

THE ROLE OF R & D AND OPEN INNOVATION ACTIVITIES ON INNOVATION PERFORMANCE; A CASE OF INDONESIA COMPANIES

Askawati

Graduate School of Management, Universitas Islam Indonesia, Yogyakarta,
Indonesia

Corresponding author email: askawati27@gmail.com

ABSTRACT

R&D activities and implementation of open innovation in Indonesian companies are still very limited. Research related to the relationship between R&D activities and innovation performance based on the type of innovation and implementation of open innovation is only carried out in the manufacturing industry. Therefore, this study aims to develop previous research to see the effect of R&D activities and the implementation of open innovation on innovation performance in Indonesian companies, especially in the service and manufacturing sectors. Innovation performance is measured by the sales capacity of innovative products, both radical and incremental. The data used is the 2014 Indonesia Innovation Survey (IIS) for the period 2011-2013. The research data were processed using the Tobit regression method. The results found that internal R&D activity has a positive effect on the company's innovation performance both radically and incrementally. Indonesian companies are still lacking in collaborating with other partners because external R&D activities that are carried out both separately and simultaneously do not have an impact on innovation performance. In addition, the implementation of open innovation in Indonesian companies can have a radical influence on the company's innovation performance.

Keyword: Internal and External R&D, Open Innovation, Innovation, Performance

INTRODUCTION

Indonesia is a developing country with low competitiveness compared to other developing countries. Based on The Global Competitiveness Report in 2019, Indonesia's competitiveness position goes down to 50th from 141 countries which previously ranked 45th out of 140 countries in 2018. One of the reasons for the decline is due to the slow pace of innovation carried out by the industries in Indonesia.

The success of innovation can be seen in the company's ability to introduce new products to the market (Delgado-Verde *et al.*, 2020). To introduce new products, companies need to improve their innovation capabilities to maintain their business. According to Becheikh, Landry & Amara (2006), to achieve successful innovation, companies need an established strategy, adequate company size, and intensive research and development (R&D). In addition, the performance of the innovation on the processes produced by the company is a benchmark for measuring the company's innovation ability.

Companies in developed countries certainly have R&D divisions. Research explains that the existence of R&D affects the innovation performance of a company (Ayari, 2013; Berchicci, 2013; Hagedoorn & Wang, 2012; Muñoz-Bullón, Sanchez-Bueno & Massis, 2019). R&D activities and their influence on input or innovation output have been carried out by many companies, especially in the manufacturing industry (Delgado-Verde *et al.*, 2020; Muñoz-Bullón *et al.*, 2019; Radicic & Balavac, 2019) and the service industry (Berchicci, 2013). R&D activities can be developed by the company itself (internal R&D) or through collaboration with other parties (external R&D) (Segarra-Blasco & Arauzo-Carod, 2008).

Internal R&D has an important contribution to a company's competitive advantage. Companies in developed countries generally have better resources (both financial and non-financial), so all business decisions are made based on R&D. Research on the effect of internal R&D on innovation performance has been carried out (Delgado-Verde *et al.*, 2020; Kim *et al.*, 2016; Paula & Silva, 2018). The results showed that internal R&D has a positive influence on innovation performance.

In line with internal R&D, the results found that external R&D positively affected innovation performance (Belderbos *et al.*, 2015; Berchicci, 2013; Kim *et al.*, 2016; Rehman, 2016). Furthermore, other studies reveal that the magnitude of the influence of R&D on innovation performance depends on the size of the company (Kim *et al.*, 2016) and the type of collaboration partner (Belderbos *et al.*, 2015).

Currently, the concept of open innovation has been applied by many companies. This concept was first introduced by Chesbrough (2003), where companies can obtain ideas, technology, knowledge, and capabilities from the company externally. R&D activities in the concept of open innovation can play an important role in company innovation (Kim *et al.*, 2016).

External knowledge can help companies in developing innovative products (Delgado-Verde *et al.*, 2020; Martín-de Castro, 2015). Companies can use science-based, market-based, single-group companies, and competitors information sources to gain knowledge that can affect innovation performance (Chen, Vanhaverbeke, & Du, 2016; Delgado-Verde *et al.*, 2020; Mention, 2011).

Research related to the influence of internal R&D and external knowledge sources based on science and markets with the concept of open innovation has been carried out both in developed and developing countries (Ayari, 2013; Chen *et al.*, 2016; Delgado-Verde *et al.*, 2020).

In the case of Indonesia, research by Prihadyanti & Laksani (2015) also found that R&D has an important role in corporate innovation in the manufacturing sector. However, this study found no significant differences between companies that do R&D and those that do not carry out R&D activities to produce innovations. Research related to R&D has been carried out at automotive companies in Indonesia (Aminullah & Adnan, 2012), and the result explained that Indonesian companies need more effort to spur innovation through R&D. The role of universities and public research institutions as sources of innovation is low. In addition, internal R&D activities and technology absorption in the Indonesian industry are still low as well (Lakitan, 2013).

Research related to internal and external R&D activities in Indonesian manufacturing and service companies has been carried out by Fadhilah (2018). The results found that internal R&D has a significant effect on innovation performance, while external R&D does not have a significant effect. In addition, internal and external information sources do not have a significant effect on the company's innovation performance. Meanwhile, Hartono & Kusumawardhan (2018) found that open innovation activities on Indonesian manufacturing companies have a positive effect on innovation performance.

Previous research has examined the effect of R&D activities on innovation performance based on the type of innovation carried out (product, process, organizational, and marketing innovation) (Fadhilah, 2018; Prihadyanti & Laksani, 2015). These studies suggest further studies related to incremental (new for companies but not for market) and radical (new for market) innovation categories to further investigate R&D and innovation activities in Indonesian companies.

Research conducted by Prihadyanti & Laksani, (2015) did not find the influence of R&D internally and externally and was carried out only in Indonesian manufacturing companies. Meanwhile, Fadhilah, (2018) suggested company size as a control variable to determine the effect of open innovation on large companies and SMEs. Based on this research, this study is expected to complement previous research to determine the effect of R&D activities using the open innovation approach on company innovation performance, which is measured using innovative product sales (radical and incremental) in Indonesia's service and manufacturing sectors. Internal R&D testing, external R&D and market-based and science-based external knowledge sources will be carried out to see their effect on innovation performance in companies based on the company size as the control variable.

Literature Review

Innovation Performance

According to Ebersberger & Herstad (2013), innovation performance is the result of selling new products or products that have been significantly updated. Company innovation can be seen based on the company's efforts to introduce new products for both the company itself and the (Silva & Leitão, 2009). According to Mention (2011), companies that have good internal resources and innovation performance can be measured by innovative sales, sales growth, or total products that the company has patented.

According to Van Beers & Zand (2014), the company's innovative sales can be divided into two, namely radical innovation, which is the company's efforts to sell new products to the market, and incremental or additional innovation, which is the company's efforts to create innovation and sales of products that have been introduced to the market by competitors but new to the company. Incremental innovation tends to make changes relatively little by little to meet the products in the market, this aims to meet customer demand in the local market or national standards that have been set.

Internal R&D and Innovation Performance

According to Rehman (2016), R&D is an intangible asset that is significantly related to company innovation. The existence of internal R&D can be an important determinant for corporate innovation (Love & Mansury, 2007).

For the company, internal R&D activities can increase the company's absorption ability and increase its ability to understand knowledge from

various external sources. Companies that have good absorption capacity and learning mechanisms can have a significant impact on the company's innovation performance (van Beers & Zand, 2014).

Research in developed (Delgado-Verde et al., 2020) and developing countries (Chen et al., 2016) found that internal R&D can contribute to developing company knowledge and increasing the company's absorption to produce successful innovations.

External R&D and Innovation Performance

External R&D activities are company activities carried out with external partners and aim to explore new knowledge and ideas (Pennacchio, Piroli, & Ardovino, 2018). The existence of cooperation with various external partners allows companies to obtain the necessary information from various sources.

The company's goal of conducting external R&D activities is to develop new company products or processes by reducing costs. External R&D is also useful in building external networks because companies can share risks and costs, can shorten the innovation cycle, combine technology skills so that they can complement each other and explore the economy of scale (Ayari *et al.*, 2014; Rehman, 2016).

The results of research conducted in several developed countries found that external R&D activities carried out on all types of partners could increase innovation performance (Belderbos *et al.*, 2015). In Korea, external R&D has an effect on innovation performance in large companies. Meanwhile, in developing countries such as India, Palestine and Indonesia, the influence of external R&D on innovation performance is still quite low.

Internal and External R&D Activities on Innovation Performance

Internal and external R&D activities can be carried out jointly by a company to increase the absorption and innovation of the company. Several companies in developed and developing countries have jointly implemented internal and external R&D activities. The two activities can complement each other.

Research by Giroud, Ha, & Yamin (2014); Paula & Silva, (2018) conducted in Korea and Europe found that there is a complementary relationship between internal and external R&D in high-tech companies. This is due to the higher absorption capacity of high-tech companies. In addition,

external and internal R&D can influence innovation performance in companies that have low technology intensity.

In developed countries such as Korea (Kim *et al.*, 2016), innovation in service companies is important competitiveness. Government support for innovation activities can affect the product innovation produced. In large Korean companies, internal and external R&D activities are essential for the innovation of new products to the market. Whereas in SMEs, only internal R&D activities affect product innovation. External R&D activities do not affect SMEs because the proportion of external R&D activities on SMEs is very low and still requires government support.

Previous research has concluded that companies need to have relationships with external partners to increase innovation. Internal and external R&D affect innovation performance in companies that have a high level or capacity of absorption and have high technology. Internal and external R&D can complement and substitute depending on the company's internal R&D investment.

Implementation of Open Innovation Concept

Open innovation is a solution for companies to face innovation challenges. Open innovation has been implemented by many companies in developed countries, but in Indonesia, the concept of open innovation is still limited to a few companies (Fadhilah, 2018).

Companies that apply the concept of open innovation can get ideas, technology, knowledge externally (Chesbrough, 2003). According to Denicolai, Ramirez, & Tidd (2016), open innovation is a company effort in obtaining resources from other companies and sharing internal resources and aims to develop a company's new products or services.

According to Lakitan (2012), the practice of open innovation can be measured by indicators of the breadth and depth of innovation. Research conducted by Hartono & Kusumawardhan (2018) uses the breadth of innovation to measure the number of external sources of knowledge that companies use in innovation activities. Meanwhile, the depth of innovation is used to measure the extent to which companies can get knowledge from various external sources to make innovations.

External sources of company knowledge can be obtained by collaborating with suppliers, customers, competitors, public or private research institutions and universities (Hartono & Kusumawardhan, 2018; Mention, 2011). External

knowledge sources can be classified into two types, namely science-based external knowledge such as universities and research institutions, and market-based knowledge such as customers and suppliers (Chen *et al.*, 2016; Du *et al.*, 2014).

Research shows a direct positive impact of internal R&D and external knowledge. Internal R&D contributes to developing unique and specific knowledge, resulting in distinctive competence when creating a new product. Meanwhile, external knowledge encourages the creation of new technology and increases various knowledge so that it can produce marketable innovations (Delgado-Verde *et al.*, 2020).

In developing countries, internal R&D is important to maximize the impact of external knowledge on the innovation performance of companies. Hartono & Kusumawardhan (2018) found that the concept of open innovation has a positive and significant impact on innovation performance. However, excessive external knowledge can negatively affect innovation performance as measured by the proportion of new product sales to the market. The study also explains that there is a complementary relationship between internal R&D and external knowledge from the market and open sources toward innovation.

Thus, it can be concluded that internal R&D and external sources of knowledge have a positive impact on the company's innovation performance. Furthermore, the two variables can complement each other. The knowledge gained depends on the type of partner selected. The company's absorption capacity and technology also affect the results of innovation.

Based on the description above, the hypothesis is as follows:

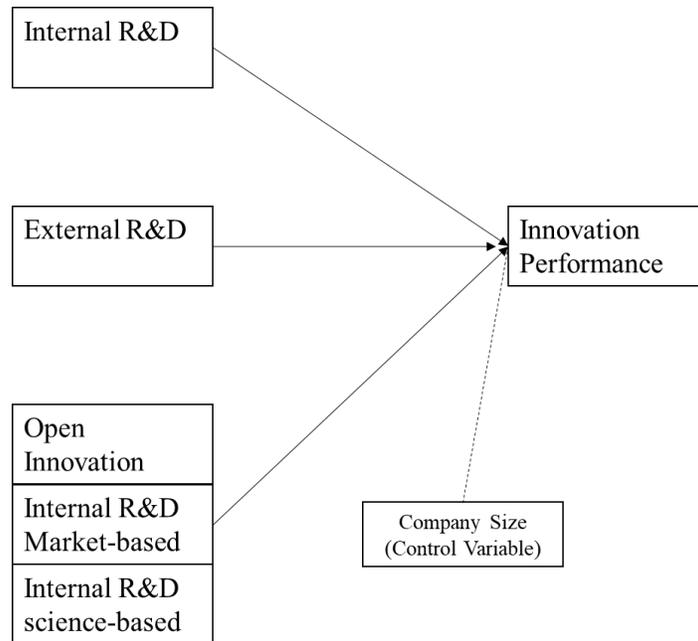
H1: Internal R&D has a positive effect on the company's innovation performance.

H2: External R&D has a positive effect on company innovation performance.

H3: Internal R&D and external R&D simultaneously have a positive effect on the company's innovation performance.

H4a: Internal R&D and external market-based knowledge sources simultaneously have a positive effect on the company's innovation performance.

H4b: Internal R&D and external science-based knowledge sources simultaneously have a positive effect on the company's innovation



performance.

Figure 1. Model Construction

METHOD

Research Design

This study aims to examine the effect of R&D activities with the concept of open innovation on innovation performance in Indonesian companies. The independent variables are internal R&D, external R&D, and external sources of knowledge. The dependent variable is innovation performance. In addition, company size is used as a control variable.

The indicator uses a binary scale (yes or no), and an ordinal (OECD & EUROSTAT, 2005). This study uses four different variables, so the measurement scale used is not the same between variables as described in Table 1.

Table 1. Measurement Scale

No	Variable	Scale
1	Company Performance	(%) sales of new product innovations that were not previously available in the Indonesian market (radical

		innovation). (%) sales of new products produced by the company for the first time (incremental innovation). (Mention, 2011; van Beers & Zand, 2014)
2	Internal R&D Activities	Yes (1) = the company carries out internal R&D activities. No (0) = The company does not carry out internal R&D activities
3	External R&D Activities	Yes (1) = The company carries out external R&D activities. No (0) = The company does not carry out external R&D activities.
4	<p>External Knowledge Sources</p> <p>Market-based External Knowledge Sources are measured by indicators:</p> <ol style="list-style-type: none"> 1. Suppliers of equipment, materials, components, or software, 2. Clients and customers, 3. Competitors or other companies, 4. Consultants, 5. Commercial laboratories or private R&D institutes <p>Science-based external sources of knowledge are measured by indicators:</p> <ol style="list-style-type: none"> 1. University or other higher education institution 2. Polytechnic, 3. Government R&D institutes, 4. Non-profit R&D institutes. 	<p>(1) Not relevant</p> <p>(2) Low</p> <p>(3) Middle,</p> <p>(4) High.</p>
5	Company Size	(1) Small (under 20 employees)

	(2) Moderate (20-99 employees) (3) Large (more than 99 employees)
--	--

Population and Sample

The data used is the 2014 Indonesia Innovation Survey (IIS) from 2011-2013. The data population is all companies in the business sector, both services and manufacturing in Indonesia, which carry out innovation activities. The sectors used are mining, manufacturing, electricity, gas & water, construction, trade, hotels & restaurants, transportation, storage, communications and finance. Meanwhile, the sample selection was carried out using the multi-stage random sampling technique which is part of simple random sampling. Samples were taken based on the criteria of companies in the manufacturing and service sector that carry out internal R&D activities, external R&D, and use external sources of knowledge as input for company innovation. A total of 927 company data were collected and 570 company data were used as samples in this study.

Data Analysis

In this study, descriptive analysis is seen based on the mean, standard deviation, maximum, and minimum values of incremental innovation performance, radical innovation performance, internal R&D, external R&D, external knowledge sources, and company size. Hypothesis testing is carried out using the TOBIT model. This model is used because the dependent variable in this study has limitations, namely a lower limit and an upper limit (0-100). Meanwhile, data analysis was performed using Stata IC 13.

In this study, descriptive analysis is seen based on the mean, standard deviation, maximum, and minimum values of incremental innovation performance, radical innovation performance, internal R&D, external R&D, external knowledge sources, and company size. Hypothesis testing is carried out using the TOBIT model. This model is used because the dependent variable in this study has limitations, namely a lower limit and an upper limit (0-100). Meanwhile, data analysis was performed using Stata IC 13. The accepted hypothesis can be seen by looking at the p value. The hypothesis can be accepted if the p value is <5% (Fadhilah, 2018; Kim *et al.*, 2016).

RESULT AND DISCUSSION

Descriptive Analysis

Table 2 describes the results of descriptive analysis on each variable in this study.

Table 2. Descriptive Statistic

Variable	Obs	Mean	Standard Deviation	Minimum	Maximum
Incremental Innovation Performance	570	30.58	32.69	0	100
Radical Innovation Performance	570	19.01	26.75	0	100
Internal R&D	570	0.44	0.5	0	1
External R&D	570	0.16	0.37	0	1
Supplier	570	2.68	1.14	1	4
Consumer	570	3.28	0.90	1	4
Competitor	570	2.74	1.05	1	4
Consultant	570	1.85	1.01	1	4
Commercial Lab	570	1.58	0.88	1	4
University	570	1.51	0.82	1	4
Polytechnic	570	1.4	0.74	1	4
Government R&D	570	1.43	0.76	1	4
Private R&D	570	1.42	0.74	1	4
Company Size	570	1.56	0.7	1	3

The data shows that the majority of Indonesian companies do not carry out R&D activities either internally or externally. However, the majority of Indonesian companies carry out more internal R&D activities at 44% compared to external R&D activities about 16%.

The test results show that market-based knowledge such as suppliers, customers and competitors in Indonesian companies has better results than science-based knowledge sources such as universities, polytechnics, government R&D and private R&D. The percentage of external knowledge sources from suppliers, customers and competitors is higher than other sources of knowledge.

The role of radical innovation in Indonesian companies is smaller than incremental innovation. This can be seen through the average percentage of the implementation of radical innovations which is 19.9%, smaller than incremental innovation, 30.58%. It means that companies generate more innovation by producing new products even though these products are already on the market.

The size of the company as a control variable shows that as many as 317 are small companies, 185 are middle companies and 68 are large companies. These results indicate that the majority of companies that filled out the questionnaire are small companies with 20 employees.

RESULT

A hypothesis can be accepted by looking at the p-value. In this study, the hypothesis will be accepted if the p-value is <0.05 (Fadhilah, 2018; Kim *et al.*, 2016). The following are the results of hypothesis testing that has been done.

H1: Internal R&D has a positive effect on the company's innovation performance. Based on the results of data processing, the value of internal R&D activities on radical innovation performance is 17.52 and incremental is 23.58 with a significant level of 1%. The p value generated by internal R&D on radical innovation performance is 0.001 and incremental innovation performance is 0.000. Thus, it can be concluded that internal R&D has a positive influence on the performance of radical and incremental innovations in all company sizes. So that H1 in this study is accepted. However, firm size as a control variable shows insignificant numbers.

H2: External R&D has a positive effect on the company's innovation performance. Based on the test, the value of external R&D activities on the performance of radical innovations is 9,479 and incremental is 12,040 at a significant level of 10%. The p-value generated by external R&D on the performance of radical innovation is 0.170, so it can be concluded that it is not significant. Meanwhile, the p-value generated by external R&D on incremental innovation performance is 0.073 less than 0.10. The role of company size as a control variable shows insignificant results. Since the p-value is not significant, it can be concluded that external R&D does not have a positive effect on innovation performance at all company sizes. So that H2 is rejected.

H3: Internal R&D and external R&D simultaneously have a positive effect on the company's innovation performance. Testing simultaneously produces insignificant results from internal and external R&D activities on innovation performance, both radically and incrementally, with a value of 8,342 and 10,258. The role of company size as a control variable shows insignificant results.

The p-value generated by internal R&D on radical innovation performance is 0.001 and incremental innovation performance is 0.000, both variables have a value less than 0.01. Meanwhile, the p-value generated by external R&D on radical innovation performance is 0.221 and incremental innovation performance is 0.113.

It can be concluded that internal R&D and external R&D simultaneously do not have a positive effect on firm innovation performance across company sizes. This is because only internal R&D that influences the company's innovation performance both radically and incrementally. So that H3 in this study is rejected.

H4a: Internal R&D and market-based external knowledge sources simultaneously have a positive effect on the company's innovation performance. Based on the test, the coefficient value of the influence of internal R&D and external market-based knowledge sources on the performance of radical innovations carried out simultaneously is 15,101 and incremental innovation performance is -0,716 (not significant). The role of company size as a control variable shows an insignificant number. The p-value of internal R&D on radical innovation performance is 0.003 and the incremental innovation performance is 0.000, the p-value of the two variables is less than 0.01. The p-value of market-based knowledge sources for radical innovation performance is 0.000, less than 0.01 and the incremental innovation performance is 0.833.

It can be concluded that internal R&D and market-based external knowledge simultaneously have a positive effect on radical innovation performance across company sizes. While the performance of incremental innovation, only internal R&D activities have a significant effect. Thus, H4a is partially accepted.

H4b: Internal R&D and science-based external knowledge sources simultaneously have a positive effect on the company's innovation performance. Based on the test, the coefficient value of the influence of internal R&D and external science-based knowledge sources on radical innovation performance is 10.020 and incremental innovation performance is 3.037 (insignificant). The role of company size as a control variable shows an insignificant number.

The p-value generated by internal R&D on radical innovation performance is 0.001 and incremental innovation performance is 0.000. Both have p values less than 0.01. Meanwhile, the p-value from science-based

knowledge sources on radical innovation performance is 0.006 (1% significant level) and incremental innovation performance is 0.385 (insignificant).

It can be concluded that internal R&D and external science-based knowledge sources simultaneously have a positive effect on radical innovation performance for all company sizes. Meanwhile, for incremental innovation performance, only internal R&D activities had significant results. Thus, H4b in this study is partially accepted.

DISCUSSION

The test results show that internal R&D activity has a positive effect on the company's innovation performance, both radically and incrementally. This result is in line with the research of Fadhilah (2018) which explains that there is an effect of internal R&D activities on the innovation performance of Indonesian companies. The results of this study are also in line with several studies in developed and developing countries in the service and manufacturing sectors which found a positive direct effect on the company's innovation performance (Delgado-Verde *et al.*, 2020; Paula & Silva, 2018).

The majority of companies in Indonesia do not carry out R&D activities. Therefore, it requires greater efforts to encourage innovation through R&D activities (Aminullah & Adnan, 2012) Expensive and risky R&D activities can be the reason some service and manufacturing industries do not carry out R&D activities.

The result explains that external R&D activities do not have a positive effect on the company's innovation performance both radically and incrementally. This result is in line with the research of Fadhilah (2018) which explained that there is no significant effect of external R&D activities on the innovation performance of Indonesian companies, especially in the manufacturing industry. Meanwhile, in developed countries like Korea, Kim *et al.*, (2016) found that external R&D has a greater influence on large companies than small companies such as SMEs. In Indonesia, service and manufacturing companies have not collaborated with other partners such as customers, suppliers, competitors and research institutions that can improve the company's innovation performance. Aminullah & Adnan, (2012) explained that Indonesian companies need to collaborate with universities and public research institutions to encourage innovations.

Both internal and external R&D activities simultaneously do not have a positive influence on innovation performance in Indonesian companies, either radically or incrementally. The descriptive analysis shows that the average internal R&D activity is greater than the average external R&D activity carried out in the service and manufacturing industries in Indonesia. This result is not in line with research conducted in developed countries by Muñoz-Bullón *et al.*, (2019) which found that both internal and external R&D activities can simultaneously perform a positive effect on innovation performance. In addition, internal R&D activities and external R&D activities simultaneously show a significant relationship over the innovation performance of large service companies in Europe (Kim *et al.*, 2016).

According to Paula & Silva (2018), internal and external R&D that is carried out simultaneously can provide challenges for companies. These activities can complement or replace each other depending on the company's absorption ability. In Indonesia, internal and external R&D activities produce substitutive results. This is because internal R&D shows significant results while external R&D is not. Indonesian companies still lack cooperation with external parties.

Based on hypothesis testing, it can be concluded that the concept of open innovation in Indonesia can have a positive impact on the company's innovation performance radically when Indonesian companies collaborate and gain knowledge from suppliers, customers, competitors, commercial labs, and consultants. This research is in line with Hartono & Kusumawardhan (2018), which found that the concept of open innovation in Indonesian companies has a positive impact on innovation performance. This is due to the complementary relationship between internal R&D activities and external sources of knowledge (customers and suppliers) on the performance of radical innovations in Indonesian manufacturing companies.

Research by Chen *et al.*, (2016) and Delgado-Verde *et al.*, (2020) found that there is a positive direct impact between internal R&D and external knowledge. However, when tested simultaneously, it generates a negative impact due to the substitution effect between internal R&D and external knowledge (Delgado-Verde *et al.*, 2020).

In addition, companies that collaborate with science-based knowledge such as universities, polytechnics, government R&D and private R&D have a positive impact on the company's innovation performance radically. This research is in line with Delgado-Verde *et al.* (2020) which found that the

concept of open innovation has a positive direct impact on new product innovation to the market. The knowledge gained from universities, polytechnics, consultants, government R&D, private R&D and commercial lab has an irrelevant impact on Indonesian manufacturing and service companies. However, collaboration with science can have a significant influence in supporting innovations to the market (Mention 2011). Universities collaboration provides fewer benefits to the company's innovation performance. This is because the absorption capacity of companies in developing countries is still very low.

Variable	Radical	Incremental	Radical	Incremental	Radical	Incremental	Radical	Incremental	Radical	Incremental
Internal R&D	17.525*** (5.039)	23.584*** (4.699)								
External R&D			9.479 (6.893)	12.040* (6.703)						
R&D Internal & External					8.342 (6.816)	10.258 (6.463)				
Internal R&D *SPE							15.101*** (5.004)	-0.716 (3.405)		

Table 3. Hypothesis Test

market-based										
Internal R&D *SPE Science-based									10.020*** (3.638)	3.037 (3.49)
Company size	0.243 (3.558)	-3.769 (3.357)	-0.181 (3.685)	-4.199 (3.585)	-0.790 (3.651)	-5.142 (3.467)	-0.575 (3.522)	-3.715 (3.366)	-0.297 (3.527)	-3.977 (3.364)
Observation	570	570	570	570	570	570	570	570	570	570
Log Likelihood	- 1541.727	- 1931.804	- 1546.906	-1942.513	- 1540.980	-1930.542	- 1534.4203	-1931.7822	- 1537.9481	-1931.4256

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

CONCLUSION

This study found that internal R&D activities had a positive influence on the innovation performance of Indonesian companies, both radically and incrementally. Although the majority of Indonesian companies do not carry out R&D activities, these activities can influence the company's innovation performance. Meanwhile, the study found that external R&D activities did not have a positive effect on the innovation performance of Indonesian companies, both radically and incrementally. This is because Indonesian companies lack cooperation with suppliers, customers, competitors and universities. Internal and external R&D activities that are tested simultaneously do not have a positive effect on the innovation performance of Indonesian companies, either radically or incrementally. The two R&D activities carried out simultaneously provide challenges for the company. In Indonesian companies, internal and external R&D activity are substitutive. This is because Indonesian companies lack partnerships with other companies. In addition, the concept of open innovation carried out by Indonesian service and manufacturing companies have a positive impact on the company's innovation performance radically. Companies can create innovations to the market when they can collaborate and acquire market-based and science-based knowledge. Conversely, collaboration and market and science-based knowledge do not have a positive impact on new-to-enterprise or incremental product innovation.

REFERENCES

- Ades, C., Figlioli, A., Sbragia, R., Porto, G., Plonski, G. A., & Celadon, K. (2013). Implementing Open Innovation: The Case of Natura, IBM and Siemens. *Journal of Technology Management & Innovation*, 8(0 SE-), 12–25. <https://doi.org/10.4067/S0718-27242013000300057>
- Aminullah, E., & Adnan, R. (2012). The role of academia as an external resource of innovation for the automotive industry in Indonesia. *Asian Journal of Technology Innovation - ASIAN J TECHNOL INNOV*, 20, 99–110. <https://doi.org/10.1080/19761597.2012.683946>
- Ayari, N. (2013). Internal Capabilities, R&D Cooperation and firms' Innovativeness Level. *Gestion* 2000, 30(2), 33–53. <https://doi.org/10.3917/g2000.302.0033>
- Ayari, N., Du, J., Leten, B., Vanhaverbeke, W., Belderbos, R., Gilsing, V., ... Lokshin, B. (2014). Does Internal and External Research and Development Affect Innovation of Small and Medium-Sized Enterprises? Evidence from India and Pakistan. *Research Policy*, 43(2), 33–53. <https://doi.org/10.3917/g2000.302.0033>
- Becheikh, N., Landry, R., & Amara, N. (2006). Lessons from innovation empirical studies in the manufacturing sector: A systematic review of the literature from 1993–2003. *Technovation*, 26(5), 644–664. <https://doi.org/https://doi.org/10.1016/j.technovation.2005.06.016>
- Belderbos, R., Carree, M., Lokshin, B., & Fernández Sastre, J. (2015). Inter-temporal patterns of R&D collaboration and innovative performance. *The Journal of Technology Transfer*, 40(1), 123–137. <https://doi.org/10.1007/s10961-014-9332-4>
- Berchicci, L. (2013). Towards an open R&D system: Internal R&D investment, external knowledge acquisition and innovative performance. *Research Policy*, 42(1), 117–127. <https://doi.org/https://doi.org/10.1016/j.respol.2012.04.017>
- Chen, Y., Vanhaverbeke, W., & Du, J. (2016). The interaction between internal R&D and different types of external knowledge sourcing: An empirical study of Chinese innovative firms. *R&D Management*. <https://doi.org/10.1111/radm.12162>
- Chesbrough, H. (2003). *Open Innovation: The New Imperative for Creating and Profiting From Technology*. *Journal of Engineering and Technology*

Management - J ENG TECHNOL MANAGE (Vol. 21).

- Delgado-Verde, M., Martín-de Castro, G., Cruz-González, J., & Navas-López, J. E. (2020). Complements or substitutes? The contingent role of corporate reputation on the interplay between internal R&D and external knowledge sourcing. *European Management Journal*.
<https://doi.org/https://doi.org/10.1016/j.emj.2020.07.001>
- Denicolai, S., Ramirez, M., & Tidd, J. (2016). Overcoming the false dichotomy between internal R&D and external knowledge acquisition: Absorptive capacity dynamics over time. *Technological Forecasting and Social Change*, 104, 57–65.
<https://doi.org/https://doi.org/10.1016/j.techfore.2015.11.025>
- Du, J., Leten, B., Vanhaverbeke, W., and Lopez-Vega, H. (2014). When Research Meets Development: Antecedents and Implications of Transfer Speed. *Journal of Product Innovation Management*, 31(6), 1181–1198.
- Ebersberger, B., & Herstad, S. (2013). The relationship between international innovation collaboration, intramural R&D and SMEs' innovation performance: A quantile regression approach. *Applied Economics Letters*, 20, 626–630. <https://doi.org/10.1080/13504851.2012.724158>
- Fadhilah, S. (2018). Dampak Pendekatan Open Innovation Terhadap Kinerja Inovasi Perusahaan Di Indonesia. *Journal of Management and Business Review*, 15, 235–259. <https://doi.org/10.34149/jmbr.v15i2.125>
- Giroud, A., Ha, Y., & Yamin, M. (2014). Foreign subsidiaries' internal and external R&D cooperation in South Korea: Explanatory factors and interaction. *Asian Business & Management*, 13. <https://doi.org/10.1057/abm.2014.8>
- Hagedoorn, J., & Wang, N. (2012). Is there complementarity or substitutability between internal and external R&D strategies? *Research Policy*, 41(6), 1072–1083. <https://doi.org/https://doi.org/10.1016/j.respol.2012.02.012>
- Hartono, A., & Kusumawardhan, R. (2018). Searching Widely or Deeply? The Impact of Open Innovation on Innovation and Innovation Performance Among Indonesia MANUFACTURING FIRMS. *Journal of Indonesian Economy and Business*, 3(2). <https://doi.org/https://doi.org/10.22146/jieb.29218>
- Kim, S., Kim, E., Suh, Y., & Zheng, Z. (2016). The effect of service innovation

- on R&D activities and government support systems: the moderating role of government support systems in Korea. *Journal of Open Innovation: Technology, Market, and Complexity*, 2. <https://doi.org/10.1186/s40852-016-0032-1>
- Lakitan, B. (2012). National Innovation System in Indonesia : Present Status and Challenges.
- Lakitan, B. (2013). Connecting all the dots: Identifying the “actor level” challenges in establishing effective innovation system in Indonesia. *Technology in Society*, 35(1), 41–54. <https://doi.org/https://doi.org/10.1016/j.techsoc.2013.03.002>
- Love, J. H., & Mansury, M. A. (2007). External Linkages, R&D and Innovation Performance in US Business Services. *Industry and Innovation*, 14(5), 477–496. <https://doi.org/10.1080/13662710701711380>
- Martín-de Castro, G. (2015). Knowledge management and innovation in knowledge-based and high-tech industrial markets: The role of openness and absorptive capacity. *Industrial Marketing Management*, 47, 143–146. <https://doi.org/https://doi.org/10.1016/j.indmarman.2015.02.032>
- Mention, A.-L. (2011). Co-operation and co-opetition as open innovation practices in the service sector: Which influence on innovation novelty? *Technovation*, 31(1), 44–53. <https://doi.org/https://doi.org/10.1016/j.technovation.2010.08.002>
- Muñoz-Bullón, F., Sanchez-Bueno, M. J., & Massis, A. De. (2019). Combining Internal and External R&D: The Effects on Innovation Performance in Family and Nonfamily Firms. *Entrepreneurship Theory and Practice*, 44(5), 996–1031. <https://doi.org/https://doi.org/10.1177/1042258719879674>
- OECD, & EUROSTAT. (2005). Oslo Manual: Guidelines for collecting and interpreting innovation data (3rd ed.). Paris, France.
- Paula, F. de O., & Silva, J. F. da. (2018). Balancing Internal and External R&D Strategies to Improve Innovation and Financial Performance. *Brazilian Administration Review*, 15(2), 1807–7692. <https://doi.org/https://doi.org/10.1590/1807-7692bar2018170129>.
- Pennacchio, L., Piroli, G., & Ardivino, O. (2018). The Role of R&D Cooperation in Firm Innovation. *International Journal of Innovation and Technology Management (IJITM)*, 15(01), 1–27. Retrieved from <https://econpapers.repec.org/RePEc:wsi:ijitmx:v:15:y:2018:i:01:n:s021987>

7018500037

- Porter, M. E. (2011). *Competitive advantage of nations: creating and sustaining superior performance*. New York : Free Press c.1990.
- Prihadyanti, D., & Laksani, C. S. (2015). R & D Dan Inovasi Di Perusahaan Sektor Manufaktur Indonesia. *Jurnal Teknologi Manajemen*, 14(2), 187–198.
- Radicić, D., & Balavac, M. (2019). In-house R&D, external R&D and cooperation breadth in Spanish manufacturing firms: is there a synergistic effect on innovation outputs? *Economics of Innovation and New Technology*, 28(6), 590–615. <https://doi.org/10.1080/10438599.2018.1546557>
- Rehman, N. U. (2016). *Does Internal and External Research and Development Affect Innovation of Small and Medium-Sized Enterprises? Evidence from India and Pakistan*.
- Segarra-Blasco, A., & Arauzo-Carod, J.-M. (2008). Sources of innovation and industry–university interaction: Evidence from Spanish firms. *Research Policy*, 37(8), 1283–1295. <https://doi.org/https://doi.org/10.1016/j.respol.2008.05.003>
- Silva, M., & Leitão, J. C. (2009). Cooperation in innovation practices among firms in Portugal: do external partners stimulate innovative advances? *International Journal of Entrepreneurship and Small Business - Int J Enterpren Small Bus*, 7. <https://doi.org/10.1504/IJESB.2009.023357>
- Simamora, M., Maludin, S., Yantyo, P., Dwi, N., Syukri, N., Nasution, Y., & Rosa, E. (2016). *Kajian Kebijakan Insentif dalam Pengembangan Taman Sains Teknologi di Indonesia Desember 2015 Pusat Inovasi Lembaga Ilmu Pengetahuan Indonesia*.
- van Beers, C., & Zand, F. (2014). R&D Cooperation, Partner Diversity, and Innovation Performance: An Empirical Analysis. *Journal of Product Innovation Management*, 31(2), 292–312. <https://doi.org/10.1111/jpim.12096>