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Technology Exploration and Technology Exploitation in Japanese Chemical Companies

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ABSTRACT

This study analyses Japanese chemical companies' performance based on open innovation activities. 19 listed chemical companies from Tokyo Stock Exchange were selected for the study. Secondary data from chemical companies' patents information and company transactions are collected through the private patent database, Derwent Innovation - Clarivate and private financial database, Thomson Reuters - Eikon. The findings indicate that open innovation practices did not improve Japanese chemical companies' performance (return on net operating assets). Overall, neither technology exploration nor technology exploitation competencies are contributing to company performance, but one significant finding is found where divestitures of subsidiaries and joint ventures are improving company performance. In conclusion, some suggestions have been made for Japanese chemical companies to practice open innovation activities more efficiently.

1. Introduction

Research and Development (R&D) activities are of utmost importance for any company's involvement in innovation. Companies worldwide keep investing in R&D to sustain inventions and/or innovations that lead them to perform better in the industry where they belong. Innovations are increasingly seen as fundamental to the competitiveness of enterprises and economies [1]. The ability to be innovative in product, process, or both, gives companies a competitive advantage. For example, chemical companies use high technological capabilities and innovative products to keep them in competition and depend heavily on product innovation to maintain their competitive advantage [2]. As a result, the chemical industries' investment in R&D activities is high [3,4]. The chemical industry also has promising potential [5,6]. According to Japan Chemical Industry Association (JCIA), it is the second largest sector among manufacturing industries that contributed to Japan's economy in 2016. The global chemical industry sales increased by 121%, from €1.458 trillion in 2004 to €3.232 trillion in 2014 [3,4]. Globally, investment in R&D for the chemical industry has

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been increasing for the past decades. Although the Japanese chemical company's R&D spending intensity was the highest globally, the sales did not grow in proportion to the global sales. There is evidence from previous studies that stated R&D expenditures have a positive impact on sustainable corporate growth at the firm level in selected organization for Economic Co-operation and Development (OECD) countries [7].

The level of innovation within the company can also be considered as an output of the investment in the R&D besides the level of sales. During 2004-2014, Japanese chemical companies filed over 40,000 patent applications annually, and around 9,000 were published annually, on average [3]. It shows the technological competencies of the Japanese chemical companies, even though they have not been as competitive in terms of sales over the decade. Traditional innovation guides companies to do all the jobs independently from idea generation until market penetration for a long time. In contrast, because of the complexity of modern technology, even large companies find it challenging to develop new products alone [8]. Innovation focuses on developing new or improved products and processes, new services, marketing, branding and design methods, and new forms of business organization and collaborative arrangements. Open innovation (OI) is one of the best solutions for solving problems related to developing new products [9-12]. Hagedoorn *et al.,* [13], and López [14] have pointed out that OI involves cooperation with external partners, and cooperation with external partners can be necessary as both parties need to agree on their mutual benefits. Both parties need to be benefitted from cost- and risk-sharing opportunities. Vanhaverbeke and Cloodt [15] have argued that the resources and capabilities of different organizations can be brought together through OI to offer value to the targeted customers. As a result, the companies have to rely heavily on partnerships with external companies and sometimes with competitors. In OI, exploring and exploiting technology skills are critical [16,17]. Festel [18] has argued that chemical companies depend on effective and efficient OI to compete in the global market. This paper tries to investigate the competencies of Japanese chemical companies in the exploration and exploitation of technology to make the Japanese chemical industry competitive again.

The rest of the paper is organized as follows. Section 2 consists of a literature review, which is followed by hypotheses development. The methodology is described in section 3. The results of the study and the findings are in Section 4. Conclusion and recommendation follow in section 5.

2. Literature Review
2.1 Open Innovation

Chesbrough [19] has defined open innovation as the purposive inflows and outflows of knowledge to accelerate internal innovation and expand the markets for external use of innovation. Compared to the closed innovation model, the OI model is more complex as OI takes into account several external activities [20]. Gassmann and Enkel [21] have proposed Inward-OI and Outward-OI as the two core paths of OI. They defined Inward OI (an outside-in path) as enabling ideas to flow from outside the organization and later combined with internal ideas to complete research and development activities. On the other hand, an inside-out path (Outward OI) allows new or underused internal ideas to go outside the organization for others to use in their research and development activities [21-24]. Industries are more prone to be engaged in OI if they are characterized by global, technology intensity and knowledge leveraging [25]. Wang *et al.,* [26] have argued that OI was operationalized along two dimensions: technology exploitation and exploration. Exploration and exploitation can be referred to as the outward OI process and inward OI process, respectively, as had been proposed by Hafkesbrink and Schroll [16] and Chesbrough and Crowther [27]. Stejskal and Hajek

[28] confirmed that both internal and external collaboration significantly contributes to the creation of innovation.

2.2 Technology Exploration and Inward Open Innovation

Exploration of technology is the ability to develop and utilize new resources and competencies [29]. Chesbrough and Crowther [27] have referred to the Inward OI (exploration) activities as the ones stemming from external sources of knowledge, which enhance and complement internal technological capabilities. Technology exploration relates to innovation activities to capture and benefit from external sources of knowledge to enhance current technological developments [30,31]. Merger and acquisition of company [32,33], inward licensing of intellectual property [8,20,34,35], and establishment of external networking [27,30,36] are famous practices in technology exploration. A study by Stejskal *et al.,* [1] in the Czech machine industry stated that systematic partnership and collaboration could make valuable ideas either inward or outward the enterprise and improve the enterprise's overall performance.

2.3 Technology Exploitation and Outward Open Innovation

Duysters and Lokshin [29], Greve [37], and Hafkesbrink and Schroll [16] have defined exploitation as the ability to make efficient use of existing available resources. Technology exploitation implies innovation activities to leverage existing technological capabilities outside the boundaries of the organization [17,23,38,39]. Outward OI (exploitation) is associated with the commercialization phase of the innovation process, whereby companies outsource the market expansion to external organizations that are better suited to commercialize existing technologies [27,40]. Venturing [41, 42], outward patent licensing, and selling out patents [8,43,44] are standard practices in technology exploitation.

2.4 Patent Citation

Backward and Forward Patent citations are part of the legal patent process wherein the patent applicant has to disclose any knowledge of 'prior art' amongst previous patents [45]. Citation information is one of the most critical parts of patent data because it can be used for various purposes, including tracing the technology development process and evaluating a patent's importance [46]. The citation number of a patent can also be linked to the market value of the company owning the patent and the value of the technology [47]. They also concluded that patents with high citations improve stock price performance. There are two types of technology development flow in the patent citation: backward citation and forward citation [45,48,49]. Figure 1 shows the patent citation network.

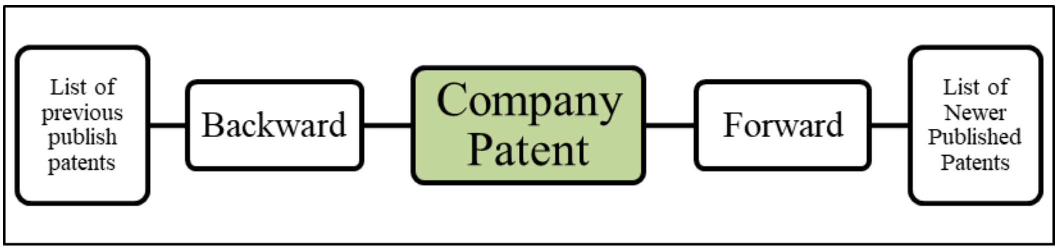

Fig. 1. Patent citation network

References made to previous patents are called backward citations, and references received from future patents are called forward citations [50,51]. For backward patent citation, the prior art is collected during the examination process and listed on the patent document to prove the novelty [52,53]. On the other hand, references received from future patents are called forward citations.

2.5 Hypotheses Development

OI is increasingly recognized as a critical source of the company's innovativeness by providing access to external knowledge [29] and is essential for companies' sustainability and gaining competitive advantage in most business environments [10]. For example, Mitsubishi Chemical Holding Corporation (MCHC) actively invests in R&D and collaborates with universities, public institutions, and venture companies. MCHC also acquired many potential ventures for the past decade to keep competitive in the market.

The summary of the previous literature on technology exploration and exploitation is in Table 1. Each research used various theories to analyze open innovation practices and patent activities. However, the complete combination of theories between open innovation practices and patent activities is less frequently used and needs better clarification. Thus, this study combined open innovation practices and patent activities in the research framework.

Table 1
Theory from a previous study on technology exploration and technology exploitation

	Collaboration and partnership	M&A and patent acquisition	Backward patent citation	Establishment of new ventures	Patent assignment, & divestitures	Forward patent citation
Chesbrough and William [20]	✓	✓		✓	✓	
Gassmann and Enkel [21]	✓	✓		✓	✓	
Abulrub and Lee [56]	✓	✓		✓	✓	
van de Vrande *et al.,* [31]	✓	✓		✓	✓	
Lichtenthaler [39]				✓	✓	
Ji *et al.*, [64]			✓		✓	✓
Breitzman and Thomas [73]		✓	✓			✓
Hall *et al.*, [47]			✓			✓

This study focuses on the competency of Japanese Chemical companies in technology exploration and exploitation and their impact on the firm performance (refer to Figure 2). As has been discussed, technology exploration and exploitation can be in different forms, and we will test the impact of those individual activities.

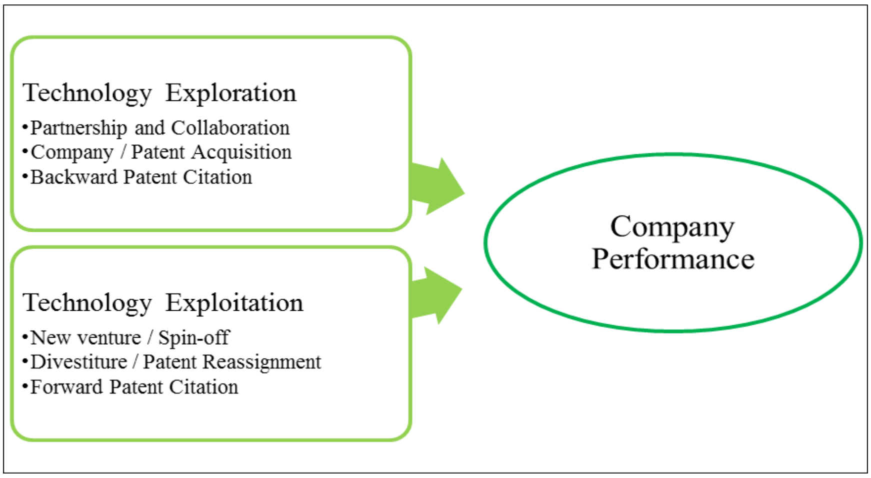

Fig. 2. Conceptual framework

2.5.1 Technology exploration

A company can establish a joint venture with other companies to commercialize technologies and jointly develop technologies with external partners such as universities or other companies [16,31, 54,55]. We can include joint ventures and development in technology exploration activity [56].

H_{1a}: Broad collaborations and partnerships improve technology exploration competencies.

Buying a patent license (patent acquisition) from external partners is one of the ways to become an owner of technologies or patents [35,57-59]. Indirect purchase of technologies and patents can happen in merger and acquisition (M&A) deals [60-62]. A company can acquire companies with promising technologies in the case of having difficulty in-house development thru M&A deals.

H_{1b}: Frequent M&A and patent acquisition improve technology exploration competency.

A patent application must cite all ideas that precede the patented idea. Most of the research focused on an area related to a valuable patent is more likely to result in more citations to the original patent [63]. Backward citations are patents that are cited by a specific patent. Once a company cites a patent from the past, it means the past patented technology is essential in developing the present technology within the company and will be important in the future. Backward citation helps the patent owner or applicant identify potential technology that might suit the owner or applicant's solutions [64]. The patent cited can be included as one of the technology exploration proxies.

H_{1c}: Higher backward patent citation increases the patent value and improves technology exploration competency.

2.5.2 Technology exploitation

Creating new ventures or spin-offs based on internal knowledge and with all the support from the parent company or organization shows the competencies of technology exploitation [21,23,38,55,65,66]. This way, a company can transfer the internal technology to another party. The frequent new ventures will have an impact on the internal R&D of the firm.

H_{2a}: Frequent establishment of new ventures improves technology exploitation competencies.

A company can sell unused or underused patents to exploit internal technologies to another party instead of commercializing using its internal resources to establish the new venture. Previous patent owners will also receive payment from the new owner (reassigned) after changing ownership [19,54,67-69]. Divestiture is a business unit's partial or complete disposal through sale, exchange, closure, or bankruptcy. A divestiture mainly results from the management's decision to cease operating a business unit because it may not be part of core competency [21,67,70].

H_{2b}: Frequent patent reassignments, spin-offs, and divestitures improve technology exploitation competencies.

Using patent citation data, companies can identify their technology or knowledge flows. The knowledge can flow in the same specific technological field or to unrelated technologies fields [71]. Patent citations in the past can be a good indicator of incremental technology needs or demand in the future. A patent citation analysis can improve the identification of potential patent users for specific industries [49,63,64]. Forward citation of patents is a patent being cited by another patent. Patents cited more frequently than others in the portfolio can be viewed as relatively more valuable [46,53,72]. Ji *et al.,* [64] and Breitzman and Thomas [73] argued that the company listed in the patent citing would likely be a future assignee of technology transfer.

H_{2c}: Higher forward patent citation increases the patent value and improves technology exploration competency.

2.5.3 Company performance

Financial performance is one way to measure company performance in open innovation [74,75]. Previous studies in open innovation performance used accounting measurement to measure company performance, whereas studies by Ahn *et al.,* [76] and Hwang and Lee [77] used company sales to measure company performance. This study used two types of measurements to represent company performance. Return on Net Operating Assets (RNOA) captures the return on the company's assets generating revenue. It is a good indicator of how well a company uses operating assets to create profit, and RNOA is key to predicting future company performance. The second performance measurement is the stock price change. The effect of implementing open innovation sometimes cannot be measured in accounting terms. Stock price change has been used as performance measurement several times in previous studies related to innovation activities [63,78,79]. Accounting measurement is reported quarterly and annually, and accounting measurements do not capture long-term impact. Stock price for listed companies changed on a daily basis based on the information available. The changes in price indicate the performance of the company. The stock price tends to increase when the company provides positive information and stock price also tend to decline when the company performances are unsatisfactory.

Table 2 summarizes the hypotheses developed and the expected impact of the factors on the Return on Net Operating Assets (RNOA).

Table 2
The expected impact of the factors on the Return on Net Operating Assets (RNOA)

	Factors	Notation	Measurement	Hypothesis	Expected effect on RNOA
Technology Exploration	Collaborations and partnerships	CP	Frequency	H_{1a}	Positive
	M&A and patents acquisition	MAP	Frequency	H_{1b}	Positive
	Backward patent citation	BPC	Number of citations	H_{1c}	Positive
Technology Exploitation	Establishment of new ventures	NV	Frequency	H_{2a}	Positive
	Patent reassignments, spin-off divestitures	RSPD	Frequency	H_{2b}	Positive
	Forward patent citation	FPC	Number of citations	H_{2c}	Positive

3. Methodology
3.1 The Models

We tested the effect of both Technology Exploration and Technology Exploitation on the firm's Return on Net Operating Assets (RNOA). Ceteris paribus,

Return on Net Operating Assets (RNOA) = f (Technology Exploration, Technology Exploitation)

This relationship is further divided into the following models for clear understanding

For technology exploration

$$\Delta \mathrm{RNOA}_{i,t} = \alpha_0 + \beta_1 \mathrm{CP}_{it} + \beta_2 \mathrm{MAP}_{it} + \beta_3 \mathrm{BPC}_{it} + u_{it} \quad (1)$$

where, CP_{it}, MAP_{it} and BPC_{it} are Collaborations and partnerships, M&A and patents acquisition and Backward patent citation for company i in time t.

For technology exploitation

$$\Delta \mathrm{RNOA}_{i,t} = \alpha_1 + \gamma_1 \mathrm{NV}_{it} + \gamma_2 \mathrm{RSPD}_{it} + \gamma_3 \mathrm{FPC}_{it} + \varepsilon_{it} \quad (2)$$

where, NV_{it}, RSPD_{it} and FPC_{it} are new ventures, Patent reassignments, spin-offs, divestitures, and Forward patent citations for company i in time t.

3.2 Sample and Data

Samples for this study are selected from Japanese chemical companies for the financial year 2006 to 2014. Thomson Reuters Business Classification (TRBC) and Japan Standard Industrial Classification (Rev. 13, October 2013) Structure and Explanatory Notes are used to identify Japanese chemical companies. For TRBC classification, chemical companies classified under the basic materials sector and chemical industry group are used. Using Japan Standard Industrial Classification, chemical companies belonging to Division E Manufacturing are selected. Division E comprises establishments that manufacture and wholesale new products by rendering physical and/or chemical changes to organic or inorganic substances. Only Japanese chemical companies listed on the Tokyo Stock Exchange are selected. 19 listed Japanese companies have been selected for this study. Selected companies have at least 100 published patents registered in Japan Patent Office (JPO). Chemical companies that other companies have acquired are treated as a subsidiary of the acquiring company.

All data for this study come from annual financial reports, patents publication, business deals, and business transactions. The data periods are set between the fiscal year 2006 and the fiscal year 2014. Sample's patents should have patent families, at least from the United States Patent Trademark Office (USPTO) and European Patent Office (EPO). All the transactions and deals are done in Japanese Yen. This study uses the Derwent World Patent Index (DWPI) patent family, and all the sets of patent data come from Thomson Innovation Clarivate. The financial and ratio for this study come from Thomson Reuters Eikon. Most of the Japanese companies' fiscal year started on the 1st of April current year and ended on the 31st of March next year. All the data also have been classified into three phases: the fiscal year 2006 until 2008, the fiscal year 2009 until 2011, and the fiscal year 2012 until 2014. The reason for this study to separate data into three periods is to show the differences in the OI adoption phase. It is pretty hard to see open innovation implementations annually by dividing the research period into three phases, three years for each phase; implementations of open innovation might be seen clearly. Not all companies are directly implementing OI after OI was introduced by Chesbrough and William [20]. By Classifying the time for all the activities, the results of this study give a different viewpoint on the implementation of OI in Japanese chemical companies.

3.3 Analytical Method

All the data are analyzed by using correlation and regression analysis. Correlation analysis is used to investigate the relationship among the variables. Regression analysis is also used to understand which independent variables are related to the dependent variable and to explore the forms of these relationships. Regression analysis can be used in restricted circumstances to infer causal relationships between the independent and dependent variables. Correlation analysis is used to check how strongly technology exploration and technology exploitation is related to company performance

4. Results and Discussion

The primary purpose of this study is to know how open innovation activities improve Japanese chemical companies' performances. Table 3 presents the descriptive statistics of 57 observations of the 19 chemical companies.

Table 3
Descriptive statistics

	Technology exploration competency				Technology exploitation competency			
	CP	MAP 1	MAP 2	BPC	NV	RSPD 1	RSPD 2	FPC
Mean	1.98	4.67	1.95	262.86	0.68	4.00	1.28	30.25
Std. Dev.	2.10	7.81	2.54	164.74	1.35	10.72	1.71	26.54
Min	0	0	0	28	0	0	0	1
Max	8	42	12	738	6	63	8	118

After collecting all the data from 19 chemical companies through 57 observations, not all the variables are typically distributed, which may make the results of this study biased. There are 113 joint venture and joint development agreements that happened from April 1st, 2006 to March 31st, 2015 and a total of patent acquisition deals in this study is recorded at 266 deals. Acquisition of company activities in this study is recorded at 111 through all nine fiscal years. Spin-off and new venture establishment activities in Japanese chemical companies are accumulated at 39 companies and at the same time Japanese chemical companies change 228 patent ownership to other parties. In this study, divestiture of a company's subsidiary and joint venture dissolution are recorded at 73 transactions through all nine fiscal years.

The first factor considered for technology exploration competency is broad collaboration and partnership (CP). We start by examining how CP will improve the company's technology exploration competency and positively affect company performance. Most major companies in Japan's chemical industry collaborate with external partners. They work together to gain favourable outcomes, such as establishing a joint-venture company to serve new and emerging markets. Chemical companies in this study not only established a new joint venture with their partner to serve Japan market, they sometimes even cater to the regional market. They are sharing patent ownership with an external party is also an everyday thing in the Japanese chemical industry. In all 57 observations, a patent will be filed with more than one applicant.

Table 4 shows the regression analysis results using technology exploration as a predictor and RNOA as the dependent variable. The table presents the effect of collaboration and partnerships, M&A and patents acquisition, and Backward patent citation for company i in time t on the changes in Return on Net Operating Assets. Significance is at 5% level.

Table 4
Technology exploration [regression analysis]

Variables	Std. Error	P-value
CP	0.00397	0.78775
MAP	0.00109	0.08564
	0.00314	0.19057
BPC	0.00005	0.13278

With all these activities done by Japanese chemical companies, the cost of establishing new ventures and applying for patents is not only for one company's responsible holding. The costs related to R&D are shared with the partner/s and fewer resources are required. However, not all joint development agreements considered in this study were commercialised. Some of the joint ventures were also unsuccessful and resulted in a loss to the company. After all, the concept that Chesbrough [19] constructed and introduced makes sense where joint development and joint venture should make research and development and commercialization easier, positively affecting the company's performance.

H_{1b} focused on the relationship between patents and company acquisitions with company performance. Patent acquisitions also improved Japanese chemical companies' performance. Big players in the Japanese chemical industry used their superior resources to purchase patents from less prominent chemical companies. On average, the Japanese chemical company in this study acquired four patents per phase. The purchase of patents is not only limited from Japan market. In this study, Japanese chemical companies procure patents from developed countries such as Germany and America. Drastic changes in the number of patent ownership also happen when more established Japanese chemical companies merge and acquire less established companies that own a series of patents. Diversified and commodity chemical companies are keen to expand their market. One of the best ways to expand their market is through mergers and acquisitions. Mergers and acquisitions activity is less risky for established companies to choose than to start a new company to cater to a new market. This is because a different market requires a different environment. With lesser risk faced, the company can reduce the probability of losing resources and achieve better RNOA. In this study, merger and acquisition deals do not improve technology exploration competency. For example, a merger and acquisition deal aim to expand a company's market share and production capacity. This type of acquisition is less related to the open innovation dimension.

The last hypothesis for technology exploration competency was to examine the potential of inward technology transfer from backward patent citation analysis. A list of backward patent citations is the best reference that the applicant uses for their patent application. Backward patent citation frequencies among Japanese chemical companies in this study are high. Thus, the knowledge from prior technology somehow helps patent applicants develop new patents or improve the existing patent. A high-quality patent improves company performance and becomes one of the main parts of the company's intangible assets. However, the backward patent citation list is still not convincing to become the source that supports technology transfer deals as previous patent publications listed in the backward citation are still a list and only a procedure for a new patent to be granted. Chemical companies are not taking the potential inward licensing or patent acquisition deal from the previously granted patent seriously. Japanese chemical companies will think that the list made by patent examiners is used only to track technology development and the crucial phase of getting patent applications granted. The capabilities of exploration granted external patents are still not fully optimized. Thus, this study failed to reject hypothesis $H_{1c.}$

The first variable for technology exploitation competency is insignificant, meaning that the analysis found that the establishment of the new venture improved company performance. After investing more than millions in R&D and resulting in a granted patent, the assets should be turned into something that can catch a value from it. The establishment of a new venture from internal resources did improve company performance. Unutilized and under-used patents should be utilized to get a better RNOA ratio. In this study, the number of self-establishments of new ventures is relatively low and not adopted by all companies. Only established chemical companies with patents are active in spin-off establishment activities. Only established chemical companies can provide enough resources to set up new companies based on internal capabilities. Table 5 presents the effect of new ventures, M&A and Patent reassignments, spin-offs, divestitures, and Forward patent citation for company i in time t on the changes in Return on Net Operating Assets. Significance is at a 5% level.

Table 5
Technology exploitation [regression analysis]

Variables	Std. Error	p-value
NV	0.00492	0.59838
RSPD	0.00059	0.09778
	0.00420	0.00085
FPC	0.00027	0.06663

The unutilized and under-utilized patent problem can be solved by reassigning it to other parties needing it. The average number of patent assignments is recorded at four transactions. The company gets some payment by selling out or licensing unutilized and underused patents to others. At the same time, the volume of assets is also reduced. It coincides with what Chesbrough [68] argued: the company could sell their unused or underused patent to exploit internal technologies to an external party and gain positive outcomes. Established Japanese chemical companies in this study did let go of their unused or underutilized patent to an external party after receiving payment in the form of royalties, license fees or payment transactions. From this situation, any transaction related to patents improved chemical company performance. RNOA ratio can be improved when intangible assets, especially patents, generate extra revenue and profit.

Hypothesis H_{1c} is built to examine the potential of forward patent citation analysis with outward technology transfer. As studied by Hall [80], Sterzi [81], and Nagaoka *et al.,* [49], high-quality patents should have a high number of forward patent citations. Similar to backward patent citation, high-quality patents can improve chemical company performance. A company can only obtain a competitive advantage when competitors cannot offer what they offer to the market. A high-quality patent can be turned into a core competency, leading the company to obtain competitive advantages. In this study, almost all 19 companies have at least a patent cited more than 20 times. Each of the company did have their own core competencies and offer a unique product from other chemical companies. However, chemical companies are not yet to consider forward citation list for granted patent as the potential outward licensing or patent assignment deal. Japanese chemical companies are not transferring their internal patent to the company listed on the forward citation. The values of the company's patents are still not fully exploited from this perspective.

5. Examples of Technology Transfers among Japanese Chemical Companies

Technology transfer is crucial in driving innovation and competitiveness in the chemical industry. Technology transfer involves the sharing and disseminating knowledge, expertise, and technologies between organizations. Technology transfer enables firms to enhance their research and development capabilities in the chemical sector, improve product quality, optimize manufacturing processes, and gain a competitive edge. It facilitates collaboration and fosters innovation by enabling companies to leverage each other's strengths, exploit synergy, and accelerate the commercialization of new technologies.

Merger and acquisition (M&A) activities, as a form of technology transfer, play a crucial role in shaping the business landscape of the chemical industry. In Japan, several notable mergers and acquisitions have occurred within the chemical sector, demonstrating the strategic moves made by companies to enhance competitiveness, expand market presence, and leverage synergy. Few examples of Japanese chemical companies that have engaged in M&A activities and discussed their implications are discussed below:

i. Mitsubishi Chemical Corporation and Mitsubishi Rayon Co., Ltd.
One notable merger in the Japanese chemical industry occurred in 2017 when Mitsubishi Chemical Corporation (MCC) and Mitsubishi Rayon Co., Ltd. merged to form Mitsubishi Chemical Holdings Corporation (MCHC). The merger aimed to consolidate the Mitsubishi Group's chemical businesses and create a more integrated and efficient entity. By combining its resources, technologies, and market knowledge, MCHC aimed to enhance its global competitiveness and expand its product portfolio across various sectors, including automotive, electronics, healthcare, and agriculture.

ii. Sumitomo Chemical Co., Ltd. and Nihon Oxirane Co., Ltd.
2019 Sumitomo Chemical Co., Ltd., a leading Japanese chemical company, acquired Nihon Oxirane Co., Ltd. This acquisition aimed to strengthen Sumitomo Chemical's position in the epoxy resin market. Nihon Oxirane has established a strong presence in the production and sales of epoxy resins, which are widely used in various industries such as electronics, construction, and automotive. By integrating Nihon Oxirane's expertise and production capabilities into its operations, Sumitomo Chemical aimed to enhance its

product offerings and meet the growing demand for domestically and globally epoxy resins.

iii. Asahi Kasei Corporation and Polypore International, Inc.
Asahi Kasei Corporation, a diversified Japanese chemical company, completed the acquisition of Polypore International, Inc. in 2015. Polypore was a leading global manufacturer of high-performance microporous membranes used in various applications, including lithium-ion batteries, healthcare, and industrial filtration. This strategic acquisition provided Asahi Kasei access to Polypore's advanced membrane technologies and expanded its presence in key markets. It enabled Asahi Kasei to strengthen its position in the energy storage sector, particularly in the growing market for electric vehicles and renewable energy storage systems.

Implications of technology transfer through M&A:

The Technology transfer through M&A within the Japanese chemical industry has several implications for the companies involved and the broader market:

i. Enhanced Competitiveness: M&A enable companies to pool their resources, capabilities, and technologies, enhancing their domestic and international competitiveness. By leveraging synergy, companies can achieve cost savings, improve operational efficiency, and develop innovative products to gain a competitive edge in the market.
ii. Diversification and Market Expansion: M&A activities allow companies to diversify their product portfolios and expand into new markets. By acquiring companies with complementary products or entering into strategic partnerships, Japanese chemical companies can tap into new industries, capitalize on emerging trends, and reduce reliance on specific market segments.
iii. Technological Advancements: M&A activities often facilitate the exchange of technical expertise and R&D capabilities. By integrating technologies from acquired companies, Japanese chemical firms can accelerate their product development processes, introduce innovative solutions, and stay ahead in a highly competitive industry.
iv. Global Reach: Mergers and acquisitions provide companies access to international markets and distribution networks. This enables them to expand their customer base, establish a global presence, and increase market share. Diversifying geographical exposure also helps mitigate risks associated with regional market fluctuations.

4. Conclusions

Technology transfer among Japanese chemical firms catalyzes innovation, collaboration, and competitiveness. Through strategic partnerships and knowledge exchange, companies can leverage their respective strengths to drive technological advancements, improve product quality, and optimize manufacturing processes. This paper tries to add some value to the existing literature evaluating the performance of companies in adopting OI practices. The adoption of OI among Japanese chemical companies did help them to improve their performance. Theoretically, OI is helping companies improve their performance, but Japanese chemical companies do not all fully implement open innovation practices. Both technology exploration and technology exploitation competencies for Japanese chemical companies are progressing toward optimization. The real motivation for adopting OI in Japanese chemical companies is growing, and this study shows that they are in the transition phase from the closed innovation concept to the OI concept. Currently, Japanese chemical companies implement OI in their business, but they only implement it partially. Implementing OI requires the company to practice all the activities listed in theory; it should come together with a full package of OI culture, OI motivation, OI procedures, and OI skills [82]. Many joint ventures and joint development happened in the last 10 years. Still, many joint ventures and joint development did not promise highly successful outcomes from the collaboration or partnership.

The potentials of patent citation are untapped and still vague. The evolution of technology can be tracked and analyzed thru patent citation, but not all companies are fully aware of and react to this gem. Japanese chemical companies should improve and take massive action with their patent's potential because the chemical's technology generality index is high and implies positive technology spill-over to other technology fields [46]. Extensive future research should focus more on patent citation potentials in technology exploitation. Companies listed in the forward citation might become the potential licensee or assignee of that patent, capable of taking OI in Japanese chemical companies to the next level. The benefits of implementing OI are also not limited to monetary aspects. Studying the non-pecuniary benefits of implementing OI is also a good subject in the future. The company's dynamic capabilities might be another potential factor that should be included in future research development. Dynamic capabilities help the firm improve its resource base to deal more efficiently with environmental changes, and OI is an inherently dynamic process [83]. The change in RNOA in 3 years might be affected by other factors, as this study will include data from the 2007 global financial crisis. The effect of open innovation implementation sometimes cannot be measured in accounting terms. Accounting measurement is reported based on quarter and annual time period and accounting measurements do not capture long-term impact. The stock price change is another way to measure the company's performance, giving different results from accounting terms. Over time, stock price changes based on the company's perceived value. All sample companies are listed on Tokyo Stock Exchange, and the average stock price change can be measured.

Further study on stock price change based on the implementation of open innovation activities should be held as the different paces of change might show different results from what RNOA shows. Unfortunately, this study only used data that was strongly balanced. After all, only the data from 2006 until the year 2015 data are completely available for analysis.

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