Stevens and J. Burley, "3,000 raw ideas=1 commercial success," Research Technology Management, vol. 40(3), pp. 16–27, 1997.

[12] Z. Griliches, "Patent statistic as economic indicators: A survey," Journal of Economic Literature, vol. 28(4), pp. 1661–1707, 1990.

[13] Z. Griliches, A. Pakes, and B.H. Hall, "The value of patents as indicators of inventive activity," Working Paper no. 2083, NBER, Cambridge, MA, 1986.

[14] A. Pakes, "Patents as options: Some estimates of the value of holding European patent stocks," Ecomometrica, vol.54, pp. 755–784, 1986.

[15] A. Pakes and M. Schankerman, " The rate of obsolescence of patents, research gestation lags, and the private rate of return to research resources," in R&D, Patents, and Productivity, Z. Griliches, Ed. Chicago: University of Chicago Press, 1984, pp. 73–88.

[16] E. Sapsalis, B. Van Pottelsberghe De La Potterie, R. Navon, "Academic versus industry patenting: An in-depth analysis of what determines patent value," Research Policy, vol. 35(10), pp. 1631–1645, 2006.

[17] F.M. Scherer, "Firm size, market structure, opportunity, and the output of patented inventions," The American Economic Review, vol. 55, pp. 1097–1125, 1965.

[18] F.M. Scherer and D. Harhoff, "Technology policy for a world of skew-distributed outcomes," Research Policy, 29(40), pp. 559–566, 2000.

[19] M. Schankerman and A. Pakes, "Estimates of the value of patent rights in European countries during the post-1950 period," Economic Journal, vol. 97, pp. 1–25, 1986.

[20] M. Trajtenberg, "A penny for your quotes: Patent citations and the value of inventions," RAND Journal of Economics, vol. 21, pp. 172–187, 1990.

[21] J. Lerner, "The importance of patent scope: An empirical analysis," RAND Journal of Economics, vol. 25(2), pp. 319–333, 1994.

[22] J.D. Putnam, "The value of international patent rights," Ph.D. diss., Yale University, 1996.

[23] D. Harhoff, F.M. Scherer, and K. Vopel, "Citations, family size, opposition and the value of patent rights," Research Policy, vol. 32(8), pp. 1343–1363, 2002.

[24] D. Guellec and B. Van Pottelsberghe De La Potterie, "Applications, grants and the value of patent," Economics Letters, vol. 69(1), pp. 109–114, 2000.

[25] J. Foltz, B. Barham, and K. Kim, "Universities and agricultural biotechnology patent production," Agribusiness, vol. 16(1), pp. 82–95, 2000.

[26] Y.G. Lee, J.D. Lee, Y.I. Song, and S.J. Lee, "An in-depth empirical analysis of patent citation counts using zero-inflated count data model: The case of KIST, Scientometrics, vol. 70(1), pp. 27–39, 2007.

[27] L. Tang and P. Shapira, "Effects of international collaboration and knowledge moderation on China's nanotechnology research impacts," Journal of Technology Management in China, vol. 7(1), pp. 94–110, 2012.

[28] F. Yoshikane, "Multiple regression analysis of a patent's citation frequency and quantitative characteristics: The case of Japanese patents," Scientometrics, vol. 96(1), pp. 365–379, 2013.

[29] J.O. Lanjouw and M. Schankerman, "Characteristics of patent litigation: A window on competition," RAND Journal of Economics, vol. 32(1), pp. 129–151, 2001.

[30] J.O. Lanjouw and M. Schankerman, "The quality of ideas: Measuring innovation with multiple indicators," Working Paper no. 7345, NBER, Cambridge, MA, 1999.

[31] X. Tong and J.D. Frame, "Measuring national technological performance with patent claims data," Research Policy, vol. 23(2), pp. 133–141, 1994.

[32] C.G. Harris, R. Arens, and P. Srinivasan, "Comparison of IPC and USPC classification systems in patent prior art searches," Proceedings of the 3rd international workshop on patent information retrieval, ACM: 27–32.

[33] S. Adam, "Comparing the IPC and the US classification systems for the patent searchers," World Patent Information, vol. 23(1), pp. 15–23, 2001.

[34] K. Tantiyaswasdikul, "The impact of the breadth of patent protection and the Japanese university patents," International Journal of Innovation, Management and Technology, vol. 3(6), pp. 754–758, 2012.

[35] M. Trajtenberg, R. Henderson, and A.B. Jaffe, "University versus corporate patents: A window on the basicness of invention," Economics of Innovation and New Technology, vol. 5(1), pp. 19–50, 1997.