The Catalysts of university-industry Research Collaborations for Innovation

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DOI: https://dx.doi.org/10.4314/ajasss.v5ispecialissue.1

Abstract
Cooperation between academia and industry is becoming an important part of an effective national innovation system in the world. The research cooperation between universities and industry is the key answer to the solution to the complex problems facing the current society. This study aimed to find the reasons for the relationship between industry and higher education in research, particularly to make these factors a driver in the continuation of changes in the existing situation of cooperation between these two parts, leading to innovation in the nation. The study used a conceptual analysis design within a qualitative approach to reviewing the literature on university—industry collaboration. Furthermore, our study used quantification in some aspects of methodology, such as in obtaining samples and processing data. It used a convenient sampling procedure to obtain 631 journal articles through Web of Science searches, including journals and peer-reviewed journals, consisted articles from 2010 to August 2021, as a review of industry-university-research collaborations. It builds on a rising amount of academic research on industry-university collaboration and provides advice from experienced managers. Important findings about collaborative practices relied on organizational and personal habitats, knowledge aspects and interactions are the sources of university-industry alliances. The research shows that universities, organizations, and research institutions are looking at the best factors that can help them in making a long-term relationship-enhancing innovation. As far as research is concerned, the partnership between universities and industry is still in its infancy. This is due to the lack of communication between the two parties, low awareness of industry owners, and lower-than-average university leadership's commitment and ability to establish such connections. From the findings, other important motivational factors obtained were intuitional factors, and trust. Moreover, this paper concludes with a discussion of the relevant implications to universities, industry, research institutions, management, and policy development, pointing out directions for the future.

Keywords: *Collaboration, university-industry relationship, effectiveness, innovation realization, economic benefits*

1.0 INTRODUCTION

University-industry research collaboration is a fundamental and common feature of scientific research. It takes many forms, from idea sharing among researchers to corporate partnerships andresearch joint ventures. Improving and transforming scientific and technological achievements are the basis of promoting national progress and international competitiveness. Theinnovation network is developing into an international network within and across science (Martin, Pahor et al. 2015). Zhao and Cui, (2021) explained that accelerating the transformation of scientific and technological achievements is the basic way to carry out the strategy of independent innovation and transform economic development. Also, the study of Yoda and Kuwashima (2020) showed that cooperation and scope of the relationship development between leading universities, industry, and government are changing with the reform of regulations. According to El-Ferik and Al-Naser, (2021), a visionary partnership between industry and universities can hasten innovation. University–business cooperation in research plays an important role in initiating and promoting the transformation of scientific and technological achievements (Shang, Zhang et al., 2021). University-Industry Inter-organizational knowledge integration network enhances the flow of knowledge in national and regional innovation systems, as well as the technological capabilities of national industries (Li-Rong, Yu, & Si-Feng, 2015). Onthe other hand, the structure of any industry-university partnership must meet the company's laws, trusts, and business needs; scholars need scientific work and freedom of publication; and public demand for privacy and potential social goods (Ripoll Feliu and Díaz Rodríguez, 2017): Tian, Suet al. (2021)). Moreover, scientific excellence explains the quality of the university's productivity and research outcomes, and takes allows for the frequency of cooperation in each “scientific disciplinary sector” (SDS) (Abramo, D'Angelo, & Di Costa, 2011). The successful evolution of the role of technology transfer in universities, startups, and business partners with which it works, requires an increasingly comprehensive view of all innovation ecosystem factors (Bodas Freitas & Verspagen, 2017). Mirza, Al Sinawi et al., (2020), express that typically, companies and universities will initially agree to the royalty terms of a particular patent, and renegotiate these terms once the actual product of the particular patent is used and many other patents appearand their level of success is clear.

According to Tero & Ukko (2018), all partners in research collaboration are encouraged to analyze the current state of the learning partnership and determine which of the partnerships are valid and which are not. Whether a university makes a significant contribution to the innovation and development of a particular industry depends in part on the university's industrial support for research (Lin, 2021). From an economic incentive perspective, collaboration with research

institutions or universities poses fewer problems for companies with potential competitors in the product market because information can be shared more easily (Lemos and Cario 2017). Furthermore, for small companies, the credibility of their potential partners is assessed primarily based on the authenticity of their knowledge, depending on how well they fit into the project the company wants to pursue (Colombo, Guerini, et al., 2021). Industry-university-research cooperation is an important source of knowledge innovation (Puerta-Sierra, Montalvo et al., 2021). However, many successes and failures of the IUR Institute Cooperation Alliance indicate the need to select good partners. When interpreting the diversity and frequency of interaction between academic researchers and the industry, personal characteristics are more influential than the characteristics of their department or university (D'Este and Patel 2007). While trying to understand why some university-industry partnerships are thriving while others are unable to thrive, Rajalo and Vadi, (2017) explained that, this was due to the multi-level heterogeneity of understanding the collaborator's premises. De Fuentes and Dutrenit (2012) argued that the best channels of interaction are those that help firms gain long-term benefits. Direction-baseddifferences can thwart the partners' common rational efforts, preventing them from solving their ability based on conventional differences (Paay, Kuys, et al., 2021). To promote Industry-University-Research Cooperation (UIC), financial support from the government and industry is necessary for resource allocation (Tseng, Huang, et al. 2020). Three fundamental elements of the UIC environment are university - governance mechanisms, a climate of innovation, and a reward system identified as key antecedents of UIC funding and the university. According to Sjöö and Hellström (2019), the factors that stimulate collaborative innovation are resources, university organization, cross-border functions, collaborative experience, culture, place centrality, and environmental context. Furthermore, investment in knowledge, networks, and research and development (R&D) in general are the most important factors influencing UIC performance (Ćudić, Alešnik, et al., 2022). Strengthening the innovation system and removing all barriers to cooperation between all process players - industry, education, and research, as well as legal and financial systems, are vital prerequisites for ensuring the transition and implementation of an innovation economy (Mce and Rumbinaite, 2016).

2.0 MATERIALS AND METHODS

The study used a conceptual analysis (CA) design that lies within the scope of the qualitative approach. Furthermore, it used quantification in some aspects of methodology, such as in obtaining samples and processing data. The methods largely meant an activity in which the concept its characteristics and its relationship with other concepts are clarified (Aspers and Corte, 2019).

Conceptual analysis methods are used to study and modify the dominant concept theory of a language. It is usually done as a study of its conceptual network (Kosterec, 2016). All methods of the CA under study begin with the collection of knowledge about the initial concept system. The researcher then modified knowledge by using intuition while respecting logical constraints or by providing constructive steps that do not negatively impact the correctness of the conceptual theory being studied.

Each concept analysis involves other concepts and requires careful examination of the relationship. Though, when conducting research, many conceptual analyses were done through thinking and presenting the results by discussing, for example, different perspectives, definitions,or classifications. However, in this paper, a set of "tools" is proposed to show the concepts and relationships between them in a graphical diagram (Nuopponen 1994, 2005a). Tools include several models from previous research and bring together various types of concepts and conceptual relationships into more formal types to form a hybrid concept system. These models are designed to provide ideas for building and comparing concepts at different stages of research, conceptual analysis is used as the primary method for analyzing research materials, such as background information for a study object (Nuopponen 2010a, b, 2011). Components from all models are integrated as satellite systems in a single concept map model, or they are represented separately. In this system analysis, the focus may shift from the core concept to another concept, which combines more concepts around it than the original concept. When comparing concepts based on various theories, methods, previous research results, etc., a separate alternative satellite model is needed to create a basis for comparison like as when analyzing concepts and terms in two.

The iterative review process consisted of multiple phases, summarized in Figure 1. Following theprinciples of Tranfield et al. (2003), the process consists of three main steps: (1) study positioning; (2) study selection and evaluation; and (3) analytical synthesis.

Data acquisition and processing

This study used a convenient sampling procedure to obtain 631 journal articles by searching from the Web of Sciences. In the first step, the process began by searching the database in Web of Science Source Premier, which included journals and peer-reviewed journals Web of Science (WOS), which included the articles from 2010 to August 2021, as interest in university-industry collaboration. The data of the study as summarized systematically under concept analysis from Web of Science were finally processed through SPSS (Statistical Package for the Social Sciences).

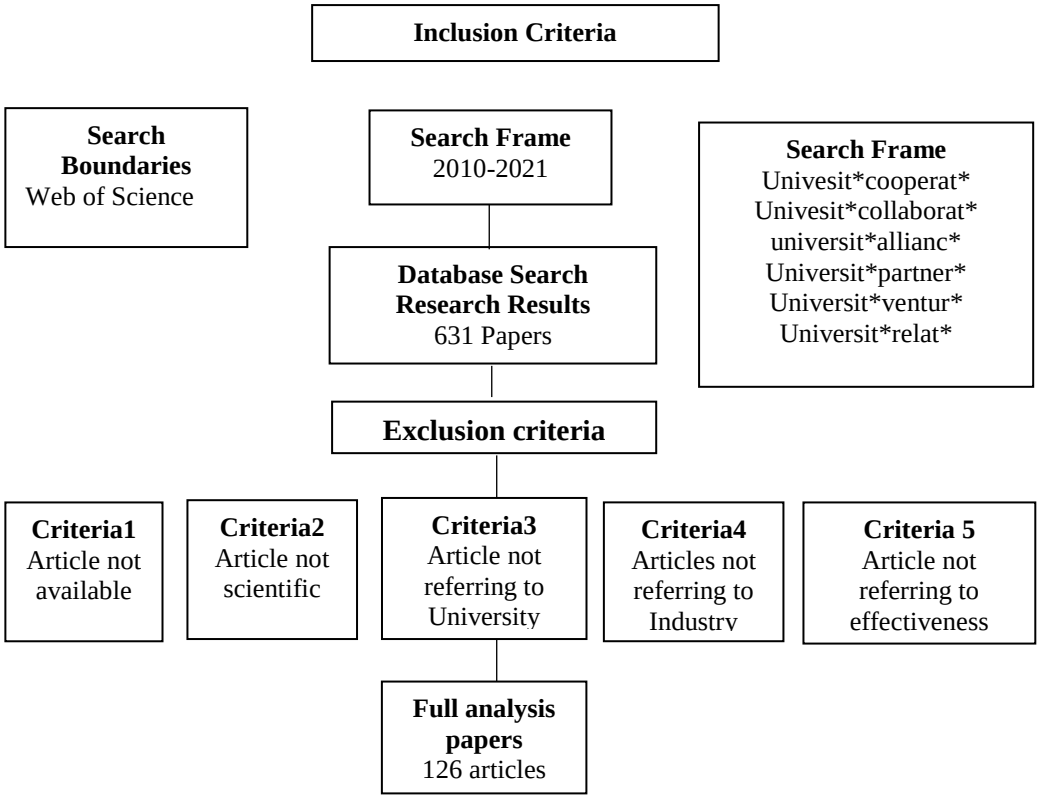

Figure 1: Systematic process
Source: Study, 2021.

The search only includes peer-reviewed papers published in English. The search terms for database search wereb'universit * cooperat *'; 'universit * collaborat *'; 'universit * allianc *'; *''; 'universit * ventur *' and 'universit * partner * '. These terms were sufficient on the one hand to capture the most appropriate article and, on the other hand enough to express a lesser education as a synonym. To ensure comparability, we then avoided using broader and vague terminology, but acknowledge that this may lead to the exclusion of potentially relevant searches. A database searchidentified 631 papers.

In the second step, we selected and evaluated the literature on our research area of catalyst of university and industry collaboration. As suggested by Perkmann & Walsh, (2007), all 631 paperswere evaluated by reviewers who extracted data from these studies. The study hired three research assistants to perform these tasks. The assistant holds a master's degree and is employed in a junior research position at one of the author's universities during the study period. They have research experience and a methodological discussion with them. The iterative

process of analysis and discussion is deliberately designed to achieve a high inter-rater agreement. The author elaborates on the definition of these terms, coding guidelines, and interpretation specifications. The decision regarding the adaptation is the sole responsibility of the author. The evaluators' findings and interpretations were compared to minimize errors, resolve differences, and produce more powerful data sets (Damen. 2018). We developed a set of five exclusion criteria to evaluate each study. Terms that do not meet these criteria are excluded. First, we exclude articles in the comments in the rare case where the file is inaccessible. The second exclusion criterion involves the scientific approach to the paper - we exclude, for example, book reviews or any type of non-scientific article. Using the third and fourth exclusion criteria, we removed articles that entered our search results but did not involve universities (Standard 3) and industry (Standard 4). The fifth exclusion criterion is whether a paper explicitly addresses the factors that influence the success of the collaboration.

Based on the recommendations of Johnson, Buehring, Cassell, & Symon, (2006) and Lopez- Fernandez & Molina-Azorin, (2011), we decided to include extensive research in our inspectionsto capture new insights into our understanding of these factors. To ensure this, the exclusion and in-depth analysis of the article was designed as an iterative process. In this step, some articles are still under investigation but were excluded when in-depth analysis showed that these articles did not ultimately involve success factors. To evaluate and evaluate the article, the above explanation guide was used. Finally, a total of 109 academic papers were excluded during the exclusion process.

The study produced 126 suitable articles that met our inclusion criteria. Of these, 96 included quantitative analysis and 30 qualitative analyses, 24 of which were case studies. In addition, 16 literature reviews were analyzed (we note that some papers use a hybrid approach that is assigned to multiple categories.) A large number of case studies indicated that research on UIC is still largely exploratory.

3.0 RESULTS

After reading all the literature sources and collecting all the information about the catalysts of university-industry research collaborations for innovation which can lead to transformation practice. The explanation below illustrates our study findings on the Catalysts of University-Industry research collaborations for innovation.

The factors driving effective partnerships are the development of a strong understanding not justof each other's needs, but also of their capabilities, working practices, and constraints (related to working with universities/firms). This helps to build mutually beneficial value propositions, more realistic

assessments of what can be achieved together, and an understanding of how to realize value. Central to the sustainability of these partnerships is the ability to adapt to changing needs and conditions.

In striving to understand why some U-I collaborations thrive while others do not, we explained that it comes down to understanding the multi-level heterogeneity of individual preconditions of collaborators. Our findings (fig.2) are consistent with previous findings on the catalysts of university-industry research collaborations for innovation which have concluded the necessity to choose the right partner, but we take a step further to explain how to determine the "right". The three distinct relationship types, that emerged, are each characterized by different levels of individual preconditions and each requires different boundary-crossing mechanisms to be applied. The usage of the most efficient mechanism in turn depends on the match of precondition levels between collaborating partners. So the choice of the "right" has to be made by the individual level of preconditions.

Classification of Influencing factors leads to University-Industry research CollaborationImpacting Innovation practices

In a University-Industry relationship with all participating parties, it is best to look at the key elements that can make the partnership better as shown in Figure 2 below about the classification of Influencing factors that lead to University-Industry research Collaboration Impacting Innovation practices. The finding shows that university-industry research effectiveness is affected by relational factors (65 out of 126 articles) from comparing with others like Institutional, Output, and framework factors as shown below in Figure 2.

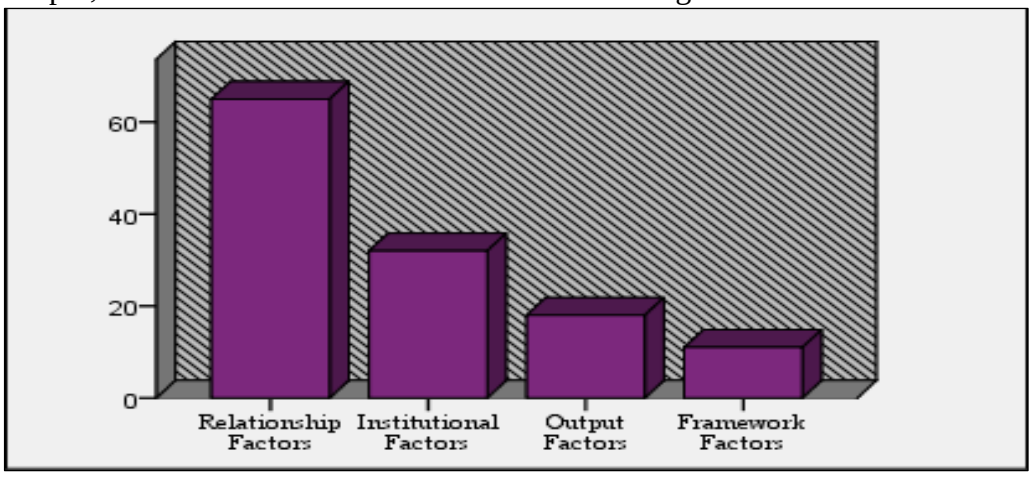

Figure 2: Classification of Influencing factors lead to University-Industry researchCollaboration Impacting Innovation practices

Source: Study, 2021.

As a research project, industrial partners have the potential to treat their academic peers as experts and therefore expect no substantial contribution beyond financial and occasional technical support (Rajalo and Vadi, 2017). As promoters, industrial partners may have realized that they have to pay researchers to do the job, as a form of contract research. These issues canbe easily addressed by ensuring that the roles of each partner (university/ industry) and their responsibilities in the business are communicated and agreed upon from the outset. The forecast of academic and industry partners needs to be consistent throughout.

Balancing factors of University and Industry research collaboration effectiveness

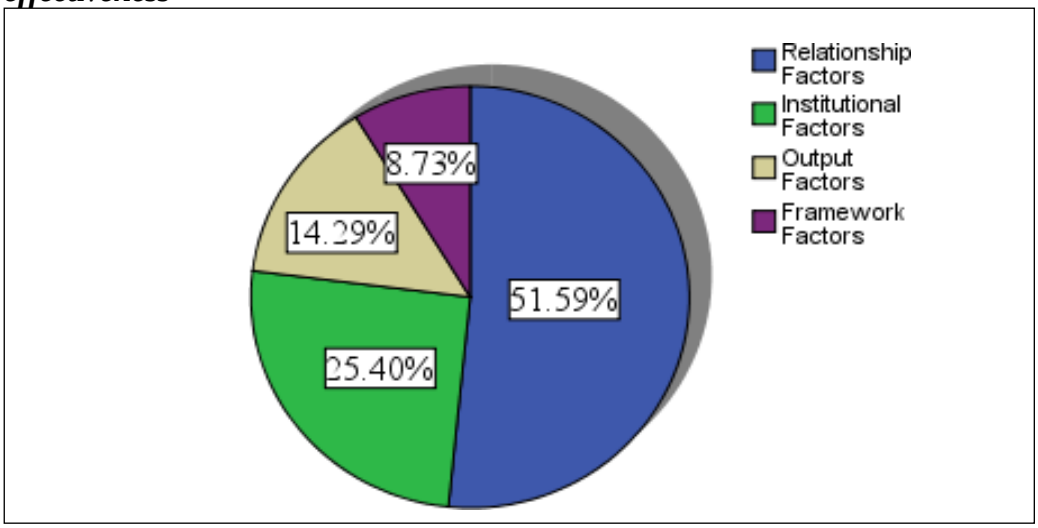

Figure 3: Balancing factors of University and Industry research collaboration effectiveness

Source: Survey, 2021.

Cooperation between universities and industries cannot produce great achievements of research effectiveness without looking at the challenges that hinder them if they are not properly monitored or made public by minimizing their effects and on each side knowing the outcome. The results of our study suggest that a lack of factors related to cooperation (52% such as trust, and better communication contribute to the failure of the partnership or the success. Also, 25% of all articlesindicated that institutional factors such as the structure of the institution, resources, acceptance of flexibility, and many more make the partnership suspected of not being successful or successful to research collaboration between university and industry if they are not properly considered. 14% of all articles indicated that productive factors such as goals and how

knowledge could be transferred from the relevant parties would in part contribute to the success of the partnership. Furthermore, framework factors (9%) including environment, legal contract, stakeholders' distance, and other factors can harm or influence positively the success of research effectiveness between the university and industry. After surveying 126 articles closely we were able to find the factors that enhance university and industry partnerships as described below as follows.

Effective exchanges of information

The study pointed out that some projects tended to use the "Guidance Group" forum as a general forum for discussion and detailed progress review. In this study, the term "steering group" is defined as an organization composed of the main representatives of each partner organization, and meetings are held regularly throughout the cooperation process to discuss policy developments, strategies, directions, and issues. Therefore, it is clear that good practice guidelines for the effective management of university-enterprise interactions in research projects should include encouraging the development of clear communication strategies and setting the frequency of meetings and the measures on which they are based.

Trust

In some case study projects, distrust between partners is sometimes a function of direct competitors in the same project. Evidence suggests that this affects the flow of information between partners or, in some cases, even the main focus of the project – technical issues. Trust between partners has been identified as a key issue affecting the effectiveness and success of collaboration (Kodikara, 2021). Trust between partners, especially those eager to protect technological advantage in a highly competitive industry, takes a lot of time to develop. Ithas been pointed out that trust can take years and repeated cooperation to develop (Goel, 2021). From the observation of the literature review, it is clear that the manager responsible for the entireproject should encourage the development of trust by playing a leading role in creating conditions conducive to its development.

Diverse priorities and perspectives

Research on cultural issues related to academia and industry has identified issues related to academic and industrial collaborators' perspectives, priorities, and differences in values (Fontana,Geuna, et al., 2006; Şendoğdu and Diken, 2013; Rampersad, 2015). Almost all articles analyzed indicate these issues are obvious, although the importance of the problem varies from one research collaborative research to another. One of the reasons for the difficulties is that any university partner uses its research activities to achieve certain important academic goals, such aspublishing research results in academic journals and setting up graduate programs for postgraduate qualifications.

Partner Commitment and Contribution

The findings show that industry partners involved in one of the researches are not always able torespond quickly to the needs of researchers as expected. Industry partners' comments on resources indicate that, despite the real strategic benefits of the project, some partners are still unable to provide sufficient support. Part of the appeal of the company's collaboration is that it can conduct research that cannot be done internally because it provides a way to share the costs and risks of the work.

The commitment of partners has a major impact on industry-university cooperation (Abramo, D'Angelo et al., 2011; Kawasaki, 2016). A high degree of commitment will lead to a situation where both parties can achieve personal and common goals. Sutrisna, Tjia, et al., (2021) comment on the partner literature to support the argument that effective implementation begins with the allocation of sufficient resources, such as funds, people, materials, and time.

Partner Assessment - Implications for Good Practice

In many cases according to the results, it is not possible or feasible to choose a partner; a partner may, to a large extent, be self-selecting based on the organization that is the only one interestedin research and willing to fund the research. In addition, the choice of partners may be limited forpolitical reasons, to meet public funding standards, or to the requirements of appropriate partners with expertise and/or technology. However, even in this case, by evaluating potential partners, considerable gains can be made, so that partnerships can be built around specific situations and the preferred way of working for all relevant people.

Preliminary project progress and fruit formation

The case data contains examples from many industrial partners who are frustrated by the perceived slow progress in the project. Some of the comments indicate that their academic peers should concentrate on providing tangible results. Industrial partners equate the delivery of actual results with evidence of actual progress. Tangible results have been identified through case studies and literature that can be used as a means of improving motivation in future projects (Lemos and Cario, 2017).

Clearly defined objectives and practical goals

Clearly defined goals are very important in the management of any research, which is a vital firstplanning phase. Without a clearly defined goal, the project becomes broad and clumsy, and the results are not the intent or expectations of the participants. While the nature of research projects often makes it difficult to predict the result, well-defined goals (even if they change as the project

progresses) provide the basis for a strong and focused research process. A collaborative project can suffer from a lot of misunderstandings and unrealistic expectations without clearly defining and communicating goals (Ryan and Daly, 2019).

Research setting up and advancement monitoring

Some of the papers in this research problem (usually industrial partners) show that there isfrustration at their perceived slow progress in the project and poor project planning. The development of a mutually agreed project plan has been identified as an important success factor in the published literature (Mathisen and Jorgensen, 2021). The initial expression of slow progress in some projects, mainly expressed by industrial partners, maybe just a function of their impatience in achieving results. As a result, they can gain a significant competitive advantage in a rapidly changing, highly competitive market.

Chief researcher role

Although research managers are considered to play an important role in the effective management of any project (Ali, Ali et al., 2018), the study also highlights the important role that Principal Investigators/Researchers play in university-industry cooperation. It has been suggested that the authority of project managers is limited due to cooperation across organizational boundaries (Moeliodihardjo, Soemardi et al., 2012). In the area studied here, it is clear that the project manager (designated by the major industrial partners in each case) has little leverage to ensure that researchers follow their briefings and agreed timelines. However, these problems are reduced when the lead researcher is responsible for managing research work and research activities. Given that university researchers perform a significant percentage of work on all projects, it is logical to divide project management responsibilities in this way.

Continuity of Personnel

The lack of continuity of personnel is another issue raised in articles. This factor is also closely related to trust because trust tends to develop on a personal-specific basis (if not more) rather than on a company-specific basis (Plewa, Korff et al., 2013). It was found that in some research projects, there were some personnel changes in the representatives of the partner companies. This in itself raises some concerns because it is necessary to give a brief introduction to each new contact, so the progress of the project is sometimes limited. However, the personnel of the major industrial partners responsible for the research management changes. Some industrial partners do not express appreciation for the changes, which they believe are the main industrial partners' lack of commitment to related research, the inability to select effective individuals from the outset, or the attempt to “breathe new” evidence. Therefore, lack of

continuity in the cooperation is destructive, it is not advisable, but the changes in research management personnel attract the greatest attention. However, this change is difficult to prevent.

Government/Regulatory authority

The role of the government is to build infrastructure that attracts human resources and technology flows.Financial incentives and regulations are the two main policy instruments. The government plays a very important role in R&D and industry-university cooperation. The government provides a wide range of services such as financial support, tax cuts, and the establishment of scientific industrial parks, university and industrial cooperation centers, research centers, and incubators (Silva, Ribeiro et al., 2020). Quaglione, Muscio, et al. (2014) confirm the complementary between various forms of public research funding and funding from consulting and contract research activities, consistent with other recent scientific contributions. In theory, there is a positive relationship between public funds and funds obtainedfrom contract research and consulting institutions. As long as the knowledge base is expanded and the technical and human capital supported by public research funds is accumulated, the marginal rate of return (or incremental growth) is increased. The World Bank (2000) pointed out that higher education systems in developing countries rely on additional resources to catch up with academics and research compared to developed countries.

Corporate steadiness

The literature review provided examples of the impact of unstable partners and the impact ofthis on the success of the collaboration. Study evidence from one of the industry partners shows that when joining one of the projects, the company has undergone a change of ownership and a thorough change of the senior management team. The project is the first collaboration of the newmanagement team. However, due to the large amount of organizational turmoil caused by the company's recent historical changes, the company's representative of the project said that the cooperation has not received the attention or support it should have. The lack of attention from the project manager did not attract attention, and he was disappointed with the company's apparent lack of interest and contribution to cooperation.

Exclusive interest

The main focus of partners in research collaboration is their results and the benefits of collaborative activities. Thus, the literature suggests that perceptions of the benefits of interest can have a significant impact on the behavior of partners throughout the collaborative process and their perceived perception of success

(Malik, Bashir, et al., 2021). For the project under study, the impact of the perceived proprietary benefits of the partner is observed.

It is particularly noteworthy that the participation experience of the two partners is that their participation is almost superfluous for the projects involved in the change of project direction. Therefore, in both cases, partners believe that their participation in the project has little benefit.In particular, one of the partners involved withdrew from the project before completing the project, because in the words of the company's participants, “we did not get a reasonable return on investment”.

4.0 DISCUSSION

Based on the literature review, the analysis of this paper introduced the rationale of university and industry research collaboration leading to innovation which reflects to factors influencing their success. The survey results show that U-I research interactions are influenced by relationship factors(52%), followed by institution factors (25%). These results imply that industry and universities should focus more on relational factors to build stronger partnerships. A partner assessment approach is needed to ensure that partners are truly interested and committed to the intended research direction and can support them with adequate resources. From the very beginning, how many industrial partners should actively contribute to the work. Provide high-quality project management, especially in terms of goal setting, progress monitoring, effective communication, and deployment of trained high-quality project managers. The literature shows that factors such as trust, commitment, and continuity are critical to the success of collaboration and promote innovation. This research reinforces this discovery and provides some further insights to enable practitioners to better manage these key issues. The management process needs to be flexible enough to respond to changes in the external environment. This includes the ability to manage company changes (within industrial partners) and changes in strategy or project direction. The model needs to include factors that maintain the interests and commitments of university-industry partners. These include ensuring that sufficient proprietary benefits are achieved and that tangible results are achieved through early planning of the project and then throughout the duration of the phase. The model needs to reflect the importance of achieving mutual benefit, namely ensuring an appropriate balance between academic goals and industrial priorities, and paying special attention when determining the role of researchers. Each stakeholder should first consider what he or she has done before entering into partnership agreements. Each of the barriers mentioned above should be properly addressed to develop good partnerships that can in the long run bring benefits to all parties.

5.0 CONCLUSION

This study examined and discussed important evidence available in published literature relating to the rationale of university and industry research collaboration leading to innovation practices. This research raises the various factors that influence the success of university and industry cooperation effectiveness, and this knowledge is important to manage this relationship for the acceleration of innovation. As advocated by Hanid, Mohamed et al. (2019) universities and industry need to be aware that successful strategic collaboration is based on the interaction of individuals (52%) rather than organizations or institutions (25%). Mutual trust is critical to building relationships and enabling UIC to thrive in long-term cooperation in the future important findings about collaborative practices that depend on organizational and individual habitats, knowledge aspects, and interactions are the source of university-industry alliances. Research shows that universities, organizations, and research institutions are looking for the best factors that can help them build long-term relationships that foster innovation. In terms of research, partnerships between universities and industry are still in their infancy. This is due to a lack of communication between both parties, low awareness among industry owners, and below-average commitment and ability of university leadership to build such connections. From the results of the study, other important motivating factors were the intuitive factor and trust. In addition, the paper concludes with a discussion of the relevant implications for universities, industry, research institutions, management, and policy-making, pointing out the direction According to the study, implications are discussed at three different levels: the researcher, the organization, and the government. Conclusions provide researchers and policymakers with the opportunity to consider opportunities and limitations to improve the relationship between educational research and its potential users that can make useful linkages that impact innovation. All parties involved should focus their efforts on ensuring that each party knows and performs his/her duties that can encourage the link.

Future research should concentrate on further validation of these findings to make good cooperation between academic institutions and firms. Such work would enable further testing and refinement of the best relationship so that its usefulness as a tool for practitioners may be maximized.

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