

A Quiet Place: Exploring the Implementation of Open Innovation in Government's R&D Institution

Jalan yang Sunyi: Studi Eksplorasi terhadap Implementasi Inovasi Terbuka di Institusi Penelitian Pemerintah

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Abstrak

Berkembangnya implementasi strategi inovasi terbuka di sektor swasta menimbulkan pertanyaan, apakah strategi tersebut juga efektif untuk meningkatkan kinerja inovasi di lembaga pemerintah. Studi ini mengobservasi proses adaptasi lembaga riset pemerintah dalam menerapkan strategi inovasi terbuka dalam beberapa kegiatan risetnya. Observasi penerapan inovasi terbuka di lembaga pemerintah dipandang perlu untuk mengisi kesenjangan studi mengenai topik tersebut. Mengingat strategi ini umumnya digunakan di sektor swasta untuk mendorong kinerja inovasi. Studi ini merupakan penelitian kualitatif, menggunakan pendekatan studi kasus untuk mengobservasi serta mengukur implementasi inovasi terbuka pada Badan Litbang, Kementerian Pekerjaan Umum dan Perumahan Rakyat. Proses adaptasi melibatkan tiga aspek, yaitu ketersediaan sumber daya, mekanisme pengetahuan, dan kapasitas kemitraan. Temuan penelitian ini mengindikasikan bahwa dua faktor yang berperan signifikan dalam implementasi inovasi terbuka adalah mekanisme pengetahuan dan kapasitas kemitraan. Salah satu pusat di Badan Litbang memiliki kapasitas kemitraan yang lebih baik karena fungsinya sebagai lembaga perantara. Hasil observasi menunjukkan bahwa kegiatan penelitian, yang tidak memerlukan riset dasar serta berada dalam jaringan kemitraan strategis, umumnya memiliki tingkat adaptasi yang lebih baik.

Kata kunci: inovasi, inovasi terbuka, pemerintah, publik sektor, litbang.

Abstract

The growing success of the implementation of open innovation in private sector raised questions whether this strategy is also effective in improving innovation system in government institution. This research examined the adaptation process of government R&D institution in implementing open innovation in some of their R&D activities. It is important to explore the implementation of open innovation in government R&D institution in order to fill the gap of study about open innovation that commonly

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aimed to boost the innovation performance in private sector. This research was a qualitative research with explanatory case study that involved R&D Agency Ministry of Public Works and Housing. This study explored and measured the best practice of open innovation in R&D Agency of Ministry of Public Works and Housing to address how and why open innovation was possible to be implemented by applying Open Innovation Maturity Framework (Enkel, Bell, & Hogenkamp, 2011). The adaptation process were involving three aspects, namely the availability of resources, knowledge mechanism, and the partnership capacity. The findings showed that only two factors play significant role in the implementation process, namely the knowledge mechanism and the partnership capacity. A research center performed excellent partnership capacity due to this organization's function as intermediary. The findings suggested that open innovation strategy are appropriate to be implemented in government institution to increase the quality of public service.

Keywords: innovation, open innovation, government, public sector, R&D.

1. INTRODUCTION

Many attempts have been made to study about optimizing the speed and number innovation (Chun, Shulman, Sandoval, & Hovy, 2010; Albury 2005; Nieto & Rodríguez, 2011). Innovation defined as "a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)" (Gassmann & Enkel, 2004; OECD, 2018). The newest definition of innovation is paying more attention on how the outputs of innovations are become more available and accessible to potential users. In order to smoothen the access to potential users, Chesbrough (2006) introduced the concept of open innovation. Open innovation is a condition when a firm can and should use external as well as internal ideas; and also, internal and external paths to the market. This concept is still new for Indonesian R&D system, especially for government R&D institution.

Government R&D institution found difficulties to distribute their products to the potential users due to lack of connectivity between innovation actors (Lakitan, 2013). Research is done partially in government R&D institution and adopted closed innovation system. As the opposite of open innovation, "closed innovation is a system when firm generates their own ideas and then develop them, build them, market them, distribute them, service them, finance them, and support them on their own" (Chesbrough, 2006). This closed innovation system, which adopted by government R&D institution, is more or less become the reason why it is not easy to build networks among innovation actors. However, some of the government R&D institution are also practicing open innovation strategy, along with closed innovation strategy, one of them is R&D Agency of Ministry of Public Works and Housing (MOPWH).

R&D Agency MOPWH implemented the characteristic of open innovation in some of research projects, such as do not originate basic research, collaborate with strategic partners, and combining internal strength and external resources to profit from it (Chesbrough, 2006). One of the research projects that implemented open innovation is BIM (Building Information Modelling) that developed by Research Center for Policy and Technology Implementation (RCPTI) under the management of R&D Agency MOPWH.

The growing study has been made to explore the open innovation system (Bogers, et al., 2017; Vanhaverbeke & Cloudt, 2006; Gassmann, Enkel, & Chesbrough, 2010). Those studies were focused on some firms that successfully adopted open innovation as their new innovation system. Most of those firms are operated in high-technology area, such as Apple, BASF, Xerox, and Phillips. Those studies provide broad explanation on the shifting paradigms of innovation, from closed to open innovation. Moreover, Hilgers and Ihl (2010) study

questioning whether the basic principles of open innovation can be transferred for revitalizing public sector institutions. In their study, Hilgers and Ihl (2010) introduced the concept of Citizen sourcing. The basic idea of citizen sourcing concept is that by incorporating a much larger variety of ideas and knowledge into new product and service development and the resulting product will have better fit with the market requirement (Hilgers & Ihl, 2010). In the case of R&D Agency MOPWH, the R&D product are not meant for market, but for the communities as user. The Citizen sourcing concept is translated in some of R&D Agency products that engaging citizen's voice in operationalizing it, for instance is the JAKI (Jalan Kita/Our Roads) application.

Furthermore, Enkel, Bell, and Hogenkamp (2011) study explains how to measure the maturity level of firm which implements open innovation as their innovation strategy. However, studies about open innovation is mostly done in a high-tech firm or industry (Gassmann, Enkel, & Chesbrough, 2010) with profit-making orientation, therefore, this study wants to explore the implementation of open innovation strategy in the government R&D institution, specifically in the R&D Agency of Ministry of Public Works and Housing (MOPWH).

Studies related to open innovation in private sector such as Procter and Gambler (P&G) and Xerox have been proven that this system successfully boost their innovation performance (Chesbrough, 2006) and it is necessary to explore open innovation further in government R&D institution. Although government R&D institution are not for profit-making orientation, most of the R&D activities in this institution are funded by taxpayer's money. For that reason, it is needed to optimize the innovation system in government R&D institution, of which is through the open innovation system. R&D Agency MOPWH have had experience where the product designed and developed by researcher still need more improvement to solve the social problem; this product is JUDESA (Jembatan Untuk Desa/Bridge for Village). However, there are several research projects that actively engaged with external resources and took benefit from it, or conclude as implementing open innovation strategies. Therefore, this study wants to explore how R&D Agency MOPWH adapt to open innovation system through three different aspects: the availability of resources, knowledge mechanism, and partnership capacity. Not many academic studies have focused on observing the implementation of open innovation in public sector, moreover, in Indonesia's context, thus, this is another critical research gap. Studies related to open innovation often times took place in high-tech firm in private sector setting that is focused on profit-making, therefore, it is necessary to observe the adaptation process of open innovation implementation in government institution which is focused on catering public service.

2. LITERATURE REVIEW AND PREVIOUS RESEARCH

2.1 Open Innovation and Closed Innovation

Large companies, such as IBM and Intel, have historically invested on research and development activities to boost their innovation and provide sustainable growth. Later, these companies recognized that not all good ideas will always appear within the organization and not all the good ideas from inside the company can be well-marketed internally (Chesbrough H., Managing open innovation., 2004). Companies recognized the need to open their innovation process by engaging external parties and also known as open innovation. The concept of open innovation as the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for eternal use of innovation, respectively, was introduced by Chesbrough (Chesbrough H., Open innovation: The New

Imperative for Creating and Profiting from Technology, 2003). This concept was not completely new, open innovation emphasized the importance of exploiting external resources and combining them with internal resources in order to achieve better performance.

Gassman and Enkel (2004) added that what distinguishes open innovation from closed innovation is a firm that implements open innovation interacts with external resources more efficiently and effectively. That being said, closed innovation is defined as a system where firm create their own ideas and then develop them, build them, diffuse them, finance them, and support them on their own (Chesbrough, 2006). Chesbrough adds, in closed innovation systems, a successful innovation requires control. Closed innovation is quite different from what Hilgers and Ihl (2010) suggest in their study: the process of product and service development is becoming more open and accessible, focusing more on external knowledge and connecting with more external actors to attain and sustain innovation. Chesbrough (2006) distinguishes the basic principles of closed and open innovation in his study as follow (table 1):

Table 1. Characteristic of Open and Closed Innovation

No	Open Innovation	Closed Innovation
1	Not all the smart people work in our organization. We need to work with smart people from inside and outside the company.	The smart people in our field work for us
2	External R&D can create significant value, internal R&D is needed to claim some portion of that value.	To profit from R&D, a firm must discover it, develop it, and market it by themselves.
3	We do not have to originate the research to profit from it	If a firm discover it first, then it will market it first.
4	Building better business model is better than getting to the market first.	If a firm that gets an innovation to the market first will win.
5	If we make the best use of internal and external idea, we will win.	If a firm create the most and the best idea in the industry, it will win
6	We should profit from others' IP, we should buy others' IP whenever it advances our own business model.	A firm should control the intellectual property (IP), therefore the other firm do not profit from the ideas.

Source: (Chesbrough, 2006)

Looking back to the definition of open innovation as “the purposive inflows and outflows knowledge” (Chesbrough, 2006), this term is basically focused on vibrant economic literature on spillovers that begin from the firm’s investment in research and development activities. This spillover comes from a firm’s inability to specify what outcomes of this investment in the future. Chesbrough and Bogers (2014) study suggests that basic research resulted in more spillovers due to limited capability to benefit from the investment. Furthermore, Cohen and Levinthal (1990) emphasize the importance of investing in internal research and development activities in order to be able to utilize external resources; they termed this ability as *absorptive capacity*. Later, the concept of absorptive capacity will be developed further by Gassman and Enkel (2004) as one of the core competence that a firm should owned in their open innovation activities.

Further inquiry originated from Rosenberg’s (Rosenberg, 1990) study that questioned why firms invest their money to do the basic research. Rosenberg’s study suggests that firms should enhance their ability to exploit external knowledge and resources. Rosenberg’s point of view toward basic research also become important

characteristic that distinguish open innovation to closed innovation on Chesbrough study (2004). Based on the previous studies that demonstrate the existence of spillovers in research and development activities, in the open innovation model, spillovers are transformed into inflows and outflows of knowledge that can be purposively managed (Chesbrough, 2006). However, in a recent study, Chesbrough & Bogers (2014) clarify and develop the concept of open innovation as “distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organization’s business model” (p. 1). Firms can establish their own processes to find out and transfer external knowledge into their innovation activities, as shown on figure 1. On the contrary, firms are also able to create a medium to shift unutilized internal knowledge to the external parties who need it.

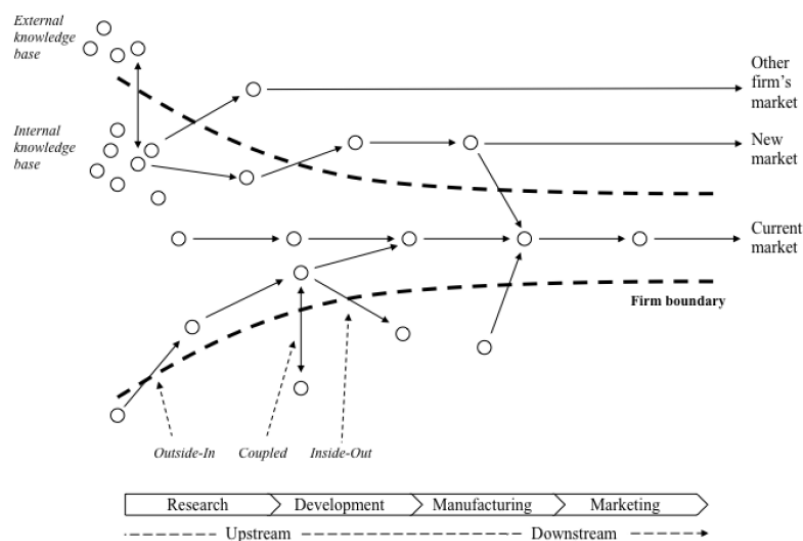


Figure 1 The Open Innovation Model

Source: (Chesbrough, 2006)

In this definition, innovation attributes to the advancement and commercialization of new or developed product, process or services whilst the openness aspect is depicted by the knowledge flows across the accessible organizational boundary. In addition, it is almost certain that an organization’s business model play important part in this knowledge flows.

2.2 Knowledge Flow and Core Competencies of Open Innovation Firm

The difference between firms that implemented open and closed innovation is their interaction with external parties, which affected their innovation process efficiency and effectiveness (Gassmann & Enkel, 2004). In open innovation, a firm commercializes both its own ideas as well as ideas from other firms in order to finds ways to bring its in-house ideas to the market (Chesbrough, 2006). Furthermore, Chesbrough pinpoint important factors that influence firms to transform their innovation plan into more adaptable open innovation: skilled workers’ increasing availability and mobility along with external suppliers’ improving capability. Interaction with external parties is also available for unutilized internal ideas and the venture capital market, which created new opportunities for the firm (Gassmann & Enkel, 2004). In addition to that, on inter-company level this is achieved from the creation of linkages

and the system of relationship (Reagans & McEvily, 2003). Gassman and Enkel's (2004) study explains that there are three different mechanisms or in their term "archetypes" of open innovation. These mechanisms depict how a firm interacts with external parties: the outside-in, the inside-out, and coupled process.

a. The Outside-In Process

On the outside-in process, a firm improves their innovation level by enhancing their own knowledge based on the integration of suppliers, users, and external knowledge sourcing. Exposing the internal innovation process by accommodating suppliers and customers is not something brand-new. Exposing firms through an outside-in process in R&D management is important for attaining high direct and indirect innovation output effects (Inauen & Schenker-Wicki, 2011). At this point, firms are trying to generate knowledge from outside at the early stage of innovation activities. Knowledge and technology from outside will be developed further by combining it with internal capacity to enhance the firm's innovation process. At this stage, a firm needs to screen the environment to seek knowledge and technology and not necessarily rely on their own in-house knowledge (Spithoven, Clarysse, & Knockaert, 2010). Therefore, firms should own an absorptive capacity in order to internalize the external knowledge and technology. Firm can generate idea, knowledge, or technology from outside and combine it with the internal resources that they already have to boost their commercialization. This is important to enhance their own innovation capabilities. Absorptive capacity basically is the efficiency of both knowledge generation and its application (Gassmann & Enkel, 2004).

b. The Inside-Out Process

Firms that adopt the inside-out process as their strategy are focused on externalizing firms' knowledge and innovation to the market. This strategy is necessary to bring their ideas to the market faster than they can through the internal development. In addition, the locus of the innovation is shifting from the origin of the ideas to the external parties or other firms. Firms in this archetype are familiar with activities such as licensing IP from the other firm or technology transfer to the other company. Gassman and Enkel's study suggests that firms who commercialize ideas in other companies (cross-industry innovation) and focus on the inside-out process can improve their revenue significantly (Gassmann & Enkel, 2004). A different approach to the outside-in process can be summarized as follows: enhancing a firm's knowledge by opening the firm's barrier and achieving favorable position by letting ideas flow to the outside. The inside-out process is an important process in an open innovation strategy and develops substantial benefit for a firm that meets certain criteria. To facilitate the transfer process of knowledge and technology from inside the firm to outside, a firm should be able to spread the two important factors and multiply it. These competence is also known as multiplicative capacity.

c. The Coupled Process

A firm that uses the coupled process as their open innovation strategy means that firm is gaining knowledge from the external parties (outside-in) and bringing their ideas to the market at the same time (inside-out). In order to do both strategies, this firm should collaborate with other firms in a crucial network, such as consortia of competitors, supplier (Dyer & Singh, 1998), customer, universities, and research institute (Chesbrough & Bogers, 2014; Gassman & Enkel, 2004). In this archetype, the term co-operation is common, which is defined as joint development of knowledge with specific partners, such as suppliers, customers, joint ventures and alliances, and so forth (Gassmann & Enkel, 2004). This interaction frequently results in an intensive exchange of knowledge

and process of mutual learning (Lane & Lubatkin, 1998). Firms that are working on crucial alliances or joint ventures should understand that the key to success for collaboration is the right balance of give and take. To perform equal give and take, firms should be able to integrate external knowledge with their own knowledge and to externalize their knowledge in order to enable partners to learn. This capability to build and manage relationship with partners to facilitate joint advancement in an important alliance also known as relational capacity (Dyer & Singh, 1998). A firm can be distinguished from other firms by the networks to which it relates to the alliances and joint ventures. Therefore, the affiliation with other companies, complementary companies, and competitors could be a firm's important assets and precondition for the related processes within an open innovation strategy (Gassmann & Enkel, 2004)

2.3 Citizen Sourcing: Applying The Concept of Open Innovation in Public Sector

In their study on open innovation, Hilgers and Ihl (2010) explored whether the basic principles of open innovation can be adapted for revitalizing of public sector institutions. Their study presents an overview of how external collaboration and innovation between citizens and public institutions can provide new alternatives of citizens integration and participations. The participation of citizens can promote public value creation and even the process of political decision-making.

Hilgers and Ihl (2010) use the concept of "citizen sourcing" which often times linked with the concept of "crowd sourcing" by Howe (Howe, 2008). The principles of these two concept is to minimize the "local search bias" and to maximize new knowledge sources from external parties in research and development setting. Local search bias here is defined as the tendency of the institutions or individuals not to exploit the new external sources of information when they are solving obstacles; and to only use available internal knowledge and methods (Luhtje, Herstatt, & Hippel, 2005). The constraint to exploit external resources attributed to the geographical proximity or an established technological or disciplinary sources (Hilgers & Ihl, 2010). In order to explain the concept of citizen sourcing and open innovation, Hilgers & Ihl (2010) use the following framework:

1. *Citizen ideation and innovation*: this first step targets the general capability of knowledge and creativity within the citizens to boost the quality of the common goods by implementing open innovation program, for instance in innovation contests. It is noticeable that in this process organization is also implement the outside-in process, where organization generates idea from outside and in this case is from the citizens.
2. *Collaborative administration*: the second step of this frameworks directly addresses the integration of citizens for improving current public administrative processes. Knowledge and experiences from firms' user-innovation demonstrate new functions and procedures for public organizations. In this process organization is on their way to implement the inside-out process. Organization opens their administrative process and allow the citizens to participate to solve the internal problem.
3. *Collaborative democracy*: this last step compiles a new model of collaboration to enhance public participation within policy making, including the elaboration of public values into decisions, enhancing the quality of decisions, strengthening trust in institutions, and educating the public. At this point, organization is practicing the coupled process, where they gained new knowledge or ideas from public participation and at the same time also try to apply the result to the society.

2.4 Open Innovation Maturity Framework

Open innovation could offer a new approach to organize the innovation process within firms, but these new methods and processes naturally need some time to mature and work effectively (Enkel, Bell, & Hogenkamp, 2011). An effective innovation system is necessary because it does not only determine a firm's competitive benefit, but often times it is about the survival of that firm too (Soderquist & Godener, 2004). Measuring innovation management can help to observe and improve innovation processes, but the result may not be particularly clear and the success of innovation projects may be influenced by factors that cannot be controlled (Enkel, Bell, & Hogenkamp, 2011). However, measurement is important to align, prioritize, evaluate, and encourage learning and improvement of a firm. Measurement to evaluate the innovation process of a firm under the new concept of open innovation have yet to be developed.

The Open Innovation Maturity Framework that has been developed by Enkel, Bell, and Hogenkamp is based on the assumption that maturity is a measure of the effectiveness of innovation processes. This framework is an improvement on the Innovation Capability Maturity Model (ICMM) (Essmann & Preez, 2009). ICMM consists of three-dimensional framework concerning the innovation capability construct, organizational construct, and capability maturity (Enkel, Bell, & Hogenkamp, 2011). At the innovation capability construct tier, (Essmann & Preez, 2009) define three areas: *the innovation process*, which relates to the practices, procedures and activities throughout all innovation stages; *knowledge and competency*, which relate to management and requirements and technology that are needed; and *organizational support*, which relate to resources, structures, strategy, and leadership. The second dimension ensures that the model addresses all basic aspects of an institution. And by combining two dimensions, the maturity of innovation capability of a firm can be addressed. The ICMM describes five level of maturity (Essmann & Preez, 2009):

1. Level 1: Individual creativity declines. Firm focuses on common operations. Innovation output is inconsistent and unpredictable.
2. Level 2: Firm can identify the need to innovate and has basic awareness of the influential factors. However, the output is still inconsistent but attributable.
3. Level 3: The suitable practices, procedures, and tools are in place. Employees are encouraged to innovate. Outputs are consistent and assure market share and positioning.
4. Level 4: Practices, procedures, and tools are used for integrating innovation activities. The firm is fully aware of innovation and starts to build a model of internal innovation and relates it to the business requirements. Outputs are consistent and diverse.
5. Level 5: Practices, procedures, and tools are institutionalized. Individuals are encouraged to innovate. There is a synergy between business strategy and the synchronization of innovation activities. Outputs provide sustained competitive advantage and creates a new market.

The ICMM is focused on internal research and development. Therefore, this framework is not completely suited to measure open innovation in a firm. However, this framework can be functionalized as a reference point to develop open innovation maturity framework. Enkel, Bell, and Hogenkamp (2011) combined the five levels of maturity concept on ICMM with three proposed theories:

1. Proposition 1: The presence of partnership capacity correlates positively with the effectiveness of an organization's open innovation activities.
2. Proposition 2: The creation of a climate for innovation is positively related to an organization's open innovation effectiveness.
3. Proposition 3: Having the right systems and tools in place correlates positively to the effectiveness of open innovation.

By combining these two models, Enkel, Bell, and Hogenkamp (2011) research found three different level of open innovation maturity of a firm: immature, semi-mature, and mature. However, a firm does not necessarily need or want to reach the highest level of maturity in every category. In addition, the interpretation of the maturity level will be different for each firm according to the current status of open innovation, known open innovation activities as well as the progress attained in recent years.

The open innovation maturity framework which is adopted in this research to measure the adaptation process of open innovation in R&D Agency. The indicators that have been used on open innovation maturity framework are modified to adjust with R&D Agency's innovation nature which are focused on catering public needs. The indicators are employed to measure the open innovation maturity level on R&D Agency namely leadership, incentives, mindset, central coordination, resources, knowledge management process, legal and IP system, reputation, partner selection, and training and education. The results of maturity level assessment from each research center are presented in radar chart on the following section.

3. RESEARCH METHOD

This study is a qualitative research employed explanatory case-study approach. In describing what case study is, Anderson suggests that the term refers to holistic research method that employs several sources of evidence to analyze or evaluate a specific phenomenon or occurrence (Anderson & Arsenault, 2005). Yin (1994) presents at least four different kinds of situation that allow researchers to use a case-study: to explain complex causal link in real-life interventions, to describe the occurrence of the intervention in real-life context, to describe the intervention itself, and to explore the situation in which the intervention being evaluated has no clear set of outcomes. He adds that if a researcher wants to address *how* and *why* events might have happened as they did—including another possibility of “hows” and “whys” or *rival explanation*—the suitable type is likely to be an explanatory case study (Yin, *Applications of Case Study Research* (3rd edition ed.), 2012). Tellis (1997) adds that explanation-building is observed as a form of pattern-matching, in which the analysis of the case study is completed by building an explanation of the case. As each of the institution that explored in this study are having different characteristic, therefore case study are needed.

The data for this research were gathered from semi-structured interviews through phone calls, messenger application, email, and online interface calls with officials and researchers from each research center. Data triangulation was provided to improve data reliability for this research. Interviews with officials and researcher are necessary to confirm data from both sides. The informants interviewed in this study are participated in the research project mentioned above. As an essential step, this study consisted of a pilot study to test the methods and framework that employed in the expanded research project. During the pilot study, the researcher pretest the interview guideline to match it with the purpose of the study (Berg, 2001) once its settled.

This research is an explanatory case-study took place from November 2019 to January 2020 involved R&D Agency of Ministry of Public Works and Housing of Republic Indonesia. Shortly after this research finished, there was a significant change in the Ministry of Public Works and Housing where R&D agency officially disband in May 2020 due to the major change in national innovation system. When R&D Agency is still existed, this organization duties are to support the ministry by providing technical and knowledge support through the R&D activities in public works fields, policy studies, and infrastructure strategy development. More precisely, R&D Agency does not conduct infrastructure construction for communities because it is part of directorate general duty, however R&D Agency has authority to build

infrastructure only for technology prototyping purposes. In order to optimize the support to the ministry, R&D Agency conducts the activities in a different kind of strategy, both employs closed and open innovation. By doing closed innovation, R&D Agency found difficulties to diffuse the product to the potential users. Therefore, R&D Agency was trying to practice open innovation strategy, although it was still limited to some research projects.

R&D Agency MOPWH consists of four research centers and one secretariat as follows: (1) Secretariat for administrative purpose, (2) Research Center for Water Resources (RCWR), (3) Institute of Road Engineering (IRE), (4) Research Center for Human Settlement and Housing (RCHS), and (5) Research Center for Policy and Technology Implementation (RCPTI). RCPTI owns special unique tasks as a intermediaries for all research center. RCPTI plays important role as a pioneer team before research center conduct research in certain area by doing technology mapping. And after the other research center finished with their R&D phase, RCPTI starts preparing the technology replication and business forum as well to continue the technology dissemination.

This study also provides best practice of research project that employed open innovation approach on their activities. The criteria that applied in this best practice are modified from Chesbrough (2006) characteristic of open innovation. The criteria need to be modified to adapt with government institution business model. Aside from that, to select the best practice this study also employs criteria from Citizen sourcing concept and combines it with the knowledge mechanism in open innovation activities.

Three propositions from Enkel, Bell, and Hogenkamp (2011) study, namely: partnership capacity, the climate of innovation, and the correct system and tools were employed to explore open innovation in R&D Agency MOPWH. However, three propositions were modified to match with the government R&D setting, for example the availability of resources term had been introduced to supplement the climate of innovation. In addition, the knowledge mechanism had been addressed as the third proposition to be more specific than system and tools. All those modified propositions were used to observe the adaptation of R&D Agency to open innovation strategy with simple scoring system through questions. The question series consist of multiple choices and open questions. The answers from multiple choice questions were used for the scoring system.

The answers in multiple choice were put in order from low to high degree, specifically are A is for 1, B is for 2, C is for 3, D is for 4, and E is for 5. This scoring system implies that the higher the score the better the adaptation process. This scoring system is adapted from Enkel, Bell, and Hogenkamp's study (2011) that they scored the maturity level of open innovation implementation in different multi-national companies. The maturity level is divided into three: Immature, semi-mature, and mature. To ease the comparison of score on each aspect, the results were presented in radar chart.

4. RESULT AND DISCUSSION

The following part shows the findings from the interview conducted with informants. How the research projects that employed open innovation strategy performed is first and followed by the availability of resources in R&D Agency of Ministry of Public Works and Housing (MOPWH). The third part is the findings related to knowledge in-flow and out-flows and followed by how the partnership capability influenced the implementation of open innovation strategy. Eventually, a short discussion related to the overall implementation of open innovation in R&D Agency of MOPWH to close this section.

4.1 The Implementation of Open Innovation

Open innovation was not officially adopted as an innovation strategy in R&D Agency MOPWH, however three research centers were already practiced doing it in several different project. This situation was what distinguished R&D Agency MOPWH with firms that evaluated on Open Innovation Maturity Framework where they officially adopted open innovation as their strategies. This phenomenon was interesting to explore with further question, how these three research centers adapted to open innovation. The operationalization of open innovation maturity framework is presented on figure 2.

A		B	C	D		E	F
1	Indicators	Score		Indicators	Score		
2	1. Availability of capability			Clear strategy	2		
3			Score is 1-5	Communication of success stories	3		
4	1.1. Leadership			Clear targets	1		
5	Clear strategy			Assessment	1		
6				Initiative taking	2		
7	Is open innovation incorporated into a communicated strategy?		Indicate your maturity level in the line with "X" and leave other empty	Screening	2		
8				Information gathering	5		
9	a. OI is not mentioned in strategy			Communication	4		
10	b. OI is verbally supported by management	x		Innovation facilities	4		
11	c. OI is incorporated into the organization's strategy			Transaction currency	1		
12	d. OI strategy is explained and stimulated by management			Knowledge sharing	5		
13	e. OI strategy is demonstrated by management who "walk the walk"			Knowledge absorption	4		
14				Monitoring results	3		
15	Communication of success stories			Attitude	1		
16				Intensity of collaboration	4		
17	Are examples of how to do open innovation communicated throughout the organization?			Standardization	3		
18				Partner satisfaction	4		
19	a. There are no success stories at present			Diversity of collaboration	5		
20	b. Successes are shared informally, by word of mouth			Network building	5		
21	c. Some success stories are shared by management	x		Selection process	4		
22	d. Success stories are shared in a regulated way						

Figure 2. The Operationalization of Open Innovation Maturity Framework.

Source: research findings, 2022

Research Center for Policy and Technology Implementation (RCPTI)

This research center is playing role as intermediary in R&D Agency MOPWH. RCPTI conducted technology mapping need research as an effort to capture the real need of society. From this map, the other research center could continue the research until prototyping phase. If the prototype passed the technology readiness level control, RCPTI conducted business forum to connect the product of the other research centers to potential users. Seen their role as intermediary, RCPTI needed to build important and strategic networks with partners from external. And this is the reason why this research center had better understanding as well as effort to improve their partnership capacity.

This research center score is 62 (see figure 2); the highest among three research center. Several prominent factors that contributes to this score are partnership capacity, especially the network building, the diversity of collaboration, and gathering information. Many studies confirming how partnership capacity is significantly affected the effectiveness of open innovation implementation (Edler & Yeow, 2015; Vanhaverbeke & Cloudt, 2006). Aside from that, the quality of leader also influenced the process. Informant interviewed from this research center was a junior manager, who graduated from a university in Netherland. Informant had better insight and knowledge about open innovation, also eager to learn new things. "Because we do not conduct basic research, most of researcher in this research center aware of the importance of partnership with external parties," said AK, junior manager in RCPTI through online interview.

As previously explained that the focus of innovation in this research center is to expand the range of the R&D Agency products to potential users along the entire value chain, such as universities as technology developer or private sectors and state owned enterprise as the replicator of technology. In analyzing the radar chart, it is obvious that the availability of

the resources in this research center is still need more improvement. However, this condition can be understood because open innovation activities have only recently been introduced into the organization and, therefore, this research center consider itself as immature in open innovation. In addition, open innovation is not officially mentioned as the innovation strategy, hence the implementation is still need more improvement.

From the radar chart, it can be known that RCPTI expanding knowledge gathering through different channel, both informal and formal. RCPTI also takes into account of communication process by expanding knowledge sharing, however employee does not have flexibility to enter into the agreement. Additionally, results from collaboration efforts are monitored so they can develop further.

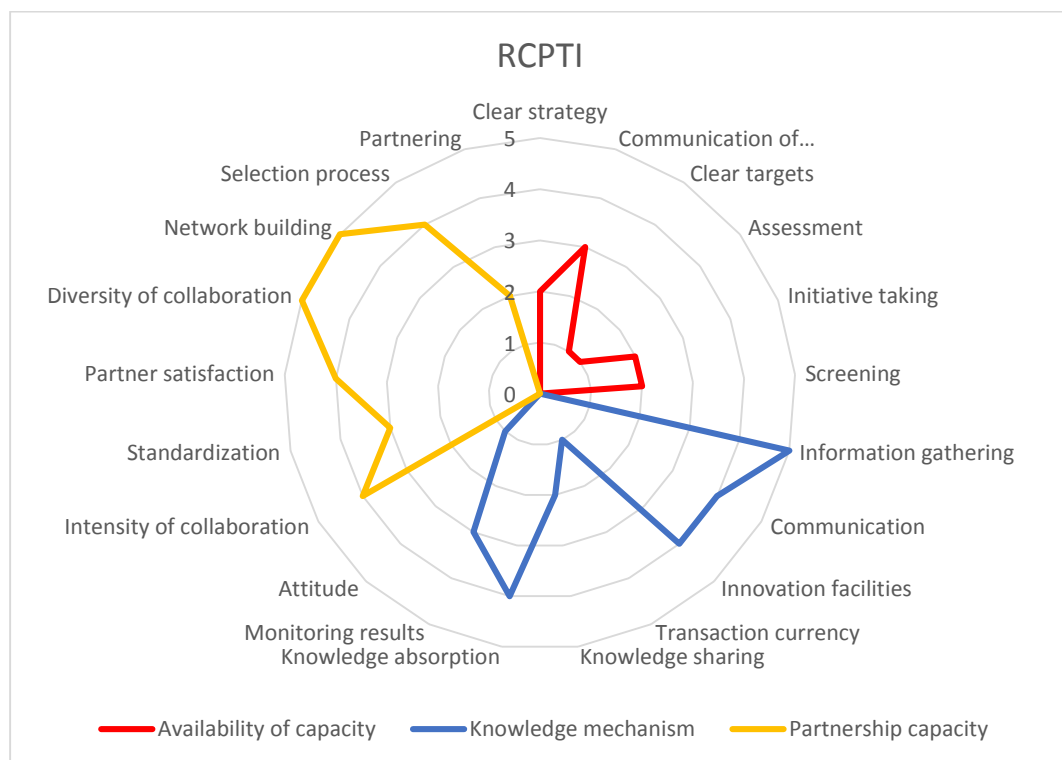


Figure 3. The Scoring Result for RCPTI
Source: Author

Research Center for Water Resources (RCWR)

This research center was a prominent research center on water resources in Indonesia with laboratory facilities on each field, such as hydraulic, water resources geotechnical, coastal, river, sabo, and swamp and peat. Due to its various research fields, the experimental stations are scattered in many cities across Indonesia, for instance experimental station for sabo is located in Yogyakarta, experimental station for river is located in Solo, experimental station for swamp and peat is located in Banjarmasin, meanwhile the headquarter is located in the heart of Bandung.

From the scoring process, Research Center for Water Resources is scored 51 (see figure 3). Almost similar with RCPTI, the highest scores are from selection process of partner and network building. One of the prominent examples from this research center was Integrated Water Resources Management (IWRM) project. IWRM was a multi-years project carried out by RCWR, which involved various partners, such as Deltares, MCGA (Meteorological, Climatology, and Geophysical Agency), and Royal Netherlands Meteorological Institute (KNMI). In 2019, this join-cooperation renewed the Memorandum of Understanding (MoU),

which took place in MOPWH headquarter in Jakarta. This research center was aware of how to choose partner is necessary to build a favourable networks to improve their innovation activities.

As depicted in the radar chart, the availability of the resources such as setting the clear targets, initiative, the assessment process are still underdeveloped. Similar with RCPTI, open innovation concept has only recently been introduced in this institution. RCWR is also identified itself as immature in the implementation of the open innovation activities. It is understood that RCWR still needs more improvement in building their own internal resources as well as strengthen the knowledge mechanism if it wants to implement open innovation further.

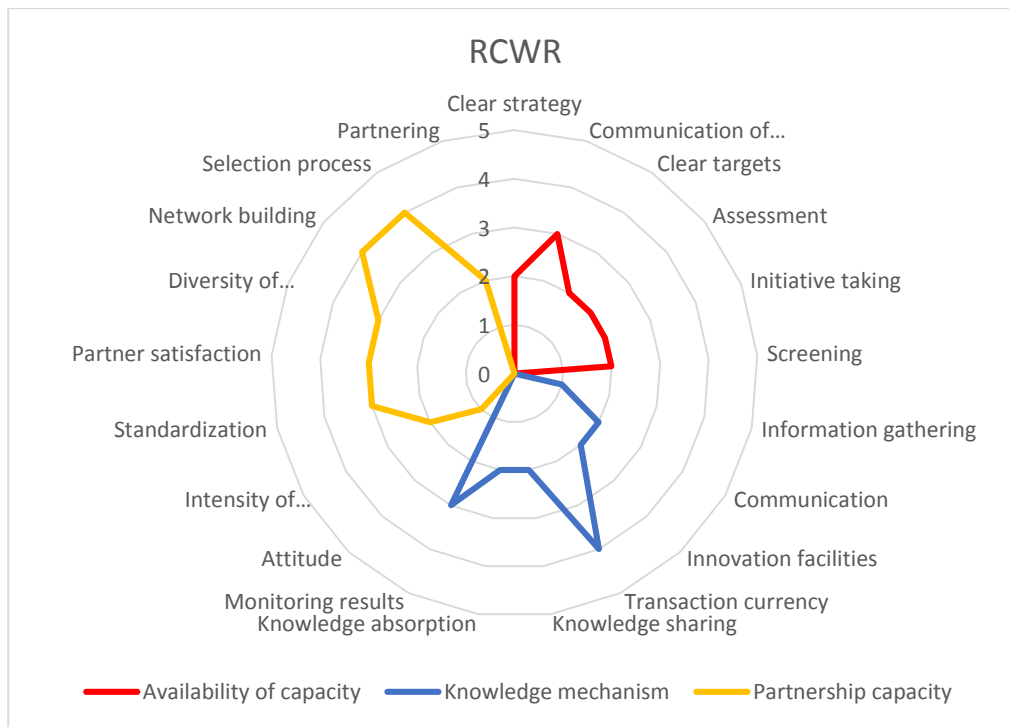


Figure 4. The Scoring Result for RCWR
Source: Author

Institute of Road Engineering (IRE)

IRE was recognized among other research centers for its involvement in collaborative research with prominent partners, for instance was with Evonik Industries, a leading chemical company from Germany. With Evonik, IRE collaborated to develop a road noise barrier in IRE headquarter in Bandung. The other example was collaboration research with Massachusetts Institute of Technology (MIT), National Institute for Land and Infrastructure Management (NILIM), Public Works Research Institute (PWRI), Korean Institute of Construction Technology (KICT), and many other institutions. However, all of these collaborative researches had a shortcomings, the results were end up without further follow up to the next value chain. In a nutshell, the results from these collaborative researches did not end up to potential users.

This research center is scored 52 (see figure 4); slightly different from RCWR. The highest score from this research center is originated from the intensity of collaboration. IRE has many collaboration research schemes, that focused on tackling the challenge development of road and bridges infrastructure in Indonesia.

As depicted in the radar chart, IRE has underdeveloped areas that still need more improvement, namely communication of the strategy, setting the clear target, assessment

process, and initiative taking. All those areas are included as the availability of resources that important as the base of the innovation process. Similar with the other research center, open innovation is still new concept to IRE, hence, IRE is identified itself as immature in the implementation to open innovation.

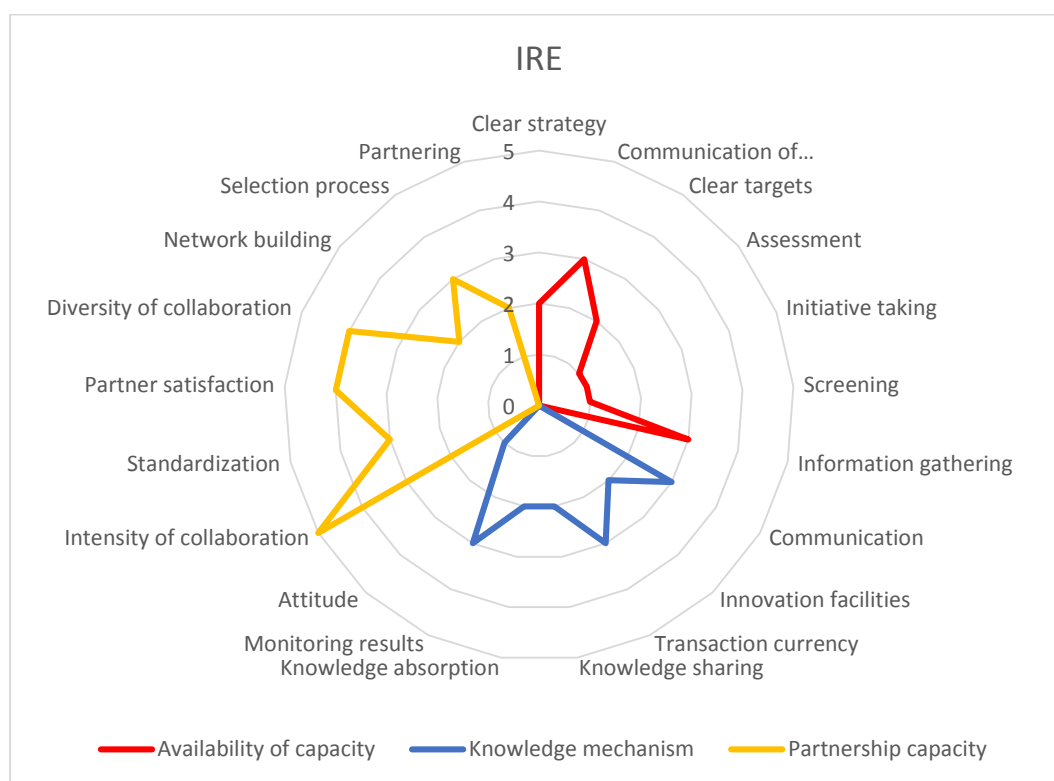


Figure 5. The Scoring Result for IRE
Source: Author

4.2 Best Practice of Open Innovation Strategy

Although open innovation was not officially adopted as the innovation strategy of R&D Agency MOPWH, three research centers were already implemented the basic characteristic of open innovation into their projects. Chesbrough (2006) in his research provides the characteristic of open innovation as follows high mobilization of employee, external R&D creates significant value, internal R&D is needed to claim some portion of that value, firm does not need to originate the basic research, building business model is more important, and exploit both internal and external idea.

These characteristics are used to observe high-tech firms in private sector. However, these characteristics may not suitable to be used in government R&D institution, because government R&D institution's business model are not focus on selling products and profit-making. Therefore, these characteristics were modified to match with government R&D setting. Indicators that were employed to explore the research projects also taking into account the open innovation archetype that described earlier in literature review. Indicator accessible for public and user oriented indicated the outside-in archetype that also linked to the Citizen sourcing concept, more precisely was the citizen ideation. Indicator of strategic partner and strategic issue more or less contained the inside-out archetype. Choosing appropriate partner was a basic competence that a firm or project manager should owned to transfer knowledge to the external parties. And this was also applied to the strategic issue indicator because a project manager should be able to choose which issue or area that they wanted to expose to

outside organization. As for the indicator of legal aspect and officially promoted by the ministry contained the coupling archetype because it meant that the ministry preparing the projects to be promoted to the strategic alliance, such as private sector, state owned enterprise, or local authorities. And in the case of RCPTI, the partner on the strategic alliance also included business start up. RCPTI indeed had different innovation nature with the other research center due to its function as intermediary. The following information in table 2 are nine best practice of open innovation strategy in R&D Agency MOPWH.

Table 2. Comparison of Nine Best Practice of Research Project that Implement Open Innovation

Indicators	RCPTI			RCWR			IRE		
	BIM	CHT	Technical advice	Irrigation Journal	IWRM	Tech4Water	JAKI	InviJ	e-product
Accessible for public	v	x	v	v	x	v	v	v	v
Strategic partner	v	v	v	v	v	v	v	v	v
Strategic issue	v	v	v	v	v	v	v	v	v
User-oriented	v	v	v	v	v	v	v	v	v
Legal aspect	v	v	x	x	v	x	v	v	v
Officially promoted by the ministry	v	v	x	v	v	v	v	v	v
Mobilization of employee	v	v	v	x	v	x	v	x	x
Start from basic research	x	x	x	x	v	v	v	v	v

Source: research findings, 2022

Some of the projects are designed for public and the rest are not, for example is IWRM. These multi-stakeholders research project is focus on providing data related to water resources management. The result for this research project is addressed for stakeholders or authorities related to water management resources in Indonesia, therefore, the data are not easily access for public. However, the data are partially open for public in website. On the other hand, BIM, JAKI, InviJ, Irrigation Journal, and e-product are the example of research project that accessible for public, specifically is for user. In fact, JAKI is a product that designed to enable interaction from citizen to IRE and local authorities. Citizens can report defect in road service and IRE will pass the data to the local authorities. JAKI is an example of how official data provided online can foster interaction and dialog between the government and its citizens. CHT or Clearing House Technology is a filtering process of knowledge or technology from outside with the goal is to test the quality and find the possibility to be adopted in ministry's infrastructure projects. CHT employs outside-in knowledge mechanism, similar with JAKI, irrigation journal, and InviJ. Technical advice is a routine task of R&D Agency MOPWH to assist the local authorities on tackling technical problem related to infrastructure. Local authorities can contacting R&D Agency MOPWH through many different channels, such as website, phone, or letter and to deliver their issues related to infrastructure. R&D Agency will arrange its experts to observe the issues and provides

technology recommendation to address the issue. Technical advice employs inside-out knowledge mechanism that also similar with IWRM, Tech4water, and e-product.

Tech4water was a real time database of telemetrical hydrology which can access freely from the website www.tech4water.com. This website contained important information related to hydrology from many hydrology station in Indonesia. The information provided in this website were crucial for stakeholders to predict the flood and prepare the mitigation. Meanwhile, e-product was an online catalogue of technology and knowledge from IRE. This catalogue could be accessed through www.pusjatan.pu.go.id. E-catalogue was one of IRE's way to diffuse their innovation product which mainly targetted to local authorities and private sectors.

4.3 The availability of the resources

Leadership

The implementations of open innovation in R&D Agency of MOPWH were varying in every research center. The variations of implementation depended on the availability of the resources, such as leadership, incentives system, and mindset of the employees. The first findings related to leadership were similar for all three research centers. Each management from every research center showed supports regarding the implementation of open innovation. The management from each research center showed verbal support for the research project that employed open innovation strategy. Moreover, the management also shared the success stories related to the implementation of open innovation, for example was Building Information Modelling (BIM) project. Similar type of support also was shown in other research center.

Incentive System

Related to the incentive system, in RCPTI, there were no targets that set which in line with the implementation of open innovation strategy of the organization. And, there were no assessment and reward provided based on open innovation activities in the organization. The reason behind these occurrences was because there was no clear offer from the top managers to develop open innovation strategy, both verbally and written. Some employees were practicing open innovation strategy at their own initiatives and often by direction from the superiors who had more open-minded perspectives. In this case, enjoying the process of making open innovation strategy to happen itself was an incentive for the employees or team. "Incentives does not always mean money, but also a pleasure knowing the effort to do the open innovation strategy is going as planned", said the informant through the phone call interview.

As for RCWR, the findings were slightly different with RCPTI. In this research center, open innovation strategy was manifested in the journal publication. This journal adopted Open Journal Systems 2.4.8.0., an open source software to manage journal and publication which developed, supported, and distributed by Public Knowledge Project under the management GNU General Public License. Although this may looked like standard journal reviewing, the process of involving external reviewer was similar with the concept of collaborative administration on Citizen sourcing concept. Given example on collaborative administration was patent reviewing in USPTO, where external patent reviewer was involved to accelerate the reviewing process. In the case of Jurnal Irigasi, external reviewer was necessary to maintain the quality and transparency of the journal. External reviewer was also important to manage the accreditation process.

Mindset

The third level of maturity was characterized by the growing level of initiative from employees. Organizations encourage the employees to take initiative and be creative. And this part was dedicated to explore how employee's mindset in three research centers. RCPTI was the first research center that had been explored. The first finding from this research center was that individuals at the lower level of organizations were actively take initiative when execute a task from supervisor. For example was in the implementation of BIM, team member were encouraged to be creative and innovative. Meanwhile, RCWR and IRE were showing the same findings related to the initiatives of the employees. However, the implementation of the findings were slightly different with RCPTI. Employees in both research centers were eager to take initiatives whenever assigned with tasks. In RCWR, for example, some employees were working harder to modify an in-house technology to match it with the characteristic of the location. And as the follow up, they had designed a research proposal for the following year. Some employees were also screening for the external environment, although at this process was still an arbitrary screening focused on own advantage. For example was the multi-years joint cooperation program between RCWR, MCGA (Meteorological, Climatology, and Geophysical Agency), Royal Netherlands Meteorological Institute (KNMI), and Deltares. This extensive joint cooperation has started in 2009 and currently on the third phase project; focused on providing crowd source data for Integrated Water Resources Management (IWRM).

4.4 Knowledge in-flows and out-flows

Research findings in this section were used to explore how the mechanism of knowledge in-flow and out-flow on each research center. To explore knowledge mechanism inside the organization, this study employed four indicators: central coordination, resources, knowledge management process, and legal and IP system.

Central Coordination

Regarding the central coordination, three research centers were showing various responses. IRE for instance, in this research center every update related to open innovation activities were reported to central position. Information were gathered in a more traditional way, such as face to face meeting, email, and internal messenger application. Communication system in this research center was related to open innovation activities usually initiated in a small team or group. However, in a particular case, such as the launching of JAKI application, communication was carried out among management via regular meetings.

Different results were shown by RCWR; in this research center, employees were not required to report updates related to the open innovation activities to the central management. This may seem an odd finding, however employee was still doing an intensive communication in a small team or groups. This type of communication could be understood since open innovation were not officially adopted to be organization's strategy, therefore, the coordination system was still informal.

Surprising findings were resulted by RCPTI, this research center were more integrated in terms of information gathering. Every open innovation activities were reported to the central management and information gathered and linked for both internal and external activities. Furthermore, open innovation activities were communicated throughout the organization via accessible intranet, although currently there was no specific coordination forum to discuss about open innovation initiatives.

Resources

At this part the findings were vary for each research center. Informant from RCPTI mentioned that there was a sharing facilities with intense partnership, for example was BIM project. RCPTI's partner for this project were IBIMI and PT. Pembangunan Perumahan. PT. Pembangunan Perumahan has currently invested on 3D printing technology from Russia with special purpose to develop BIM technology. BIM team from RCPTI had a chance to learn about this technology in PT. Pembangunan Perumahan research facility. Sharing facilities like this were based on organization's agreement and often time legalized in a Memorandum of Understanding (MoU) document; in this case was among RCPTI, IBIMI, and PT. Pembangunan Perumahan. The MoU most of the times were organizational; it meant that there was not anyone who had exclusive resource and authority to make an agreement in organizational setting.

As for RCWR, the open innovation activities enabled organization to get access to partner's research facilities based on agreement. And similar with RCPTI, there was not anyone who had authority and capability to enter agreement. However, individual who was encouraged to innitiate agreement in the name of organization and management will be provided by structural budget for this activity. In terms of sharing access to partner's facility, IRE showed similar result with RCWR. However, regarding the agreement, management in this research center will be provided budget only based on demand.

Knowledge Management Process

In term of knowledge sharing in open innovation activities, three research centers showed same result that knowledge was shared in team. In this case, knowledge sharing was done in informal and formal way. One of the common way to share knowledge between team member were from messenger application. However, there was also formal way to share knowledge via website, which was more accessible not only for the team member, but also for partner and public. As for knowledge absorption, results were vary from three research center. In RCPTI, employees were able to exploit the knowledge from intra-organizational relationship. This research center were providing basic studies related to all issues in the ministry, therefore, it was common for RCPTI to share and gained knowledge from other department in the ministry. As for IRE and RCWR, the knowledge absorption were still in informal setting.

Legal and IP System

Legal factor and Intellectual Property (IP) system were remain problematic in three research centers. Intellectual Property was still consider as protection, meanwhile, in an advance open innovation firm, IP is consider as tradable goods (Gassman, Enkel, & Chesbrough, 2010). The IP department was still lacking knowledge about IP as a tradable goods, therefore, this department demonstrate a protective attitude towards IP issue.

4.5 Partnership Capacity

Many studies about open innovation mentioned that partnership capacity is an important factor for organization that implemented open innovation. The relationships with other companies can be an organization's important assets and a significant precondition (Gassman & Enkel, 2004) to link the processes within open innovation strategy. To explore about three research center partnership capability, Enkel, Bell, and Hogenkamp (2011) on their study suggests to use these three aspects, namely reputation, partner selection, and training and education.

Reputation

The first findings that will be discuss in this section was the intensity of collaboration. Informant from RCPTI was mentioned that knowledge exchange with partner is become more intense, enduring, and focused; not only for BIM project, but also for Clearing House Technology (CHT) project. CHT was a new scheme in R&D Agency of MOPWH to guarantee that new innovation, which produced by external parties, were qualified to be implemented in ministry's infrastructure projects. CHT was fully supported by the top manager and the regulated business process was still underway. This project by far could be included as outside-in archetype according to Gassman and Enkel's study (2004). MOPWH consider CHT was an ideal scheme to foster innovation in R&D Agency MOPWH by using less resources, such as state budget and number of researchers involved, and so forth. This scheme required well absorptive capacity from RCPTI, therefore, employees were encouraged to actively learn from partner.

Different from RCPTI, RCWR were showing that partnership usually started by several informal partnerships between individual. And regarding the standardization, there are similar procedure for three research centers because it was officially regulated from the ministry and stated about clear ownership of project. However, for each partnership should benefited each parties and partner satisfaction was consider as important factor because it was strongly related to organization's reputation.

Partner Selection

Partnership capacity was an important aspect to support the implementation of open innovation strategy (Cohen & Levinthal, 1990; Enkel, Bell, & Hogenkamp, 2011; Gassman & Enkel, 2004). It was important for organization to put themselves in a strategic alliance, therefore, organization needed to be more careful in term of partner selection. RCPTI were trying to put themselves in more diverse partnership circumstances. This research center were eager to iniate partnership in all parts of the value chain and strategically expand the network.

RCPTI selected their partner based on vision and strategy that met organization's demand. On the other hand, IRE were more reserved in term of partner selection. RCWR tended to work with partner in specific form, this was related to their core business that only focus on road and bridges issue, similar with RCWR that also focused on water resources issue. However, both IRE and RCWR were also eager to expand the network with more diverse partner. Three research centers were usually building network with reputable universities, associations, and experts.

Training and Education

Three research centers were showing same result in term of training and education for employees. As for now, there was no specific training provided for open innovation strategy, particularly about partnership. Employees gained skills through experience on the job in interdisciplinary team. Employees were capable of engaging to current partners and probing new ones through intense communication, organizing joint workshop or seminar, and so forth.

5. CONCLUSION

The speed of adaptation process was influenced by several factors, namely the availability of resources, the knowledge mechanism, and the partnership capacity. The findings of this research related to those factors are different with the studies on open innovation maturity framework. However, the indicators that are used in open innovation maturity framework study can be applied to observe the implementation of open innovation

in government R&D institution. Based on the evidence from interview with informants, the availability of resources is a weak area, where all research center relatively scored low. The findings of the availability of resources are not positively related to the organization's open innovation effectiveness, which different from the second proposition on the open innovation maturity framework. In the open innovation maturity framework study, the availability of resources plays significant role in the effectiveness of open innovation implementation. There are several possibilities why the availability of resources are not play significant role in the implementation of open innovation in R&D Agency MOPWH, namely: 1) Open innovation are not officially designated as R&D Agency innovation strategy, and 2) The lack of awareness about open innovation strategy in top managerial level. These shortcomings in the availability of resources area may be the cause of why in the best practice of research projects that implemented open innovation strategy are not evenly prominent. Each research center only has one best practice that stand out among the other, for instance in RCPTI with BIM, RCWR with IWRM, and IRE with JAKI.

At the moment, three research centers were implementing different kind of knowledge mechanism. Referring to Gassman and Enkel study, RCPTI's knowledge mechanism is coupled process type. This research center is not only gain knowledge from external parties, but also transferring internal knowledge to the external. Therefore, this research center should be able to put themselves in a strategic alliance and building network with strategic partners and owned the relational capacity. Meanwhile, IRE and RCWR are implementing the inside-out knowledge mechanism. The exploitation of knowledge outside the organization is strongly related to the organization's capability to multiply and transfer some of the knowledge to appropriate partners. These two research centers have the same nature as a research center that conduct research as business as usual.

The findings of the three research center suggested that the capability to choose appropriate partner played significant role in the implementation of open innovation strategy. The selection partner process, network building, and diversity of collaboration are some features that correlates with the effectiveness of R&D Agency MOPWH's open innovation activities. This is also in line with the first proposition in open innovation maturity framework, which demonstrates the positive relation between partnership capacity with the effectiveness of organization's open innovation activities. However, based on the findings, RCPTI's excellent result on partnership capacity may correlated with its organizational nature as intermediary for the other research centers.

Based on all the evidences from interviews and best practices, it was concluded that the adaptation process of open innovation strategy in R&D Agency MOPWH weighted by the partnership capacity and knowledge mechanism from inside to outside or vice versa. These two factors are complemented the lack of availability of resources, namely leadership, incentives, and mindset of employee. The speed of adaptation from R&D Agency MOPWH is also influenced by the unconsciousness of the managers towards open innovation strategy.

Research project that did not required basic research and partnered up in a strategic alliance, for example with researcher from universities, practitioner, state owned company, or private sector was more efficient. In the future, project scheme that has the same characteristic with BIM is possible to replicate in R&D Agency MOPWH. There are some reasons why project scheme like this is better compare to the other: cost effective since this project did not start from basic research, target and output from this project is clear, the network between innovation actors is work effectively, and the innovation has better chance to sustain. Therefore, the first recommendation is project scheme like BIM should be encourage in R&D Agency MOPWH.

The following future research opportunities have been identified from the research described in this paper. Open innovation is rather new research field, especially in the case of

government organization. The early stage of assessment of open innovation implementation as described in this paper is sufficient to provide room for improvement for organization. Therefore, this provides new opportunity for further study whether open innovation is suitable to be adopted as innovation strategy for government organization in catering public service. Furthermore, it is necessary to observe open innovation strategy in much bigger innovation chain, for instance innovation ecosystem that involved government, university, and industry altogether.

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