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Does Patent Quality Differ among Firms in Japanese Chemical Sectors?

Azri Johan[a], Yoshiyuki Matsuura[b], Nurhayati Issa[b], and Mohammad Ali Tareq*[c]

[a]*Malaysia-Japan International Institute of Technology, Universiti Teknologi Malaysia, Malaysia*
[b]*Graduate School of Innovation & Technology Management Yamaguchi University, Japan*
[c]*International Joint Intellectual Property Laboratory (IJIPL), Malaysia-Japan International Institute of Technology, Universiti Teknologi Malaysia, Malaysia*

Email: tareq@utm.my

***Abstract*— Patents and chemical industry complete each other. Most chemical companies around the world used patent as their protection for inventions and innovations. There are no doubts of qualities of patents in the chemical industry, however, do all the chemical industry sector produce high quality patents? This study will identify the differences in patent quality among four chemical industry sectors which are agricultural chemical (1), commodity chemical (2), diversified chemical (3), and specialty chemical (4). This study used forward patent citation as a measurement of patent quality and analysed it by using Kruskal-Wallis test to see the similarities or differences between each sector. This research has found that there are no similarities in patent qualities in chemical industry sectors thus the quality of patent for each sector are different. Hence, in this research great emphasis will be made on its globally in relation to aspect of patent management and different characteristics of each chemical industry sector.**

Keywords— Patent quality, chemical industry sector, forward patent citation, Kruskal Wallis analysis

I. INTRODUCTION

In a knowledge-based economy where companies use patents to protect innovation, the knowledge on the usages of the patent information plays and important role. Patents gives the assignees the right to protect the intellectual property (IP) and the new products' market domination for a particular time period. The patent quality, its meaning and definitions, as well as how to measure it in practice and what it entails for innovation, entrepreneurship and technology development have been debated over the years. The cry to improve patent quality can be heard among the researcher and practitioners, and is a centerpiece of many of the major reform agendas. The understanding and the analysis of Patent quality is crucial for strategically identifying critical patents for mass customization. This is of particular interest as the owning high-quality patents protects the companies from product infringement as well as from patent trolls. High quality patents can be considered having wide claims, few prior art designs, higher forward citation and the technology related to the patent is highly applicable. Most researches on the patent quality are focused on the citation information contained in the patent as the historical trail about the development of technology can be tracked through citations. Besides, the citations provide a means to assess and rank the importance of individual patents.

The innovation is not a new thing for the chemical industry. Intellectual property, especially patent, is mostly known to protect inventions and innovations. Chemical Industry is an industry that heavily depending on product innovation to keep their competitive advantage [1]. Chemical companies around the world keeps using patent protection as their protector for technology or invention. As of May 2018, World intellectual property office or WIPO recorded more than 1.4 million patent applications related to chemical industry during 2012-2016, and data from Japan patent office (JPO) shows there are more than 40,000 patents filed during the same period. As an industry player in chemical industry along with China and the United States, Japan also uses patent protection for preventing others to infringe their creation.

Technology development is mostly concentrated in high-income countries and Japan belongs to one of them [2]. Japan's innovation, especially patents, not only great in number but also comes with better quality compared to other countries [3]. No wonder chemical industry ranked second in Japan manufacturing industry after deliver more than 43 trillion Yen shipments in 2014 [4]. Previous research on Japanese chemical industry only focusses on manufacturing capabilities [5] and market potential for small and medium enterprise [6]. Researchers did focus on Japan's chemical industry but very limited research that focus on patent quality. Thus, this research focused on the quality of patent among chemical industry sectors in Japan.

II. LITERATURE REVIEW

A. Intellectual Property – Patent

Trott [7], in the 5th edition of Innovation Management and New Product Development book, has mentioned four main types of intellectual property (IP): (1) patents, (2) copyright, (3) registered designs and (4) registered trademarks. Each of IP types have their own distinct features which also offers different kind of protections. Patents gives the right to individuals and organizations to claim a new product or manufacturing process, or to an improvement of an existing product or process, which was not previously known [8]. The rationale behind the granting of a temporary monopoly through the patent is to encourage creativity and innovation within an economy

[7]. UK Intellectual Property Office (UKIP) stated:

> " … *the granting of a patent gives the 'patentee' a monopolyto make, use or sell the invention for a fixed period of time, which in Europe and the United States is 20 years from the date the patent application was first filed. In return for this monopoly, the patentee pays a fee to cover the costs of processing the patent and more importantly publicly discloses details of the innovation*."

Not everything in the world is patentable. However, there are some exclusions from patents especially for discoveries (as opposed to inventions), scientific theory and mathematical processes under the Patent Act 1988.

Recent studies on patents are usually focused on the technology or knowledge transfer [9-11], and the effect of patents activities on firm performance [12, 13]. Noailly and Shestalova [11] in their research used patent citations to identify knowledge spill-overs in renewable energy technologies where they find out that knowledge spill-overs not only occurred in the same technology field it is also occurred to different fields of technology. Patent citation analysis study also can be used to identify the potential of technology transfer deal [9]. Kavusan, Noorderhaven [10] also investigate on possibilities of knowledge transfers happen by referring to similarities in the patent applicant fields of technology, and previous experiences with alliancesthat related to patent activities. Relationship between patents activities and firm performances also been discussed in several researches. McCarthy and Aalbers [13] showed that geographic distance of between patent assignee and assignor,and cross-borders patent transfer influence post-acquisition innovative performance. Patent protection is an important factor for firms in improving their economic value as suggested by Kim *et al* [12] in a study in renewable sector.

B. Quality of Patents

Quality also an important aspect for a patent. Empirical study shows that high-quality patent can improve company performance [14]. A research by Trappey, Trappey [15] focused on improving patent quality analysis by setting up new quality indicator. They used investment, maintenance, and litigation as the primary patent quality indicators. Co-ownership of patent also significantly improve the quality ofa patent [10, 16]. Extensive research on quality of a patent also have been done by Chen and Chang [17] where they used four indicators to measure patent quality. Relative patent position, revealed technology advantage, Herfindahl– Hirschman Index of patents, and patent citations are four indicators used by them. A study by Sterzi [18] in UKacademic patents found that quality of a patents also different when compared into the status of applicants. He concluded that patents belong to companies are higher quality than patents belong to universities for short and middle-term.

Patent citations is mostly used variable in previous researches for the classification of patent quality as the patent citations provide a historical trail about the development of technology and guide in ranking the importance of individual patents. There are two types of technology development flowin patent citation which are backward citation and forward citation [16, 19, 20]. Forward patent citations are found to be highly correlated with the value of the invention as well [17,21-25].

C. Patent Activities in Chemical Industry

The chemical industry plays a crucial role as it helps developing interrelated industries through supplying chemical products and raw materials to various industries. Besides the products from the chemical industry are widely used in producing plastics, pharmaceuticals, cosmetics, textiles, detergents, paints and agrochemicals. Thus, the chemical industry becomes a major contributor to the development of other industries and to the improvement of lives [4]. A study related to patent citation analysis in European chemical and pharmaceutical sectors found that most of patent applied in European Patent Office (EPO) are citing patent from chemical companies in the United States [26]. However, Thomas [27] has argued that chemical industry in emerging economies are not using IP at all in theirbusiness where companies are reluctant to registering the intellectual property of innovations and keep maintaining industrial secrecy.

Japan's chemical industry can be considered a pivotal industry for the next generation [6]. According to Japan Chemical Industry Association (JCIA), in 2014 there are fourout of top 30 chemical companies in the world are come from Japan. Japanese chemical companies research and development intensity is the highest in the world [4, 28]. Data from Ministry of Internal Affairs and Communications of Japan in 2014 shows chemical industry invest more than 2.6 trillion yen in research and development and at the same period Japan Patent Office report that more than 9,000 patentsare granted. On average, the level of patents quality in chemical industry are high [23].

D. Concentration of Technology Areas

The chemical industry consists of wide range of technology areas within the industry. Companies mostly focuses on specific R&D to advance technology or make newproducts. As such, the contraction of R&D and the output ofthe technology may differ among the companies. International Patent Classification (IPC) helps researchers toidentify the technology for a particular company. Thus, mapping and analyzing the IPC for the companies may give a clear idea about the concentration of the technology within the company. It may also help the researchers to compare among the companies under a particular industrial sector. This mapping may also help identifying potential partner(s). In Figure 1, the columns are referring to the related IPCs forthe 19 chemical companies in descending order and the rowscontains the usage of these IPC codes by the respective companies. The darker the colour, the higher the concentration of the technology focus on that particular IPC is. This cross tabulation, combining the IPC

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concentration together with patent quality analysis, may help to identify thepotential partners/competitors and can assist the company forstrategic technology planning.

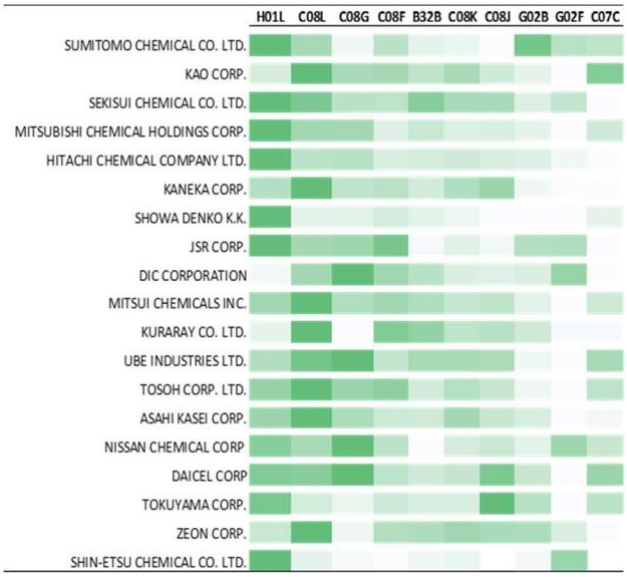

Fig.1. IPCs forthe 19 chemical companies

III. METHODOLOGY

Patent data for this study are come from year 2004 until 2013. The time period end at 2013 because of the availabilityof the forward citation data. Patent application that filed afterJanuary 2014 at JPO did not have enough forward citation inorder to be analysed. This is mostly because of the period of patent application is quite time consuming. The minimum time for a patent to be granted is set at 18 months from the patent application date. Quality of a patent can be measured by using patent citation. Patent with high citations can be considered as patent with high quality. Quality of patent are measured by using forward citation frequency. In this study, apatent should be cited more than 5 times in order be classified as high-quality patent.

$$Company\ Patent\ Quality = \frac{\sum Company\ Patent\ Application\ minimum\ 5\ forward\ citations}{\sum Company\ Patent\ Applications} \quad \text{.....(1)}$$

Sample for this study are selected from Japanese chemical companies from 2006 to 2013. To identify chemical companies, Thomson Reuters Business Classification (TRBC) and Japan Standard Industrial Classification (Rev. 13, October 2013) Structure and Explanatory Notes are used. For TRBC classification, chemical companies that are classified under the basic materials sector and chemical industry group are used. Market-oriented system is used in order to classified companies in TRBC. The market-orientedsystem tracks the primary business of a corporation and reflects global industry practices by grouping together correlated companies that offer products and services into similar end markets. By using Japan Standard IndustrialClassification, chemical companies that belong to Division E Manufacturing are selected. Division E is comprised with thecompanies which are engaged in the manufacture and wholesale of new products by rendering physical and/or chemical changes to organic or inorganic substances. Chemical industry is divided into 4 different categories: Agriculture chemical, Commodity chemical, Diversified chemical and Specialty chemical.

There are 163 listed chemical companies in total for Japan. Most of chemical companies in Japan belong to Commodity sector which up to 110 companies and there are 13 companies belong to agriculture chemical, 13 companies to diversifiedchemical and 27 companies for specialty chemical.

IV. ANALYSIS & DISCUSSION

Not all listed companies in Japanese chemical industry apply for patent application from 2004 until 2013. As this study evaluated quality of patent, companies that did not haveany patent applications are excluded from this study sample.Only 152 companies have minimum one patent and they are the sample for this research. As Figure 2 show, 103 companies with minimum a patent are belonging to commodity chemical sectors while 26 companies are for specialty chemical sectors.Diversified chemical companies resulted with 13 companies and 10 remaining companies that hold a patent in chemical industry sector is agriculture chemical.

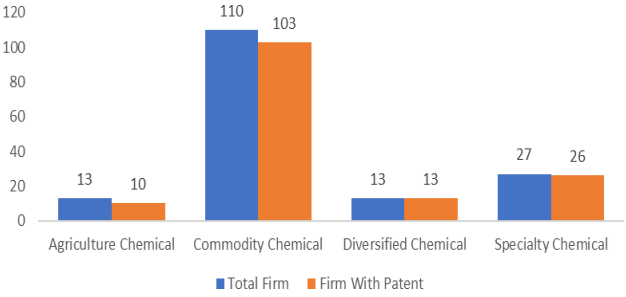

Fig. 2. Chemical Industry by Sectors.

Total patent application for listed chemical companies in Japan is accumulated at 190,614 patent applications. Commodity chemical sector ranks first as the most active patent applicant with more than 120,000 patent applications for this study period. The least active patent applicant came from agriculture chemical sector which is only at 1524 patentapplications.

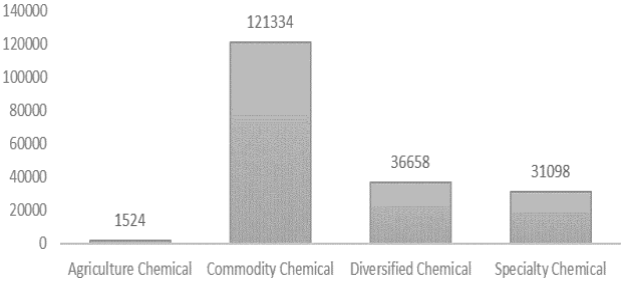

Fig. 3. Patent Application in Chemical Industry, bySectors.

On an average, companies in specialty chemical sector (25%) are leading in the patent quality if compared to companies from commodity chemical sector (21%), diversified chemical sector (20%), and agriculture chemical sector (17%). The top companies in the rank for this study dominated by commodity chemical sector. 24 out of top 38 companies are from commodity chemical sector. With average more than 35% patent classified as high-quality patent, commodity chemical sector patent clearly leading in the Japanese chemical industry. There are only one companyfrom agriculture chemical sector, three companies for diversified chemical and 10 companies from specialtychemical sectors.

TABLE I
KRUSKAL-WALLIS INPUT DATA

Industry	*R*	5_k	R^2
Agriculture	1022	10	1044484
Commodity	7956	103	63297936
Diversified	1110	13	1232100
Specialty	1540	26	2371600
DF = 3	*N* = 152	$3^2 = 7.81$	

However, not all companies in commodity chemical sector possess high quality patent. 24 companies out of 38 companies from the bottom are came from commodity chemical sector. There are six agriculture chemical sector companies belong tothe bottom of the rank and only three companies from specialty chemical sector did not perform well in this study. Last but not least, five companies classified in diversified chemical sectors perform poorly for patent quality study.

This study used Kruskal Wallis test to compared the quality among all four sectors as this test are capable to compare the distributions of scores on a quantitative variableobtained from 2 or more groups. The critical value for this study is set at χ^2 (df=3,p=0.05)= 7.81.

$$H = \frac{12}{N(N+1)}\left(\frac{R_1^2}{n_1} + \frac{R_2^2}{n_2} + \frac{R_3^2}{n_3} + \ldots + \frac{R_k^2}{n_k}\right) - 3(N+1)$$

--------- (2)

H=7.9678

After followed Kruskal-Wallis, χ^2 = 7.81, p <.05 test on Japanese chemical sectors patent quality, the percentage of high-quality patents displayed at each chemicalsector is summarized in Table II. The distributions of quality of patents displayed were significantly different among the four types of sectors. H-stat value for this study is higher (7.9678) than value which is set at degree of freedom 3 and p-value for this study came out at 0.0467 which is lower than 0.05.

TABLE II
QUARTILE VALUES FOR THE PERCENTAGE OF QUALITY BY EACHOF THE FOUR TYPES OF CHEMICAL SECTORS

	Chemical Sector Type			
Patent Quality	**Agricultural Chemical**	**Commodity Chemical**	**Diversified Chemical**	**Specified Chemical**
Median	0.1447	0.2083	0.185	0.2355
Q1	0.0970	0.1584	0.1302	0.1969
Q3	0.2089	0.2639	0.2644	0.3020

Thus, this study managed to reject H-null hypothesis andconcluded that there are differences in patent quality among chemical sectors in Japan. Although the finding is primitive, additional tests can help to analyze the impact of the patentquality on the firm activities in future research.

V. CONCLUSION

The purpose of this study is to analyze the patent quality among Japanese chemical sectors. Based on analysis of patents data, the quality of patents among Japanese chemicalsectors are varied. Each sector shows different patent quality as commodity chemical sectors being the best chemical sectors in Japan. Thus, further studies in patent quality for each sector are needed. Future studies should put more focuson why there are differences in patent quality even though they are from the same industry. Does each sector get different approach in intellectual property strategy especially patent strategy? Are different strategies for Intellectual Property being used for Japanese chemical industry?

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