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FACTORS AFFECTING EFFECTIVE UNIVERSITY-INDUSTRY COLLABORATION DURING THE DEVELOPMENT RESEARCH STAGE

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ABSTRACT

In Malaysia, collaboration between university and industry is still limited. This requires improvement of current practices in developing effective collaborations. However, there are still projects that fail to deliver, and it is quite challenging and difficult to assess the recent successful university-industry collaboration projects. In light of this, background problem, the present research was aimed at identifying the factors which hindered effective collaboration between university and industry, especially during the development research stage. The objective of this study was to determine the relationship between the success factors and the effectiveness of collaborative projects during

the development, research stage. This study adopted a quantitative research method. Survey questionnaires were distributed among researchers involved in a collaborative project funded by a government grant scheme. The results showed that reward had a positive and significant relationship with both process- and outcome-related criteria. Meanwhile, financial support had a negative and significant relationship with a process-related criterion. The findings can be used as guidelines for collaboration stakeholders to develop an effective collaborative project.

Keywords: Development research, research and development, success criteria, success factors, university-industry collaboration.

INTRODUCTION

Since the early 1990s, several initiatives have been introduced by the government of Malaysia (GOM) in order to enhance collaboration between the university and the industry in research and development (R&D) activities. The importance of university-industry collaboration was founded on the belief that the university, by virtue of its leadership role in research, was well placed to collaborate with industry and both the parties would mutually benefit from research efforts in innovation (Rasiah & Chandran, 2009). A few schemes that have been introduced to promote this kind of collaboration were the Industrial Research and Development Grant Scheme (IGS) (Chandran, 2010), Government High Technology (MIGHT), the Malaysian Technology Development Corporation (MTDC), the Intensification of Research in Priority Areas (IRPA), and TechnoFund (MASTIC, 2012; Rasiah & Chandran, 2009).

According to Malairaja and Zawdie (2008), Tapsir et al. (2010), Thiruvelcam (2004), and Abu Mansor et al. (2015), university and industry collaboration in Malaysia was, however, still limited and unsatisfactory. Tapsir et al. (2010) pointed out that in the context of Malaysia, collaboration was still limited and the current practices should be improved in order to enhance the number of successful collaborative projects. In addition, the involvement of universities in development research was considered low compared to the other stages of R&D. This might be due to the research goal of most, if

not all universities, which was to create new knowledge or new ideas (Abeda et al., 2011; Rohrbeck & Arnold, 2006), and this has always been associated with basic research. Besides, universities also depended on funding provided by the government (MASTIC, 2012). As stated in a study conducted in Malaysia by Chandran (2010), different orientations on how university and industry researchers develop their R&D activities have not helped to generate interest in establishing collaborative projects among them, thus contributing to the limited number of university-industry collaborations.

However, achieving stated collaboration objectives is quite challenging, and the recent university-industry collaboration environment still requires improvement in order to develop and attain successful projects. This was the view held by Dunowski et al. (2010), when they underscored the challenges and difficulties that needed to be faced in order to assess successful university and industry collaboration. A study conducted in the biotechnology, automotive, and electronic sectors in Malaysia by Keun et al. (2009) found that the proportion of collaboration projects between the firms in these industries and universities was expected to grow at the rate of 94.8 percent, 42 percent, and 80.6 percent, respectively. Based on the overall samples, the results indicated that 62.6 percent of collaboration projects with universities were successfully implemented. Thus, it can be concluded that almost half of the university-industry projects conducted still failed to deliver.

According to Ramli (2019), semi-structured interviews were conducted with project leaders, where the results have defined that a few collaboration projects during the development research stage were still difficult or failed to achieve the objectives. Besides that, the quantitative results showed that there were still a few projects that failed to deliver. About 66.7 percent to 76.8 percent of the respondents agreed that the collaboration project was successful, while the balance highlighted the failure to deliver the project. According to the leaders, project collaboration, which faced termination during the process of collaboration, was difficult to be completed according to the time frame, and all of the projects are still difficult to be commercialized. The projects needed to be terminated due to the shortage of budget, since the cost to maintain the pilot plant was quite expensive. Projects accomplished over the time frame was due to a few reasons. First, it was due to the university researchers' time constraints, caused by their

other responsibilities. Secondly, the process for university researchers to receive the money was quite long and the amount of financial support was limited, thus, it took time for the researchers to buy the materials and consequently affected the progress of collaboration process. Additionally, one of the interviewees had mentioned his experience during the early process, when he faced difficulties in solving the issue regarding ownership or IP matters, which consequently led to collaboration delay. The issue of commercialization can be caused by limited financial support. Initially, the researchers needed to improvise and add product value for the purpose of commercializing a product. However, financial limitations led to difficulties for them to implement. It was important for practitioners to develop effective collaboration during development research stage to move the products into the commercialization stage and to develop quality and marketable products. This is supported by Yaacob et al. (2011) in their research on lack of financial support for research, development, and commercialization that influenced commercialization activities among researchers.

As indicated by Hanid et al. (2019), there were few studies which had discussed the factors that led to successful collaboration projects. According to Butcher and Jeffry (2007), the effective project is defined based on collaboration of stakeholders including industry, university, and government perception of collaboration "efficiency" and "success". Thus, in this study, an effective and successful university-industry collaboration was one in which a desired level of success was attained, as perceived from the perspective of both institutions. The objective of this study was to determine the relationship between success factors and the effectiveness of collaboration projects during the development research stage. The factors can be implemented by the collaboration stakeholders to develop an effective collaboration project.

LITERATURE REVIEW

Level of Success

Previous researchers have established various types of criteria to measure a successful university-industry collaborative research project (Abeda et al., 2011; Faber, 2001). A successful collaboration

has been attained when viewed from two perspectives. The success criteria were to be based on achieving the objectives as stated by the stakeholders in the collaborative project. Rybnicek and Konigsgruber (2019) provided one perspective which emphasized objectives as a goal, vision, or expected findings. An alternative perspective as held by Ghauri and Rosendo-Rios (2016), indicated that time was an important criterion to determine a successful collaboration. For example, when a project was completed according to schedule or within the deadline, then the project could be defined as a success. This view was supported by Nelson (2005), who argued that a project could be considered successful when the project was completed according to the time and budget given. In addition, the study also listed other success criteria, which included the ability to measure other project outcomes such as using, learning, and valuing the output produced.

As mentioned by Seres et al. (2019), there was still a lack of tools to help measure collaboration performance. Collaboration should be measured according to the different collaboration phases such as input, process, output, and impact. For example, the output phase could be measured through performance measurements like patent application, the number of patents, copyright licenses, company spin-offs, and other commercialization outcomes. Fernandes et al. (2017) has summarized the performance indicators to measure university-industry collaboration into four different phases, namely during program preparation, benefit delivery, program disclosure, and post-program. Each phase has its own performance indicators, which included the number of products, patents, process improvement, solution concepts, publication, and turnover.

According to Barnes et al. (2002), success could be determined by the output produced from a project, such as the number of publications, new products, processes, technologies, and patents. Meanwhile, Seres et al. (2019) has suggested a few indicators to measure the performance of collaborative projects, and these indicators were divided into four categories, namely input, process, output, and impact. Some other indicators have also been suggested by them, such as commercialization of research findings, income generation, number of consultations, and others. Meanwhile, Chin et al. (2011) measured the performance of collaboration based on the tangible and intangible

output produced. Based on an industrial perspective, the intangible output can be measured through the ability to assess the technology which has encouraged rapid commercialization, and would make the firm become more competitive. Important intangible output that could be used to determine the performance of collaborative projects included problem solution, knowledge creation, and satisfactions of research findings. In addition, Chin et al. (2011) also pointed out that university researchers indicated publication, solution concepts, and new findings as tangible output that could be used in measuring collaboration success.

A study conducted by Draghici et al. (2017) provided more criteria to measure the performance of collaboration projects. They proposed the following six important criteria: competitiveness, sustainability, innovation process, internal business process, strategic partnership, knowledge management, and intellectual capacity. Based on the criteria, there are some important indicators used to measure university-industry collaboration performance such as budget allocation, the number of new outputs, new method and tools, number of collaboration project, number of intangible assets, and number of conferences and workshops.

In this study, effective collaboration between university-industry was indicated by the level of success achieved, which were seen as either process-related or outcome-related. The process-related level of success was achieved when the project was completed according to the time and budget allocation. Meanwhile, an outcome-related level of success was achieved through the use of indicators such as the ability to produce products that were required by the target market, achieving product specification and performance, creating high quality products, producing products that led to commercialization, and producing products that helped to solve the firm's problems.

Factors Contributing towards Successful University-Industry Collaborative Project

Past studies have discussed a few factors to develop successful collaborative projects between university and industry (Mora-Valentine et al., 2004; Tartari et al., 2012, Bruneel et al., 2010, Thune, 2011).

Based on the reviews, six important factors were identified, namely experience, communication, financial support, reward, management skills, and clear and flexible intellectual property (IP) policy. These factors were used as independent variables in this research.

As indicated by Thune (2011), Hemmert et al. (2008), Tartari et al. (2012), and Bruneel et al. (2010), experience was an important factor that could help to reduce the difficulty faced by stakholders in developing effective university-industry collaboration. Tartari et al. (2012) and Bruneel et al. (2010) have conducted studies based on university-industry collaboration in the United States, and they were able to determine that experience helped individuals or organizations to reduce orientation-related barriers. These studies indicated that experience had encouraged the university-industry stakeholder researchers to enhance their understanding of their partner's work practices, expectations, and research environments. Edmondson et al. (2012) explained that experience could enhance understanding, knowledge, and skills among partners, thus leading to the development of successful collaborations. This observation was supported by Thune (2011), who also claimed that experience helped university-industry researchers to enhance their understanding of the collaboration objectives. Besides that, Nokkala et al. (2008) pointed out that experience could enhance the possibility for the university-industry researchers to run collaborations smoothly. Meanwhile, Mora-Valentine et al. (2002) and Thune (2011) were of the view that experience was significant towards the establishment of successful collaboration projects between university and industry. A study by Hemmert et al. (2008) which compared the university-industry collaboration environment between two Asian countries, namely Japan and Korea have found that only companies in Japan had more experience of being involved in this type of collaboration. Previous experience with established collaborations had led the Japanese company to increase the number of experts to manage recent collaborations, thus, encouraging further successful university-industry collaborations even beyond its national border. A study among academics in Turkey by Kaymaz and Eryigit (2011) indicated that previous bad experience as a result of being involved in collaborations could reduce the possibility of universities wanting

to engage in collaborations with the industrial sector. In order to encourage universities to be involved in collaborative projects with industry, the problems during collaborations should be solved.

Moreover, previous studies have also determined that effective communication has a significant relationship with the development of a successful collaboration (Fiaz et al., 2011; Chin et al., 2011; Barnes et al., 2002; Mora-Valentine et al., 2004). Mora Valentine et al. (2002) has shared that communication was the most important factor, as this was indicated by research organizations, while industry held a different perspective. For industry, instead of experience, commitment has been seen as the most important success factor in a collaborative project. Effective communication would also encourage researchers to develop trust (Chin et al., 2011), as well as enhance knowledge and understanding (Thune, 2011), exchange information and solve problems (Abeda et al., 2011), and enable the collaborative project to run smoothly (Fiaz et al., 2011). It was to be expected that the objectives of the collaborative partners would be different. This was because universities tended to be more publication oriented, while the industry was more commercialization oriented. Thus, in order to be involved in collaborative projects, both partners' objectives should be considered and after discussions come to a consensus agreeable to both the stakeholders. Thus, effective communication has become very important as both must discuss or share their visions and objectives. This would lead to the enhancement and understanding of each other's orientation, thus allowing them to work together to achieve mutual goals (Bruneel et al., 2010; Cederholm, 2015). A study by Pertuz et al. (2021) also supported the finding that effective communication was one of the important factors towards achieving a successful collaboration. In addition, that study has also determined some other contributory factors, such as sharing similar objectives and understanding, trust, and experience in establishing successful collaborations. Based on an Audi and Technical University of Munich's case study, it was found that both partners had developed an efficient communication protocol, whereby they frequently met and communicated with each other in order to ensure a smooth and well-collaborated project (Edmondson et al., 2012). This finding was supported by Awasthy et al. (2020), who advocated that both

partners should utilise diverse communication platforms, such as face-to-face, and mobile and digital media communication to enhance their engagement in collaborative projects. They emphasized that the partners should meet and talk regularly to ensure a smooth collaboration process, as the progress of collaboration should also be communicated and monitored in each stage of collaboration. A study based on the perspectives of industry players and academicians on the success factors however, showed diverse results. Although industrial players considered effective communication between partners as the most important factor in determining a successful university-industry collaboration, university researchers were of the view that other factors such as teamwork, leadership, and financial support were the crucial elements of success (Hanid et al., 2019).

In contrast, Kaymaz and Erigit (2011) in their study indicated that there was no significant effect of communication on achieving a successful collaboration. This means that communication is not an important factor to consider in developing a successful collaboration. Hanid et al. (2019) indicated that in some cases, when the collaboration partners were committed and fulfilled their responsibility since the beginning of a project, conducting regular meetings was not compulsory. As indicated by Ndudzo and Zinyama (2014), good communication skills were required in order to develop successful collaboration projects. Their study showed that all their respondents strongly agreed with that effective communication led to a successful collaboration. Inconsistent communication among partners during collaboration would set up barriers for them to develop effective collaboration. Cederholm (2015) in a case study also claimed that communication was an important factor in collaboration. According to the study, an important channel of communication was the group meetings. Two meetings per year that involved all project research stakeholders were held to discuss any issues arising from their collaboration. Besides that, the researchers also presented their research progress or findings during the meeting, which helped them to monitor the work progress and review whether the collaboration could be completed according to the objectives and deadline.

In addition, financial support was seen as another critical factor that could contribute to the establishment of a successful collaborative project. As confirmed by Hanid et al. (2019), university researchers

indicated that financial support as a factor for a successful collaborative project. It played the role of a motivator for researchers to be involved in this type of collaboration. The government has also tried to encourage university and industry researchers to engage in collaborative projects during the development research stage through initiatives such as its TechnoFund scheme, which has provided financial support to SMEs and public universities or public research institutions. According to Yee et al. (2015), who conducted a study in Malaysia, respondents from the industry pointed out that SMEs still needed financial support from the government to enable them to engage in collaborative projects with universities. Such a strategic partnership with universities would help industry to create innovative products and services, transfer knowledge and technology, and for the universities to be involved in commercialization activities. As confirmed by the results, the university respondents pointed out that they were able to commercialize their research output by involving industry as a collaborator and thus, received funding from the government, such as through the TechnoFund scheme. Financial support provided by the government has encouraged researchers to develop university-industry collaboration and generate quality research findings.

According to Ssebuwufu et al. (2012), which was a study carried out in Africa, the findings identified the lack of financial support as the most frequent barrier for universities to collaborate with industry. The study also suggested some recommendations to address this issue. One of them was that the government should be encouraged to provide financial support. The researchers pointed out that this was because, when the amount of financial support for the researches was increased, the collaboration with industry was strengthened. This observation was also supported in a study by Worasinchai et al. (2008), who explained that the government and industry should provide financial support for university researchers because the lack of financial support was recognized as a factor that affected the development of a successful collaborative project.

In addition, Lach and Schankerman (2003) indicated that there were positive impacts from financial support targeted at income generation received from licensed activities. Besides, it also helped to enhance

the quality of findings and/or number of inventions. For a university, the financial support received from industry was able to help the researchers increase the number of patents and commercialization activities (Kamariah et al., 2008). A study conducted by Gulbrandsen and Smeby (2005) revealed that there were positive influences of industrial funding towards commercialization, filing of patents, and new company development. According to the researchers, the possibility of a university professor implementing R&D activities that could contribute to patents was one percent when he or she did not receive any financial support from industry. However, the percentage was estimated to be seven percent when financial support was provided. A study by Hottenrott and Thorwarth (2011) in contrast found the opposite results, whereby industrial funding negatively influenced the number of patents. The study also indicated that a negative result was obtained in terms of the number of publications when the university research was funded by industry. However, there was a significant positive effect on the volume of publications when the university received financial support from the government (Hottenrott & Thorwarth, 2011). According to them, the amount of money spent by industry on the research university would reduce the number of publications produced by 0.8 percent.

Another important success factor in university-industry collaboration was the impact of management skills, as management leadership could encourage the researchers to meet the success criteria, such as producing quality findings within the allocated budget and time frame (Philbin, 2008). The management of a project was important as it could help to ensure that the project planning was realistic and specifically detailed as a guideline for researchers. Proper management should clearly spell out the roles and responsibilities of every stakeholder in the collaborative project, as effective work planning would help to efficiently use project resources, skill, and time (Cederholm, 2015). As indicated by Kamariah et al. (2011), researchers needed to have the skill to ensure that the patents produced from the research activities could be commercialized successfully. According to Fiaz et al. (2011), a collaborative project as compared to a single stakeholder project, was more difficult to manage. This was because collaboration involved two institutions with different backgrounds or cultures, and

it would cause some issues and difficulties that made the project more complicated to manage. In a collaborative project, the collaboration could run smoothly when it was managed by someone who understood the different cultures of both partners. Besides, the university also needed to have someone who was capable of developing or managing the collaborative project as it could awaken the interest of industry to get involved in collaborative projects. In addition, a good leader could also help to reduce the issue of cultural gaps or differences between both partners (Edmondson et al., 2012). The project manager (Thune, 2011) and collaboration agent (Philbin, 2008) could play important roles in the university-industry collaboration by using their relevant skills and experience to bring about a more effective collaboration among the partners. These agents needed to manage and connect teams from different levels engaged in a collaboration to ensure that collaborations would run smoothly (Philbin, 2008). Project managers were seen as playing vital roles in identifying the activities and tasks that should be accomplished by the project teams, and meeting the project objectives (Faber, 2001). Besides, project managers needed to have previous experience in collaboration and networking skills. This would encourage them to be more understanding and knowledgeable about collaboration and better manage collaborative projects involving partners of different orientations or cultures (Cederholm, 2015). In addition, Hanid et al. (2019) also supported point that a project collaboration managed by a leader who showed understanding and knowledge about their partner's culture would lead to a smooth collaborative project. Therefore, the findings from previous studies seem to suggest that leadership skill was one of the important factors for ensuring effective university-industry collaboration.

Moreover, rewards also have an impact on the university-industry collaborative project. Owen-Smith and Powell (2001), Rohrbeck and Arnord (2006), and Siegel et al. (2003) have studied the incentive issue among researchers. In Malaysia, initiatives have been increased for researchers, especially for those who work in public universities, such as academic researchers. It is important for university researchers to gain financial reward and recognition by obtaining patents. A patent has been used as a key indicator to evaluate performance, and offer job promotion for academicians (Kamariah et al., 2008). Guimon

(2013) found that it was common for university researchers to not be rewarded for their involvement in collaborative projects. Teaching experience and research publications have always been the most important criteria to measure university researchers' performance or to reward them. Thus, the government has been urged to improve the current incentive system provided to the academics or researchers by including involvement in project collaborations with industry. As indicated by Boahin (2018), an efficient reward system could help to enhance the effectiveness of a collaborative project; it could serve as an attractive and powerful incentive for the institutions and researchers when there was a sharing of the profits generated from the licensed research output. The incentive will forge a strong relationship between partners. In a study by D'este and Perkmann (2011), it was determined that financial reward had influenced academic researchers to get involved in collaborative activities. This observation was supported by Schottle and Gehbauer (2012) who indicated that an incentive was a crucial element that could enhance project performances, encourage the promotion of collaborative projects, lead to completing projects on time, and meet the quality requirements. Additionally, some studies indicated that incentives or rewards also encouraged interest and motivated researchers (Buekler, 2013), as well as increased job satisfaction (Mustapha, 2013; Schottle & Gehbauer, 2012). According to Azeez and Lawal (2016), financial rewards would be able to enhance employees' job satisfaction and also improve their performance. Dissatisfied employees could result in more incidences of conflict. thus making it difficult for a company to meet their objectives or gain competitive advantage over others. They further explained that satisfied workers would bring positive vibes, such as the critical effective communication skills that would lead to positive results in the organization. In the context of collaboration, financial rewards would encourage researchers to implement a project effectively, for example, the project would be accomplished according to the deadline and at the same time meet the research goals and objectives. As suggested by Awasthy et al. (2020), universities should establish an incentive system to recognize the efforts of academicians involved in collaborative activities with industry. This type of strategy should be encouraged because the incentive could act as a powerful motivation and encourage the development of a more effective collaboration.

In addition, it was crucial to have a clear and flexible IP policy in a collaborative project. As mentioned by Edmondson et al. (2012), a formal or master agreement on IP was needed in order to acknowledge the partners on the joint ownership and help develop trust, procure a valid license, and resolve other IP-related issues. When the agreement was not clear, it encouraged more conflict and the researchers would lose a lot of time trying to solve IP issues that have affected the process of collaboration. A study by Okamuro and Nishimura (2011) on firms in Japan found that having a university IP policy has helped to enhance university-industry collaboration. In addition, a clear and fair IP policy and one which was flexible to both partner's requirements and objectives would encourage them to manage the collaborative project efficiently. In addition, Rohrbeck and Arnord (2006) have pointed out that an IP policy could help to reduce or solve any issues on IP conflicts that might occur in the university-industry collaboration. According to their study, when both partners in the university-industry clearly defined their policy regarding IP and publication, the stakeholders managed to avoid barriers in their collaboration. A study carried out in the US found that the IP policy in the university helped explain the university procedure in providing incentives for their researchers involved in technology transfer activities (Friedman & Silberman, 2003). As mentioned by the World Intellectual Property Organization (2016), having a transparent and clear IP policy has become an important criterion to be considered by a university when deciding to get involved in a collaborative project. The policy should be approved by the university authorities and this would allow for flexibility in consultation for researchers and partners in the collaboration. An IP policy can provide guidelines and regulatory rules for the commercialization of IP, explain the ownership, define the stakeholders' responsibilities and rights, outline the profit sharing benefits if the developed products get commercialized, generate income and guidelines for the administration of the IP policy, and ensure the discoveries, invention, and creations of the university staff and students are utilized to benefit society. A clear IP policy can help to ensure the smooth operation of a collaboration, while reducing the poyential conflicts that may arise from issues on IP. Besides, it can provide clear guidelines and acknowledge the stakeholders' responsibilities, thus enhancing understanding about their roles and

responsibilities. These aspects about the importance of an IP policy has been supported by Awasthy et al. (2020). They have emphasized that a clear IP policy would help reduce legal issues arising from conflicts in a collaboration. An agreed to policy would ensure that both collaboration partners already have a common understanding about their stated roles and responsibilities.

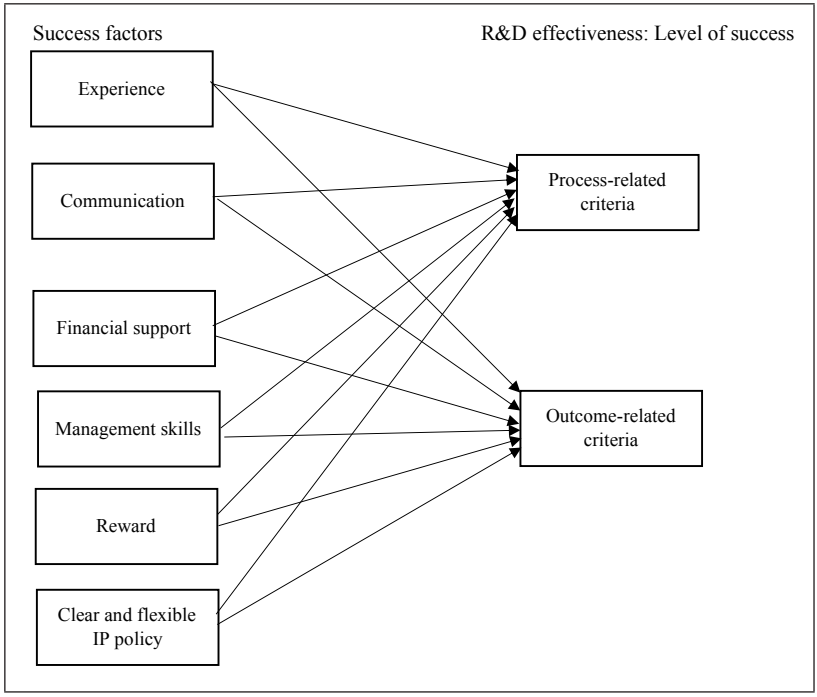
In light of the foregoing literature review, this study has proposed the following hypotheses:

H_1: There is a positive and significant relationship between experience and process-related criteria.
H_2: There is a positive and significant relationship between experience and outcome-related criteria.
H_3: There is a positive and significant relationship between communication and process-related criteria.
H_4: There is a positive and significant relationship between communication and outcome-related criteria.
H_5: There is a positive and significant relationship between financial support and process-related criteria.
H_6: There is a positive and significant relationship between financial support and outcome-related criteria.
H_7: There is a positive and significant relationship between management skills and process-related criteria.
H_8: There is a positive and significant relationship between management skills and outcome-related criteria.
H_9: There is a positive and significant relationship between reward and process-related criteria.
H_{10}: There is a positive and significant relationship between reward and outcome-related criteria.
H_{11}: There is a positive and significant relationship between a clear and flexible IP policy and process-related criteria.
H_{12}: There is a positive and significant relationship between a clear and flexible IP policy and outcome-related criteria.

The relationships between the success factors and the effectiveness of R&D collaborative projects during the development research stage are as shown in Figure 1.

Figure 1

Framework on the Relationships Between R&D Collaboration Success Factors and the Effectiveness of R&D Collaboration Between University-Industry During the Development Research Stage



METHODOLOGY

This study implemented a quantitative research method. The data was collected through a survey questionnaire and analysis was carried out using SPSS 16.0. In this study, the population consisted of researchers at the designated public Research Universities (RU) and private and Government-Linked Companies (GLCs) in Malaysia. All these institutions have had vast experience in carrying out R&D collaboration. The projects consisted of 40 projects funded by a government grant scheme. In order to collect the data for this study a stratified random sampling technique was implemented to select the relevant respondents. From the identified 40 projects, the population of researchers came up to a total of 246; 111 researchers were from

universities, and 135 researchers were from industry. As proposed by Krejcie and Morgan (1970), the recommended number in a sample size was 152 respondents. The questionnaires in the present study were distributed to 170 researchers. These researchers were still available to be contacted. Out of the170 survey questionnaires that were distributed by email, ordinary mail, and hand-distributed, 99 responses were received. The 99 respondents involved in the actual study met the minimum number of respondents in a sample size as suggested by previous researchers such as Roscoe (1975), Sekaran and Bougie (2010), and Hair et al. (2006). The questionnaire used in this study was based on a five-point Likert scale, ranging from strongly disagree to strongly agree. The operationalization of the variables and reflected in the questionnaire in this study are as shown in Table 1.

Table 1

Sources of Measures and List of Items Representing the Variables in the Study

No	Variable	Item	Source
Independent variable (Success factors)			
1	Communication	The collaborating partners and I have telephone contact.	Okamura and Nishimura (2011)
		The collaborating partners and I hold project meetings.	Okamura and Nishimura (2011)
		I work at the site of the partners', or vice versa.	Okamura and Nishimura (2011)
2	Clear and flexible IP policy	Partners' intellectual property policies are clear and easily understood.	Okamura and Nishimura (2011)
		Partners' intellectual property policies are sufficiently flexible to meet our needs.	Okamura and Nishimura (2011)
		Partners' intellectual property policies are equitable in revenue and royalty sharing.	Okamura and Nishimura (2011)
3	Experiences	Experience in previous collaboration helps me increase knowledge about the partners.	Thune (2011)

(continued)

No	Variable	Item	Source
		Experience in R&D collaboration helps me develop trust between the partners and me.	Nokkala et al. (2008), Okamura and Nishimura (2011)
		Experience in collaboration helps me increase understanding about the objectives of collaboration.	Thune (2011)
4	Financial support	Collaboration partners increase the amount of funds to support our project.	Abeda et al. (2011)
		University endowments support the research projects.	Abeda et al. (2011)
5	Management skills	Our collaboration project is managed by a skilled project leader and collaborative agents.	Thune (2011), Philbin (2008)
		Our collaboration project is managed by an experienced project leader and collaborative agents.	Thune (2011), Philbin (2008)
		Our partners have good management and leadership skills.	Friedman and Silberman (2003)
6	Reward	I receive financial reward from the commercialised R&D findings.	Kamariah et al. (2008), Mohamed Din (2010)
		I receive recognition from the commercialised R&D findings.	Kamariah et al. (2008)
		I receive job promotion from the successfully commercialised R&D findings produced from the collaboration.	Kamariah et al. (2008)
Dependent variable (Level of success)			
1	Process-related criteria	The collaboration project is completed on time.	Dunowski et al. (2010), Nelson (2005)
		The collaboration project uses the budget allocated.	Dunowski et al. (2010), Nelson (2005), Shenhar et al (2001)

(continued)

No	Variable	Item	Source
2	Outcome-related criteria	The collaboration project produces products that are required by the target market.	Nelson (2005), Shenhar et al. (2001)
		The collaboration project achieves the product specifications and performance.	Nelson (2005), Shenhar et al. (2001)
		The collaboration project produces and creates high quality products.	Nelson (2005)
		The collaboration project produces products that lead to commercialisation.	Chin et al. (2011), Shenhar et al. (2001)
		The collaboration project produces products that help solve firm problems.	Chin et al. (2011), Barnes et al. (2002), Perkmman et al (2011)

RESULTS

In this study, internal consistency reliability of the variables was assessed using Cronbach's coefficient alpha. Table 2 presents the Cronbach's coefficient alpha results for success factors and level of success variables. The results showed that the Cronbach coefficient alpha for all the variables was more than 0.60. This was considered as adequate and good (Gibson et al., 2016). Thus, it indicated that the research instrument was reliable in the context of the present study.

Table 2

Cronbach Coefficient Alpha of the Success Factors and Level of Success in University-Industry Collaboration during Development Research

Variable	No. of item	Alpha (α) value	Mean	Std. Deviation
Independent variable (Success factors)				
Communication	3	0.824	3.733	0.755
Clear and Flexible IP policy	3	0.904	3.422	0.748

(continued)

Variable	No. of item	Alpha (α) value	Mean	Std. Deviation
Experience	3	0.866	4.033	0.718
Financial support	2	0.783	3.433	0.888
Management skill	3	0.827	3.644	0.753
Reward	3	0.898	3.089	0.811
Dependent variable (Level of success)				
Process-related criteria	2	0.886	3.633	1.008
Outcome-related criteria	5	0.976	3.553	1.128

Respondent Characteristics

This study involved 99 respondents, which consisted of 51 industry researchers and 48 university researchers. Table 3 shows the majority of the respondents were Malay (84.9%), male researchers (67.7%), and those aged from 41 to 50 years old (37.40%). Besides, the co-researchers and R&D project leaders represented 61.6 percent and 38.4 percent of the total respondents, respectively. The results also indicated that 32.3 percent of respondents had between 11 to 20 years of working experience, followed by 6 to 10 years (26.3%), and only 5.1 percent had more than 30 years of working experience. For the level of education, a PhD in a foreign university was found to have the highest percentage, representing 33.3 percent of the total respondents, and all of them were university researchers. Finally, all respondents involved in this study also recounted their experiences about their engagement in collaboration projects during the development research stage.

Table 3

Demographic Statistics (N=99)

	Demography	Frequency	Percentage
Ethnicity	Malay	84	84.9
	Chinese	12	12.10
	Indian	2	2.00
	Others	1	1.00

(continued)

	Demography	Frequency	Percentage
Gender	Male	67	67.70
	Female	32	32.30
Age	Below 30 years old	14	14.10
	31-40 years old	29	29.30
	41-50 years old	37	37.40
	51-60 years old	17	17.20
	Above 60 years old	2	2.00
Position	R&D project leader	38	38.40
	Co-researcher	61	61.60
Working experience	1-5 years	14	14.10
	6-10 years	26	26.3
	11-20 years	32	32.3
	21-30 years	22	22.2
	More than 30 years	5	5.10
Experience involved in collaboration during development research stage	Yes	99	100

Relationship between Success Factors and Level of Success in University-Industry Collaboration during Development Research Stage

To determine the relationship between success factors and process-related criteria, this study conducted a multiple regression analysis. The results are as shown in Tables 4 to 6.

Table 4

Regression of Process-Related Criteria and Success Factors

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.555	0.309	0.263	0.67248

a. Predictors: (Constant), communication, financial support, experiences, reward, management skill, clear IP policy.

Table 5

Coefficients of the Regression Model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig
		B	Std. Error	Beta		
1	(Constant)	1.132	0.596		1.899	0.061
	Communication	0.151	0.112	0.129	1.344	0.182
	Clear IP	0.114	0.101	0.125	1.136	0.259
	Experiences	0.206	0.123	0.167	1.668	0.099
	Financial support	-0.197	0.091	-0.216	-2.158	0.034*
	Management Skill	0.227	0.139	0.171	1.638	0.105
	Reward	0.223	0.082	0.292	2.713	0.008*

Note. *Significant at p <0.05

a. Dependent variable: Process-related criteria.

Table 6

ANOVA Analysis

ANOVA						
Model		Sum of Squares	Df	Mean Square	F Sig	Sig
1	Regression	18.563	6	3.094	6.843	0.000*
	Residual	41.609	92	0.452		
	Total	60.172	98			

Note. *Significant at p <0.05

a. Dependent variable: Process-related criteria.

b. Predictors: (Constant), Communication, financial support, experiences, reward, management skill, clear IP policy.

The R square in Table 4 showed that these factors explained 30.9 percent (R2=0.309) of the variance in process-related criteria. The results in Table 5 also show that the factors achieved significance (p=0.000). Table 5 shows that two factors, which were reward and financial support made a significant contribution to the variance in process-related criteria, with p<0.05. The unstandardized coefficient

beta showed that reward had a positive relationship with process-related criteria. Thus, it means that more rewards given to the researchers helped to increase the probability in developing successful collaboration regarding process-related criteria. Meanwhile, financial support had a negative relationship with process-related criteria. More financial support received would decrease the process-related criteria. The final model for the relationship is given as follows:

Process-related criteria =1.132 + 0.223 reward -0.197 financial support

Tables 7 to 9 show the results of the relationship between success factors and outcome-related criteria through multiple regression analysis.

Table 7

Regression of Outcome-Related Criteria and Success Factors

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.527	0.227	0.230	0.65126

a. Predictors: (Constant), Communication, financial support, experiences, reward, management skill, clear IP policy.

Table 8

Coefficients of the Regression Model

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig
		B	Std. Error	Beta		
1	(Constant)	1.561	0.577		2.704	0.008
	Communication	0.120	0.109	0.108	1.105	0.272
	Clear IP	0.134	0.098	0.154	1.375	0.173
	Experiences	0.081	0.120	0.069	0.678	0.499
	Financial Support	-0.153	0.088	-0.177	-1.736	0.086
	Management Skill	0.240	0.134	0.190	1.786	0.077
	Reward	0.221	0.080	0.305	2.773	0.007*

Note. *Significant at p <0.05

a. Dependent variable: Outcome-related criteria.

Table 9

ANOVA Analysis

ANOVA						
Model		Sum of Squares	df	Mean Square	F Sig	Sig
1	Regression	14.980	6	2.497	5.886	0.000*
	Residual	39.020	92	0.424		
	Total	54.000	98			

Note. *Significant at p <0.05

a. Dependent variable: Outcome-related criteria.

b. Predictors: (Constant), communication, financial support, experiences, reward, management skill, clear IP policy.

The R square in Table 7 showed that these factors explained 22.7 percent (R^2=0.227) of the variance in outcome-related criteria. The results in Table 8 also show that the factors achieved a significant value (p=0.000). Table 8 shows that only one factor, which was reward, made a significant contribution to the variance in outcome-related criteria (p=0.007). The unstandardized coefficient beta also showed that reward had a positive relationship with the outcome-related criteria. Thus, it means that more rewards for researchers helped in increasing the probability of developing a successful collaboration through outcome-related criteria. The final model for the relationship is as shown below:

$$\text{Outcome-related criteria} = 1.561 + 0.221\ reward$$

DISCUSSIONS

Based on the multiple regression analysis, only the reward factor has an influence on process- and outcome-related criteria. The result from the unstandardized beta also showed positive value, thus this meant that reward had a positive relationship with these types of success criteria. The results indicated that the increased number of rewards for the university-industry researchers would increase the probability of the researchers to develop a successful collaboration in terms of time accuracy and budget, and produce effective products. Rewards should

be given based on researchers' needs and requirements in order to encourage them to get involved in a collaboration (Worasinchai et al., 2008). Some of the previous studies have determined that financial reward showed a significant relationship with the increase of job satisfaction (Mustapha, 2013; Schottle & Gehbauer, 2012). According to Schottle and Gehbauer (2012), incentives could also be in the form of financial or non-financial rewards. Instead of satisfaction, incentives also have the effect of increasing project performance, promoting collaboration, completing the project on time, and achieving quality. A study by Jonbekova et al. (2020) supported this observation, when they found that limited incentives provided by the university would lead to less motivation or became a barrier for the researchers to become involved in collaborative activities. Besides, the respondents indicated that a collaboration project would be more successful when there was a provision of additional incentives such as bonus and promotion opportunities.

Financial support also has significant relationship with process-related criteria. However, the unstandardized beta shows that this factor has a negative relationship with the process-related criteria. Thus, it means that the increase of financial support will reduce the probability to develop a successful collaboration project. This study is contrary with some previous studies that determine financial support as an important factor for a successful project (Liew et al., 2012; Ndudzo & Zinyama, 2014). Liew et al. (2012) mention that funding has a positive impact towards the quality of research findings. Besides that, financial support also encourages the rise of facilities and experts in conducting a research project. In addition, Abeda et al. (2011) and Ndudzo and Zinyama (2014) indicate financial support as among the important factors for successful collaborations.

According to Ramli (2019), it is reported that the researchers face financial problem, and some of them indicate the lack of support from their partners and university endowments. Although they face the financial issue, the project can still be completed. As informed by the researchers, they need to plan well, and sometimes reduce the research scope or objectives to meet the time and budget allocation. Due to this situation, it leads to the negative relationship between financial support and level of success.

CONCLUSION, IMPLICATIONS, AND DIRECTIONS FOR FUTURE RESEARCH

In conclusion, reward has a positive and significant relationship with a successful university-industry collaboration. The development of an effective reward system will encourage or motivate the university-industry researchers to develop an effective collaborative project in the development of research stage. This study can be used as a guideline for universities, industry, and the government to embrace the best practices that should be implemented in order to develop more effective collaborative projects and this effort will benefit the institutions, society, and the Malaysian economy as a whole.

This study was however, limited to 40 projects that received financial support from a government research grant. Some of the respondents involved in the projects were not available as they could not be contacted due to several reasons. For example, some of the researchers had either resigned, retired, or passed away. In some cases, the company they worked in had gone bankrupt. As a result, the number of population was low and this affected the number of total respondents involved in this study. In addition, the majority of the respondents comprised mainly researchers from research universities. It is hoped that future research in this area involve researchers from other public and private universities. Additionally, future researches should focus on collaborative projects that receive financial support from the private or industry sectors, as these might provide a different or much more diverse research findings.

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