A PRELIMINARY STUDY ON THE TYPES OF BARRIERS IN UNIVERSITY-INDUSTRY R&D COLLABORATION PARTICULARLY DURING DEVELOPMENT RESEARCH STAGES

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ABSTRACT

R&D is divided into three stages namely basic research, applied research, and development research. Nowadays, in order to enhance innovations, firms have established collaboration with external institutions such as university. Collaboration in R&D with university researchers provides a lot of benefits to both sides. For examples, industry can increase its product innovation, reduce operation cost, and it will become more competitive. On the other hand, university will gain benefits through enhancing its financial support for the research and gaining reputation through high-quality research findings. However, the differences between both sides lead to difficulties and barriers to establish effective collaboration. Besides, to determine a successful collaboration project is also quiet challenging and difficult. Thus, this study aims to identify the types of barriers in R&D collaboration between university and industry particularly during development research stages. The findings show that there are four types of barriers in university-industry R&D collaboration during development research stages, namely orientation-related barriers, transaction-related barriers, resource-related barriers, and operation-related barriers. The most highly important barrier is orientation-related barriers, while operation-related barriers are the least important barrier faced by the both university and industry researchers. Determining the types of barriers can increase the stakeholders’ understanding about the difficulties faced by their collaborating partners and allow them to determine the best-solutions to reduce the barriers in collaboration especially during development research stages. Thus, such an understanding can help increase the number of successful collaboration projects in the future.

Keywords: University-industry collaboration; Research and Development; Development research stages; Barriers

INTRODUCTION

Research and Development (R&D) is an innovation activity usually implemented in industries and universities (Karlsson and Andersson, 2005). R&D is based on the implementation of innovative work through established research activities that lead to improve the institutions’ stock of knowledge, which can be exploited to produce new applications (MASTIC, 2008; Fiaz et al. 2011). As stated by MASTIC (2008), R&D can be divided into three types namely basic research, applied research, and experimental research. Basic research is the research stage that produces or enhances the knowledge; applied research is the research stage that determines research discoveries that can be developed into products; and development research is the research stage at which the discoveries are developed into products. The term development research can also be used for experimental research (Shapiro, 2013; Trott, 2012).

Nowadays, in order to conduct R&D activities, the industry has established collaboration with external institution such as university. Collaboration with the university leads to several benefits such as encouraging innovation and competition (Audretsch et al. 2012; Hanel and St-Pierre, 2006; Okamuro, 2007), improving the process to develop products (Dooley and Kirk, 2007), and enhancing firm internal resources (Okamuro, 2007). However, to assess successful university-industry collaboration is difficult and challenging (Dunowski et al. 2010) due to several limitations or barriers faced by the both partners during the process of collaboration. A growing literature examines several types of barriers in establishing university-industry collaboration (Bruneel et al. 2010; Rohrbeck and Arnord, 2006; Lee et al. 2010; Hall et al. 2001; Abeda et al. 2011; Mora-Valentine and Ortiz-de-Urbana-Criono, 2009). However, most previous studies discuss the type of barriers in university-industry collaboration in general or R&D as an overall. It is still difficult to find a study specifically focuses on each R&D stage. Thus, the objective of this study is to identify the types of barriers faced by the collaboration partners during development research stages.

LITERATURE REVIEW

There are four types of barriers discussed in this study, namely orientation-related barriers (Tartari et al. 2012; Bruneel et al. 2010; Seppo and Roolait, 2012), transaction-related barriers (Seppo and Roolait, 2012; Tartari et
Orientation-related Barriers

According to Bruneel et al. (2010), orientation-related barriers are based on the different orientations of both collaborating partners. It can be in the ways how the partners implement their research activities. In this study, orientation is defined as research and organisation culture of both institutions that lead to difficulty in developing a successful R&D collaboration. A review by Seppo and Roolaat (2012) on collaboration barriers concludes that orientation-related barriers are important barriers that affect the both partners to establish effective collaboration. Besides, a study by Tartari et al. (2012) records similar results. According to them, the respondents state that they faced orientation-related barriers more than transaction-related barriers. The results also show that the most frequent barrier indicated by UK academics is industry-research development in short-term orientation.

It is difficult to establish effective university-industry R&D collaboration during development research stages due to the different orientation of research activities implemented by both collaborating partners. Studies by Banal-Estanol et al. (2011), Abeda et al. (2011), and Rohrbeck and Arnold (2006) mention that the research environment in university is more on basic research, whereas industry research focuses more on applied or product development (also see Abeda et al., 2011; Rohrbeck and Arnold, 2006). Basically, public sector focuses on implementing basic research to produce new knowledge that is essential to develop science and technology (MASTIC, 2008). On the other hand, for industry, research activities are important to improve their products and services in order to achieve competitive advantage and to generate profits. Thus, it is encouraged for the industry to focus more on applied research or product development. As supported by Seppo and Roolaat (2012), industry research is focused more on applied research because this type of research helps them solve their problems and produce new services, products, and processes. On the other hand, research activities in university are focused on creating new knowledge in terms of model, concepts, or empirical results. Moreover, research activities in university are more relaxed and intellectual compared to research activities in industry (Zaky and Faham, 2004). This is because research activities in industry are constrained with time, while research activities in university are usually implemented in long duration.

Besides, some studies have discussed the different goals between both partners, difference of which would lead to barriers in R&D collaboration. The main goal of university is knowledge (Patil, 2012), but it is different for the industry. Knowledge is useful for the industry if it can be transformed into a problem solution and can help develop competitive products to the market. It is because the main goal of industry to gain and increase the profits by commercialising the products and by gaining competitive advantage (Rohrbeck and Arnold, 2006; Cyert and Goodman, 1997). As also supported by Abeda et al. (2011), industry focuses on profit gaining, while university focuses on generating new ideas. Therefore, the different objectives between university and industry lead to barriers in collaboration. The main objectives of university are to provide education, to improve the confidence level among students, to develop students’ capabilities, and to generate students who have effective and creative thinking as required by the market (Zaky and Faham, 2004; Hamisah Tapsir et al., 2010). Lee et al. (2010) explain that academic researchers aim to achieve several objectives in implementing research activities, such as to publish the research findings successfully and to expand their research fields. On the other hand, the objective of industry sectors is mainly focused on producing competitive products (Zaky and Faham, 2004; Cyert and Goodman, 1997; Hamisah Tapsir et al., 2010).

Bruneel et al. (2010), Hamisah tapspir et al. (2011), Zaky and Faham (2004), Hazlina et al. (2011), Thune (2007), Bodas et al. (2008), Audretsch et al. (2012), and Hall et al. (2000) discuss time limitation issues in university-industry R&D collaboration. Usually, the time for academics is limited due to their responsibilities in teaching and students (Hamisah Tapsir et al. 2010). Business higher education forum (2001) states that academic staffs have limited time to get involved in collaboration projects because they have their full time duties for the university such as researching, teaching, and consultation with students. Besides, research activity in university is a part-time activity, unlike the industry that undertakes research as a full-time activity (Zaky and Faham, 2004). Some studies mention that long-term research activities implemented by university also lead to conflict in establishing collaboration due to low sense of urgency among university researchers compared to the industry researchers (Report of a workshop, Overcoming Barriers to Collaboration Research, 1999; Bruneel et al. 2010; Dunowski et al. 2010; Bodas et al. 2008).

Transaction-related Barriers

Bruneel et al. (2010) and Salter et al. (2009) define the transaction-related barriers based on conflict regarding intellectual property (IP) and university administrator. According to the studies, which are based on the difference between firm sizes in US on the barriers in collaboration, the result shows that both firm sizes (SMEs
and large firms) face transaction-related barriers more than orientation-related barriers. A study conducted in Japan on SMEs and large firms’ R&D collaboration environments also support this statement. It is because the results show that IP is one of the main barriers in establishing collaboration with university (Motohashi, 2008).

There are several issues regarding IP conflicts discussed by previous researchers, such as IP ownerships (Abeda et al. 2011; Shane and Somaya, 2007), confidentiality (Dooley and Kirk, 2007; Rohrbeck and Arnold, 2006; Zaki and Faham, 2004), lack of mechanisms to protect IP (Hall et al. 2001), and the issues of incentives for researchers (Owen-Smith and Powell, 2001; Rohrbeck and Arnold, 2006; Siegel et al. 2003). In this study, two issues, which are conflicts regarding IP confidentiality and incentives will be discussed.

One of the issues that will lead to IP conflicts is confidentiality (Dooley and Kirk, 2007; Rohrbeck and Arnold, 2006; Zaki and Faham, 2004). According to Dooley and Kirk (2007), this issue happens due to conflicts between both partners. The university wants to publish the results that are developed through collaboration, but the industry wants more the results to be made confidential to achieve competitive advantage. The values of university research depend on the number of publications in order to gain reputation (Rohrbeck and Arnold, 2006) and promotion (Zaki and Faham, 2004). But, research activities in industry are closed or confidential to make them more competitive in the market environment (Zaki and Faham, 2004) and to generate, protect the IP, and gain profits from the established and effective products (Hall et al. 2001).

Another issue under transaction-related barriers is incentive or royalty for researchers from IP revenues. Incentive issues also lead to the barriers in R&D collaboration between university and industry. According to a study on projects funded by Advanced Technology Program (ATP), this transaction-related barriers issue is because university takes that the ideas and equipments used for improving or developing new technologies should be given financial values like that gained by the industry (Hall et al., 2001). In order to increase the interest among employees towards collaboration, more companies have defined their own incentive systems (Rohrbeck and Arnold, 2006). In university, due to bureaucracy, researchers and professors who join the research projects do not offer explicit incentive (Siegel et al., 2003). This factor will form a barrier in developing an effective collaboration between both collaborating partners.

Resources-related Barriers

Resources and skills are also required by companies to develop R&D projects (Brostrom and Loof, 2008). High cost (Hanel and St-Pierre, 2006) and skilful personnel are needed to establish successful R&D collaboration. Some previous studies determine that lack of financial resources to support research activities (Abeda et al., 2011; Hamisah Tapsir et al. 2010; Hazlina et al. 2011) and lack of human resources skill (Hazlina et al. 2011; Cyert and Goodman, 1997) are the barriers in university-industry collaboration.

According to Abeda et al. (2011), university depends on the industry and government funds to implement research activities. Based on their results on university perceptions, 93% of the respondents agreed that the financial difficulty was one of the main constraints in establishing research collaboration. A study conducted by Woods et al. (2004) determines that financial resources are more important barriers for industry researchers compared to university researchers. The study gained the data from university and aerospace company in UK and Ireland. The result shows that financial resources are the second highest barrier for industry in conducting research activities. Besides, a study on comparison between Japanese SMEs and large firms shows that the main problem faced by firms with less than 20 employees in establishing collaboration with university is financial problem (Motohashi, 2008). In contrast, a case study based on 8 university-industry collaboration projects in UK and Ireland shows that all of the projects indicated that financial resources are not a barrier or difficulty faced by the researchers in developing collaboration. The study indicates that the collaboration projects faced other types of barriers such as IP, culture, project management, and labour turnover (Wood et al. 2004).

Besides financial resources, human resources are also an important factor in establishing effective collaboration (Thune, 2011; Chin et al. 2011). In R&D collaboration, researchers, project sponsors, PhD students, R&D department, senior management, program and project leaders are human resources usually involved in collaboration (Chin et al. 2011). Gracia et al. (2010) group the human resources into researchers, technical staff, and students. MASTIC (2008) determines that researchers in various academic qualification, technicians, and support staff are important human resources in establishing R&D activities. In a study conducted by Banal-Estanol et al. (2011), the result indicates that the probability to increase the number and quality of research findings is significant when the universities have efficient researchers. Besides, the researchers’ skills and competencies also have significant relationship for both partners to develop successful and high-performance collaboration (Nokkala et al. 2008).

Operation-related Barriers

Operation-related barriers in this study can be defined based on both partners’ limitations that lead to barriers in developing smooth university-industry R&D collaboration process. Several studies have discussed this type of
barriers, such as Rohrbeck and Arnold (2006), Schiller and Diez (2007), and Moryorosi and Bucsai (2010). Rohrbeck and Arnold (2006) discuss the operational barriers based on several items such as deficiency of knowledge regarding collaboration process and their partners, the problem in managing collaboration project, and lack of acceptance on the findings produced by collaborating partner.

Based on perceptions of university-industry collaboration stakeholders (e.g., managers, entrepreneurs, Technology Transfer Offices (TTOs) directors, administrators, and university scientists), the most frequent barrier in collaboration is the lack of understanding towards the norms and environments of university, corporate, and scientists' with 90%, 93%, and 75% respectively (Siegel et al. 2003). Besides, interviews with professors involved in collaboration with private sectors in Thailand show that industry sides are not ready or prepared to establish collaboration with university due to the issues of lack of knowledge about the partners (Intarakumnerd and Schiller, 2008). According to a report from a workshop, Overcoming Barriers to Collaboration Research (1999), one side of the collaborating partners (e.g., university) does not understand the other side’s (e.g., industry) internal polities, managements, and structure in decision making. In the study by Salter et al. (2009), their result allocates that 34% of SMEs and large firms believe that the issue lack of understanding towards the work practices and the expectation from established collaboration leads to barriers.

Besides, the lack of experience of industry also affects the operation (Schiller and Diez, 2007). This is due to the university rules that do not permit the university to employ their full time staffs to work in collaborating projects without fulfilling their responsibilities and traditional roles, which are research and learning. To determine and search for academics who have experience in university-industry collaboration projects is a very complicated task for a university (Schiller and Diez, 2007). In the study by Kazuyuki (2004), More than 30% of the respondents from company with 100 or fewer employees and 101 to 300 employees indicated that no experience in firm is the main barrier in establishing collaboration between university and industry.

Another operational barrier refers to structure and responsibilities within a company (Rohrbeck and Arnold, 2006). According to Cyert and Goodman (1997) and Rosenberg and Nelson (1994), this barrier is due to the situation when university-industry collaboration is established and managed by one person, or the collaboration is established in a short period of time. When the person responsible the collaboration has been changed, it will affect the effectiveness in the collaboration between both partners. Based on Kazuyuki (2004), more than 30% of the respondents from company with 300 to 1000 employees indicated that the main barrier in establishing collaboration is unclear especially regarding the responsibilities of each partner involved in the collaborating activities. This is due to unclear agreement developed between both institutions. According to Kazuyuki (2004), small company agrees that both partners have lack of understanding towards their roles and responsibilities. This issue leads to obstacles in implementing successful collaboration.

**RESEARCH METHOD**

In the preliminary study, both quantitative and qualitative methods were implemented in order to identify the relevant items to be used in quantitative study. Face-to-face interview was conducted to determine the environment of collaboration between university and industry during development research stages. A director of research centre in a Malaysian research university was selected to share the information regarding the barriers faced by the collaboration partners. This centre plays a role as an intermediate institution between university and industry researchers in order to develop and establish effective collaboration project. Besides, a total of 30 questionnaires were distributed among university and industry researchers involved in R&D collaboration particularly during development research stages in Malaysia.

**RESULT AND DISCUSSION**

Background of R&D Collaboration

This section explains the steps in developing R&D collaboration between university and industry researchers. In the interview session, the director mentioned that the research activity starts with developing the research proposal where the researchers indicate the problem statement and prepare a literature review to find whether the current technology can be used to solve the problem or not. Then, the researchers suggest a new product or advanced technology to solve that problem. When the fundamental has been done, the researchers start the lab experiment. In order to convert the lab findings into products, the researchers need to move to pre-test stages especially for product that consists of animals. After the pre-test stages have been successful, then the researchers convert the results into commercial or working prototypes. Next, the researchers need to develop a pilot product to test it in large scale before entering the markets.

In collaboration that leads to new product development, university researchers play important roles from fundamental research until the working prototype for the new product has been developed. However,
university does not have the expertise to develop an actual product; this is the main role of industry players instead. Based on the prototype developed, the role of the industry is to continuously develop or convert the prototype into an actual product based on the design required.

**Types of Barriers in University-Industry R&D Collaboration Particularly during Development Research Stages**

According to the interview result, the respondent mentioned that one of the barriers faced by the university research during the development research stages is time. The academics need to divide their time for researching, teaching, writing papers, and doing administrative tasks; they need to have time management and to plan how much time should be spent for research activities. Another barrier in implementing R&D collaboration with industry is financial funding. According to the respondent, there are competitions between researchers to get financial support. Sometimes the sources of fund are limited, thus researchers need to compete among them, and not all of the researchers will receive the fund.

Besides, there are some gaps in communication between university and industry. It is due to the difference between both institutions. They have different missions and expertise. Compared to university, the industry usually focuses more on the profits and requires short-term results. Due to the gaps in communication between the collaborating partners, usually the university would misunderstand and misinterpret the industry’s demands or requirements.

Furthermore, human resource is also one of the barriers during implementation of development research stages. Usually, in implementing research activities, researchers need assistants. Lecturers would employ their students as research assistants. However, in some cases, the funding is not allocated to pay for the assistants.

For R&D collaboration that leads to development of new products, only the experienced lecturers will be chosen to be involved in collaboration projects. For new and inexperienced lecturers, the university will train them on communication method and presentation skills in order to prepare them for collaboration with the industry.

Moreover, regarding the issue of IP ownership, it is usually not an issue during the development research stages. It is because the researchers will discuss intellectual property matters during the first meeting to develop the projects. They will state the terms and conditions, research problem, problem solution, and ownership of the IP. For example, if the projects use fundamentals owned by the university while the resources and experts from the industry transform the fundamental findings into a new technology, the fundamental findings are still owned by the university, but the new developed technology can be discussed to be owned by both institutions. All of this information needs to be stated in memorandum of understanding (MoU).

Finally, in terms of incentive provided to university researchers, there are still small amounts of financial incentive given to them. When the research findings have been accepted to be filed as a patent by the office of Intellectual Property Malaysia, the researchers will receive around RM500 for the IP. Besides, research funding and publication are other incentives gained by the university researchers. Publication is one of the main focuses by university researchers; it is one of the criteria used to measure the academic performance for job promotion purpose.

In conclusion, the respondent mentioned that there are several types of barriers faced by researchers during development research stages, as also discussed by previous researchers, such as time (Thune, 2007; Bruneel et al. 2010), financial funding (Abeda et al. 2011; Thune, 2007; Motohoshi, 2008), missions (Abeda et al. 2011; Bruneel et al. 2010; Cyert and Goodman, 1997), human resources (Hazlina et al. 2011; Cyert and Goodman, 1997), experience (Thune, 2007; Kazuyuki, 2004), and incentive (Rohnberck and Arnord, 2006; Bruneel et al. 2010). These barriers bring conflicts between both partners during collaboration. The discussion on the types of barriers gained from the interview session supported, or in other words consistent with, the results in previous studies. The previous studies focus more R&D or collaboration projects in general while this present study focuses on development research stages.

Based on the interview results, all the types of barriers discussed above were included into the questionnaire. A pilot study was conducted among 30 researchers who had been involved in R&D collaboration between university and industry in Malaysia, particularly during development research stages. The questions regarding the types of barriers included a total of 12 items, which represented orientation (5 items), transaction (2 items), resources (2 items), and operation (3 items). The result of the pilot study showed that all the items used in this study achieved the high level of consistency based on the internal consistency reliability test. The Cronbach’s alpha showed that all items scored more than 0.70. Based on the results from the pilot study, the types of barriers and the different perceptions between both partners towards the barriers in collaboration during development research stages were determined. The analysis is given in Table 1.
TABLE 1. T-TEST AND MEAN ANALYSIS ON BARRIERS IN UNIVERSITY-INDUSTRY R&D COLLABORATION PARTICULARLY DURING DEVELOPMENT RESEARCH STAGES

<table>
<thead>
<tr>
<th>Barriers</th>
<th>Mean University</th>
<th>Mean Industry</th>
<th>Sig</th>
<th>T-test</th>
<th>Sig (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orientation-related barriers (total mean)</td>
<td>3.76</td>
<td>3.76</td>
<td>0.959</td>
<td>0.569</td>
<td>0.574</td>
</tr>
<tr>
<td>Different missions between partners—university’s mission is knowledge, while industry’s mission is generating profits.</td>
<td>3.90</td>
<td>3.70</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>University focuses on providing education, while industry focuses on producing competitive products.</td>
<td>4.20</td>
<td>3.65</td>
<td>0.585</td>
<td>1.325</td>
<td>0.196</td>
</tr>
<tr>
<td>University research is extremely oriented towards pure science or basic research, while industry is extremely oriented towards applied research.</td>
<td>3.40</td>
<td>3.85</td>
<td>0.228</td>
<td>−1.184</td>
<td>0.246</td>
</tr>
<tr>
<td>Due to lower urgency, university researcher takes longer time to finish a research than industry researcher.</td>
<td>3.90</td>
<td>4.05</td>
<td>0.789</td>
<td>−0.352</td>
<td>0.727</td>
</tr>
<tr>
<td>University researchers have rather limited time in doing research as they also have other academic matters to be concerned of.</td>
<td>3.40</td>
<td>3.55</td>
<td>0.585</td>
<td>−0.407</td>
<td>0.687</td>
</tr>
</tbody>
</table>

| Transaction-related Barriers (total mean)             | 3.70            | 3.53          | 0.345 | 0.741  | 0.465          |
| There is potentially a conflict on the issue of research confidentiality. | 3.80            | 3.50          |       |        |                |
| There is potentially a conflict on the issue of royalty payments from patents and other IP right. | 3.60            | 3.55          | 0.860 | 0.122  | 0.904          |

| Resources-related Barriers (total mean)               | 3.35            | 3.55          | 0.641 | 0.697  | 0.492          |
| There is limited number of financial support to establish R&D collaboration. | 3.80            | 3.50          |       |        |                |
| There is lack of skills among researchers.            | 2.90            | 3.60          | 0.057 | −1.755 | 0.09           |

| Operation-related Barriers (Total mean)               | 2.87            | 3.47          | 0.515 | −1.959 | 0.06           |
| There is lack of knowledge and understanding about the collaborating partner’s expectation and work practices. | 2.70            | 3.60          | 0.699 | −2.464 | 0.02*          |
| There is mutually lack of experience in R&D collaboration between the partners. | 2.80            | 3.45          | 0.515 | −1.959 | 0.06           |
| There are issues on structure and responsibilities in collaboration. | 3.10            | 3.35          | 0.078 | −0.609 | 0.547          |

Notes: *Significant at the 0.05 level.

Table 1 shows that the researchers from university and industry mentioned that the most frequent barriers faced by them were orientation-related barriers with a total mean of 3.76. This finding is consistent with the result in Tartari et al. (2011). University researchers indicated the different objectives between university and industry as the most important barrier affecting the collaboration during development research stages (mean=4.20). On the other hand, industry researchers preferred the item stating University researcher takes longer time to finish a research than industry researcher as the most frequent barriers during collaboration in development research stages (mean=4.05). Other than that, operation-related barriers were found to be the lowest barriers faced by both collaborating partners.

Next, t-test results indicated that there was a significant difference between university and industry on the barriers Lack of knowledge and Understanding about the collaborating partner’s expectation and work practices (sig=0.02). This item recorded a significant value less than 0.05. However, the other barriers were found to have no significant difference between them (i.e., significant value greater than 0.05). Thus, it means that both collaborating partners had same perception on those items.

CONCLUSION

In order to develop R&D collaboration between university and industry, particularly during development research stages, there are four types of barriers faced by both collaborating partners, namely orientation-related barriers, transaction-related barriers, resources-related barriers and operation-related barriers. In this study, it was
found that the most frequent barriers faced by both collaborating partners were orientation-related barriers. The item regarding different objectives between university and industry was indicated by university researchers, while industry researchers indicated the item regarding the long time taken by the university researchers to finish a project. The findings of this study can provide relevant information for collaborating stakeholders (e.g., industry, university, and government) in understanding the barriers in collaboration during development research stages. These findings can be used to find the best solution to reduce the barriers in order to develop effective university-industry R&D collaboration, particularly during development research stages.

REFERENCES


