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Influential Factors for ICT Innovations in Sri Lanka University-Industry Collaboration: A Systematic Literature Review

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Abstract. *A university is a center of knowledge creation, and industry can be a vibrant place for innovation. This paper examines the key factors influencing university-industry collaboration (UIC) innovation catalysts in Sri Lanka. The study employed a systematic procedure based on the Grounded Theory to investigate the factors contributing to the success of UICs, and attributes for innovation capacities. The investigation was guided by the research question: what factors of UICs influence ICT innovations in Sri Lanka? A total of 41 research papers was selected from Science Direct, Scopus, and Ebscohost based on the availability of full text, and their relevance for the research question. The results of the study revealed that management directives, financial support, policies, proximity dimension, and heterogeneity are key factors for a successful UIC.*

Keywords: *Innovation, Sri Lanka, Systematic Literature Review, University-Industry Collaboration*

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1. Introduction

A university is a hub of knowledge production that can contribute to innovations in a number of ways. In such a context, UIC is emerging as a critical component of the innovation process (InterregEurope, 2020). Therefore, industries are increasingly recognizing the importance of scientific knowledge creation and seeking collaborations with universities (Tseng et al., 2020). Spencer (2003) reveals that firms that share relevant knowledge with their innovation system have earned higher innovative performance than firms that did not share their knowledge. The innovation system consists of institutions and resources established as a result of the interaction among universities, research institutes and firms. However, there are many differences between developed countries and developing countries in this regard. While developed countries are benefited from UIC, developing countries are facing many challenges which need to be overcome. The universities in developing countries, for instance, are facing a higher level of resource scarcity with respect to finance, physical infrastructure, and capabilities. Yet, there are some UIC models that exist in the world scientific literature which can be adopted for developing countries following an evaluation of the local context.

Innovation is the process of *making changes to something established by introducing something new* (Pearsall & Hanks, 1998). Further, Marrello (2007) describes five discrete stages in the innovation process

as idea generation and mobilization, advocacy and screening, experimentation, commercialization, and diffusion and implementation. The commercialization stage is significant as inventions are normally considered as such only when they have been commercialized. The term invention is something that is often confused with the term innovation by many people. But innovation is different from invention. An invention does not need to fulfill any useful customer needs, but innovation is expected to fulfill customer requirements. Therefore, an invention never becomes an innovation if the invention cannot be brought to the marketplace. For achieving this purpose, the collaboration between universities and industry becomes instrumental.

UIC can be established at different levels in the innovation process. Organizational innovation might concern services, products, or processors. Innovation can be radical, or it can be incremental. Addressing these aspects, Handen (2014) has defined innovation as *the process of making changes, large and small, radical and incremental, to products, processes, and services that results in the introduction of something new for the organization that adds value to customers and contributes to the knowledge store of the organization. (p.5)* Other terminologies used in the definition include radical innovation and incremental innovation, where radical innovation is about making major changes to something already established, while incremental innovation means an addition to an existing innovation with relatively minor technological changes. ICT innovation is a subclass of innovations that embed computational solutions and artifacts into the innovation space. Furthermore, measuring innovation capacity is troublesome as indicators have to account for many different forms of innovations. Gann & Dodgson (2019) suggest that if the government policies for innovation are informed, quantitative indicators to measure innovation can be complemented through qualitative case studies.

The motivation to study the factors which influence a successful UIC to escalate innovation and how it can be adopted in Sri Lanka has arisen from the related literature from other countries as well as the prevailing situation in Sri Lanka. According to the National Export Strategy of Sri Lanka (2018), the country is targeting to drive export growth through innovation and entrepreneurship while improving the supply of skilled and highly qualified professionals to satisfy the Information Technology- Business Process Management (IT-BPM) market. Among its operational objectives to achieve the goals, encouraging youth for innovation, increasing the industry-relevant talent workforce, and enabling access to the global talents are some factors that provide further motivation to study influencing factors for innovations in the country. Hence, the study's primary focus is on how UICs can be used to improve the innovation ecosystem in Sri Lanka. However, our suggestions, to a certain extent, are of relevance for other countries as well, depending on the political and economic contexts of those countries.

1.1 Sri Lanka UIC at a glance

Sri Lanka is a developing country located in the south of the Indian Ocean with a 21.8 million population. With a GDP per capita of USD 3,853, Sri Lanka is categorized as a middle-income country by the World Bank (*The World Bank in Sri Lanka*, 2020). Sri Lanka was ranked at position 54 among 137 countries in the university-industry research and development ranking 2017, which is a drop by 15 in comparison to its position in 2007. Sri Lanka secured the second position in the South Asian region (Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka) but was in the first position in 2007. (India was at position 26 in the global ranking in 2017 and has now secured the first place in the South Indian region moving up from the second place held in 2007, cf. (The World Bank, 2017)). The Global innovation index report 2019 ranked Sri Lanka, in line with the expectations for this level of development, at in the 89th position among 129 countries (Cornell University, INSEAD, 2019), which is a drop by one position compared to the previous year.

There are 15 state universities in Sri Lanka governed by its apex body, University Grants Commission (UGC) Sri Lanka. Also, there are a few other higher education institutes established by the acts of the parliament of Sri Lanka (*UGC*, 2020). State universities dominate the higher education system in Sri Lanka although there are a few privately owned higher education institutes registered and accredited by UGC offering degree programs.

1.2 Problem Statement

Historically, Sri Lankan universities tend to have a low level of Research & Development (R & D) activities, and the industries are not maintaining a significant record of R & D expenditure, absorption of new technologies, or innovations in terms of patents issued. A study conducted by Weerasinghe & Jayawardane (2018) reveals that there is a positive trend towards innovations in Sri Lankan universities, which is a promising indication for the future, but this is still in a very weak condition. Teaching is the main task of academia, but the traditional educational setup practiced in universities is not supportive in developing an innovative mindset among undergraduates in general. In most instances, UICs are conducted in an ad-hoc manner and mainly through personal contacts (Wijesinghe et al., 2018). The main activity between the industry and university is the undergraduate internship placement. Among other activities, universities conduct seminars, workshops, and lectures for students, and schedule faculty visits industry for consultation works. All these activities are based on personal contacts between the industry and the faculty (ibid.). The study further claim that there is a large number of researches and projects conducted by university students which are not considered elsewhere after the graduation, overlooking

the fact that these research ideas might have the potential to be commercialized via industrial collaborations. Sri Lanka is thus facing many challenges for conducting successful UICs for bringing about a more successful innovation climate. At the same time, there are many countries where UICs are considerably more successful. Among these, UICs in the field of ICT are quite prominent. Being a field that is in a constant state of advancement, ICT has a strong link to the development of a country (Martínez-Frías, 2003). The marketability of many innovations becomes higher when they are influenced by ICT. Therefore, this study is focused on which factors of UICs influence ICT innovations in Sri Lanka.

2. Literature Review

Since early 2000, more attention has been paid to University-Industry Collaboration (UIC). With the rapid evolution of such activities in many countries, there have, more recently, been published a large number of research papers focusing on the innovation possibilities from such collaborations (Ankrah & Al-tabbaa, 2015, 2017). Significantly, there has been an exponential increase in the topic during the last decade (see Figure 1).

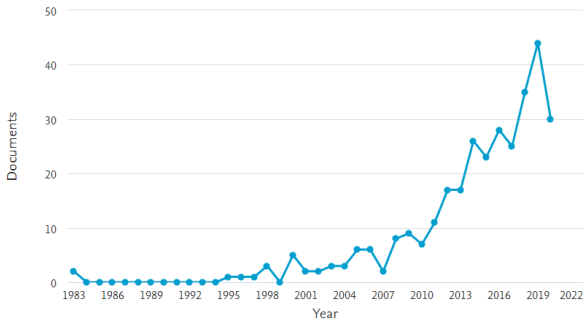

Fig. 1 Yearly number of articles in the UIC field from SCOPUS.

The knowledge production in the field is fragmented and transdisciplinary as well as interdependent, but a systematic literature review can bring the field closer together (Tranfield et al., 2003). The knowledge contribution to various issues of different countries and economies is significant and can be used to address similar issues in other countries. In any National Innovation System, successful UICs bring numerous benefits and improvements in the innovation capacity of universities and industries that have had an impact on the national economy of the country (Wickramasinghe & Malik, 2018). Furthermore, many general findings have been replicated in other countries where the political and economic situation is similar to where the initial studies have been done.

Despite the large amount of studies conducted on the topic, there are still comparatively few systematic literature reviews addressing the various aspects of UICs, and there still seems to be considerable fragmentation within the discipline. Among the recently published systematic literature reviews, Rybnicek & Königsgruber (2019) have studied some important factors influencing the success of UIC. Further, Jugend et al. (2020) have contributed to the field by assessing what types of public practices are supportive of innovation, while Mascarenhas et al. (2018) have presented co-cited clusters in the UIC area, as well as some current research trends. Another systematic literature review on the same topic was conducted by Hossinger et al. (2020), exploring critical driving and impeding factors for the success of academic spinoffs. Sjöö & Hellström (2019) have conducted a review of innovation-related UICs, focusing on research and development activities, where they suggest seven key factors for stimulating collaborative innovations.

In developing countries, the education system, industries, and economy are significantly different from developed countries and the latter usually has a capacity to potentially gain more from UICs, while developing countries are facing a variety of added challenges. The circumstances are different because many aspects of UIC stimulating activities in developed countries are likely to be less adequate for implementation in a developing country context. In this paper, we identify factors in UIC which are influential for innovation and applicable from the perspective of a developing country such as Sri Lanka.

2.1 Theoretical framework

A good theory should be memorable and find answers to why (Webster & Watson, 2002) and at the same time, it should be falsifiable and useful (Sutton & Staw, 1995). The authors of the present study explicated the guidelines provided by Webster & Watson (2002) for identifying a theory for literature review. Wolfswinkel et al. (2011) have demonstrated the value of Grounded Theory for rigorously analyzing a carefully chosen set of studies. Grounded Theory comprises a distinctive methodology and a set of procedures for analyzing qualitative data. In line with these approaches, a five-

stage approach is adopted for the systematic literature review process: (1) defining the literature inclusion and exclusion criteria, (2) literature search (3) refining the literature (4) analyzing of selected literature, and (5) presentation of findings. The five-stage process and their subcomponents are described in the methodology section and the findings section.

3. Methodology

3.1 Defining inclusion and exclusion criteria

Ensuring the quality of review data, the search strategy covered only peer-reviewed journal articles and excluded book chapters, dissertations, and book reviews. The search terms used were "University-Industry Collaboration", "University Business Collaboration", University Business Alliance" and "Innovation". Since the present study is mainly focusing on ICT innovation, studies conducted within the last ten years were considered more relevant, due to the rapidly changing nature of the ICT industry. Therefore, the search was limited to articles published between the years 2010 to 2020. We also limited the selection of articles to research papers written in English. The criteria for inclusion and exclusion were based on the relevance of the articles for the objective of identifying catalysts to escalate innovations. There were no constraints regarding the application area apart from the above.

3.2 Literature search

The authors have selected three well-known research databases, namely, Web of Science, Scopus, and EBSCOhost Business Source Premier for the literature search since these databases have significant coverage of Information Systems (IS) journals and conference publications. Using the above-mentioned search terms, the search was limited to words in titles, keywords, and abstracts. The use of Boolean operators including synonyms increased the coverage of the background concepts. Using this searching mechanism, a total of 423 articles in ScienceDirect, 317 articles in Scopus, and 143 articles in EBSCOhost Business Source Premier were found.

3.3 Refining the literature

At this stage, the sample of texts was finalized. For instance, there were duplicates of articles found in three databases, and the articles were refined by removing duplicates. The articles were then post-selected based on the availability of full texts and the UIC relevance was determined by reading the abstracts and titles. This process narrowed down the number of articles to 108. From this set, further selection was done from the abstracts concerned with the identification of factors for improving innovation through UIC. After this process, there remained 51 articles that were selected for a full paper analysis. Yet, ten studies without the relevant focus remained, and these were excluded before the final analysis and synthesis. The key findings of the remaining 41 articles were used for the analysis as described in the next sub-section.

3.4 Analysis of the literature

Analysis of the literature consists of engaging in three types of coding, named 'open coding', 'axial coding', and 'selective coding' (Wolfswinkel et al., 2011). At the beginning of the analysis stage, articles are selected randomly and read for developing open codes. Findings and insights are highlighted in the text which is relevant to the scope of the study and the research question. Every word, sentence, or paragraph highlighted in each article represents an 'excerpt'. These excerpts were read repeatedly until a number of 'concepts' starts to appear in the author's mind, and these were then annotated. This way, all the excerpts were incorporated into a set of concepts or insights. At this stage, a codebook was maintained to keep track of the concepts and insights noted. The categorical view of the concepts is the open codes, and higher-order categories will eventually represent themes of the study. Upon identifying open codes, conceptual similarities of the open codes to generate axial codes were identified. These axial codes are the interrelationship between categories and their subcategories. Finally, after refining and integrating the higher-order categories, five selective codes were generated as the main themes in the study.

A data extraction form was used to minimize human errors and biases, via the inclusion of a table containing titles, authors, keywords, methods used, and publication details of the study in addition to the excerpts, categories, and subcategories.

Among the finally selected papers, there were 15 qualitative studies, 25 quantitative studies, and one mixed-method study.

4. Results

From the analysis of literature, five themes were identified, namely: Management directives, Financial support, Proximity dimension, Policy implications, and Heterogeneity. In the analysis of these, we use, inter alia, innovation climate rather generically, and measure this concept by the number of UIC forums and conferences held by the university, the number of Intellectual Property (IP) produced, relevant courses conducted by the university as well as the number of entrepreneurial contests conducted in the university.

4.1 Management Directives

A formal UIC management mechanism is a strong factor that has a significant impact on the academic innovation performance of universities. Those with a good innovation environment included a viable relationship between the UIC management and the developers, while universities with a weak connection between the two, performed worse (Huang & Chen, 2017). Kesting et al. (2018) propose a partly decentralized approach, supported and coordinated by a Technology Transfer Office (TTO) located in universities. In this setting, university management can direct TTO to take over tasks such as information gathering as well as creating and maintaining industry databases for innovation-related collaborations. More generally, when more staff are dedicated to UIC services, adequate management directives may stimulate UIC activities in universities and lead to academic innovations.

Therefore, university management should foster new technologies to improve internal processes as well as services that are more successful than projects on new product development (Wynn, 2018). They also need to have a good understanding of their partners in terms of the culture and the nature of the business before initiating collaboration. Bodas Freitas et al. (2013) argue that collaboration with actors in emerging industries is more productive than collaboration with mature industry companies. This is because emergent industries are more focused on new product development and training, and using new or improved processes as complementary outputs. University management can improve the motivation for collaboration with industry partners by identifying motivation gaps, and then developing skills and willingness to acquire, assimilate, transform, and exploit external new knowledge. Offering a practical suggestion to this, Kobarg et al. (2018) suggest an innovation competency model should be developed by universities including components such as creativity, enterprising, integrating perspectives, forecasting, and managing challenges. Further, Jumakulov et al. (2019) have suggested that a UIC based industrial innovation program can be developed to produce graduates as agents for innovations.

In promoting such collaborations, initial trust based on a professional reputation is an important factor as it reflects the confidence at the outset (Oliver et al., 2019). Management should, therefore, inculcate good practices such as systematized decision making, consistency in agreements, open participation, honesty, and helpfulness for building trust in long term collaborations (Striukova & Rayna, 2015; Temel & Glassman, 2013). For a successful knowledge transfer with higher innovation success, collaboration should be strongly problem-oriented and both parties should be benefited (Brem & Radziwon, 2017).

Absorptive capacity is an agent´s ability to recognize the value of new information, assimilate, and apply it into the business. Hence, absorptive capacity and strong motivation of the collaboration partners are indeed relevant factors for successful knowledge transfer (Rajalo & Vadi, 2017), which can mediate the relationship between university and technology innovations (Subramonian & Rasiah, 2016). Industries that maintain a fruitful collaboration with suppliers and clients, generally have collaborations with universities to a higher extent. High-tech companies, in particular, are more likely to cooperate with universities than other companies (Fernández López et al., 2015). In contrast, industries with shorter supply chains and low demand for knowledge workers and ICTs also have a low demand for university collaborations (Jackson et al., 2018). Therefore, the type of industry and its complexity are crucial elements for university management to establish a successful industrial collaboration.

The academic quality of the collaborating universities is also important, and the ranking of the university significantly affects the cooperation. As Szücs (2018) observes, innovation activities, and projects involving more highly ranked universities generally lead to an improved innovation climate.

When examining the challenges for establishing such collaborations, it has been observed that the usually heavy administrative workload on academics may be a diminishing factor for an effective UIC. For instance, a study in China (Hou et al., 2019) shows that some UICs have a negative effect on innovation, and the authors assume that this is an effect of the heavy administrative interventions of the Chinese university system. On the other hand, the same study shows that Research Institute and Industry Collaborations (RIICs) promote the innovation capacity, as an effect of the lesser administrative workload for research institutes imposed by the central government. Within the past decade, research institutes were encouraged to compete freely and to commercialize their scientific results. This is confirmed by Hou et al. (2019), claiming that research institutes are more effective than universities in collaborating with the industry sector when it comes to industrial innovations. The study also emphasized that academia spent more time teaching and publishing, and considerably less time engaging with industries, while research institutes are more inclined to cooperate with industries for their survival.

Since UIC is a recent phenomenon in Sri Lanka, there is a lack of adequate leadership and monitoring within the university sector (Wickramasinghe & Malik, 2016). Esham (2008) and Wickramasinghe & Malik (2016) suggest the establishment of a higher-level body comprising university and industry representatives to provide guidance for UIC.

4.2 Financial Support

Financial support received by universities plays an important role when conducting research and development as well as other activities relating to innovations. Tseng et al. (2020) have identified three fundamental factors of UIC funding and universities'

technological innovation performance, namely, management mechanisms, innovation climate, and reward system. The study shows that UIC funding is directly instrumental for universities' technology innovation as well as UIC management mechanisms. Furthermore, Ranga et al. (2017) show that the financial support received by universities is a key factor for transitioning from a national innovation system to a global innovation system. According to Hou et al. (2019), UIC exerts a negative impact on innovation efficiency in China, but the efficiency of the innovation process can be improved by government funding.

Szücs (2018) has found that the success of a project in terms of innovation, strongly depends on the number of participants in the projects, and the actual funding received by the universities involved. Universities should thus strategically choose funding sources. In Taiwan, government funding has had a greater impact on implementing regulations for UICs, while industrial funding has had a greater impact on developing the UIC management (Fan et al., 2019; Huang & Chen, 2017). Furthermore, industrial funding exerts a positive influence on the number of innovations by a university. In China, governmental funding has had a more significant impact on knowledge output, as measured in research papers and patents, than industrial funding (Cheng et al., 2020). Funding from government and industry partners in combination with reward programs has improved the innovation climate in universities and also enhanced the opportunities for joint ventures with universities (Tseng et al., 2020).

More particularly, Sri Lankan universities are mainly based on government funding and have not nurtured many industrial partnerships. The government funding is mainly aimed at producing employable graduates. Therefore, they are primarily emphasizing teaching and not research and development (Weerasinghe & Jayawardane, 2018). On the other hand, industries are reluctant to allocate funding for research activities, despite these being important for the willingness of universities to collaborate with the industry's R&D activities (Wickramasinghe & Malik, 2018). Yet, the financial allocation for higher education from the government bill is small as the government has prioritized other development activities. This urges universities to increase collaborative activities with the industry and find adequate funding for innovation activities.

4.3 Policy Implications

UIC policy formation is a central element in the innovation framework. Adequate UIC policies have positive effects at each stage of the innovation process (Cheng et al., 2020). However, policies should be implemented in a way that industries can invest in universities for research and development activities as well as for sharing knowledge and information rather than making the collaboration process cumbersome by creating limitations.

A study in China conducted by Shi et al. (2020) argues that to use the advantage of UIC fully, authorities should design policies to remove identified barriers for collaboration and reduce the associated costs for companies when starting their first collaboration. The study also argues that both academics and companies should get training in initiating and maintaining collaboration activities. Furthermore, policymakers should be aware of how innovation processes work. Policies should also consider equity allocation for ownership when commercializing intellectual property and the associated regulatory frameworks (Zhang et al., 2017). Another component of an innovation policy is increased responsiveness to social needs and social reforms (Ranga et al., 2017). Rantala & Ukko (2018) have found that Small and Medium Enterprises (SMEs) in Finland are interested in performance measurement of societal level outputs by UICs. The performance measurements in policies should support both innovation and regional development to stimulate technology and knowledge transfer as well as assist in identifying relevant research areas to fund (Calcagnini et al., 2016). Bodas Freitas et al. (2013) suggest that policies should target the development of human skills, technology infrastructures, and the creation of macroeconomic stability, promote industry incentives, and stimulate the market and non-market institutions by utilizing regulatory frameworks, IPRs, standards, codes of good industry practices etc.

Chandran et al. (2014) suggest that adequate policies might encourage industries in R&D activities to utilize university knowledge for improving their innovation performance. They also argue for demand-driven R&D activities, especially among universities and policymakers, on how to promote commercialization and make universities useful for industries in situations where industrial R&D is missing. A well-established knowledge transfer mechanism can here escalate technology innovations (Subramonian & Rasiah, 2016). The absorptive capacity of small companies can also be improved by knowledge transfer programs (Fukugawa, 2017). Further, Yoon (2015) suggests that policies should include Government Research Institutes (GRI) and universities to support SME by facilitating knowledge transfer and commercialization to stimulate innovations. This has been suggested by Yoon studying South Korea's evolution of the innovation system.

Steinmo (2015) raises another important policy factor indicating that firms can develop cognitive and relational social capital by collaborating with universities to enhance effective collaboration in research alliances for creating knowledge and innovation. However, national policies targeting high-tech industries may be ineffective as policies may reinforce over-investment and excessive competition (Bodas Freitas et al., 2013). This is because national governments worldwide target collaboration with high-tech industries and the authors emphasize that the value of collaboration seems to depend on the companies´

knowledge bases. Hadidi & Kirby (2015) emphasizes the importance of recognizing universities and including higher education in innovation policies, while Guimón & Salazar-Elena (2015) suggest policies to be implemented for collaborating with foreign subsidiaries to link national innovation systems with global innovation networks.

In particular, UIC policies in Sri Lanka should be introduced by the government at a national level, mainly addressing the areas of funding, regulatory measures, shaping the rules for governing the UIC, and establishment of intermediary organizations such as business incubators, science parks, and technology transfer offices (Larsen et al., 2016). Partnerships can be initiated with diversified entities such as universities, industries, government, research institutes, and non-governmental organizations. In many countries, these partnerships are initiated by the government to increase competitiveness. Universities can create policies to establish UIC units for commercializing R&D activities with adequate industrial partners (Wickramasinghe & Malik, 2018).

4.4 The Proximity Dimension

The proximity dimension can be measured geographically or cognitively. Geographic proximity concerns the physical distance between the university and the industry, and cognitive proximity refers to the ability to gain and interpret new knowledge related to the collaboration goals. Geographic proximity plays an important role in the face to face interaction between actors, but this alone is not sufficient for effective collaboration. The other important factor for effective collaboration is cognitive proximity, which is important for stimulating the interactions between university and industry (Garcia et al., 2018). The study also shows that cognitive proximity can substitute for geographical proximity when collaborative partners are cognitively close and they can stimulate the physical interaction even if partners are largely geographically distanced. Garcia et al. (2018) show that companies with higher absorptive capacity can more effectively collaborate with geographically distant universities when, for instance, handling complex innovation problems. Arant et al. (2019) state that it is easier to overcome a geographic distance than a cognitive distance between academia and industry, because cognitive proximity is more important than geographical proximity for radical innovations. When there is no cognitive distance, collaborating partners can cross-fertilize the ideas even if they are physically distant, rather than stemming ideas from completely different knowledge bases with closely located partners. Ponds et al. (2010) confirm that geographic proximity is less important in science-based collaborative research and that the impact on regional innovations is mediated by geographic proximity and UICs.

This also applies to Sri Lanka, as most of the industries are located in the commercial capital of Colombo, but universities are distributed over the Island. This has created a challenge for many UIC activities, and it is aggravated by poor transport infrastructure. Weerasinghe & Jayawardane (2015) claim that industries in Sri Lanka neither use external knowledge sources nor have sufficient links with external companies to absorb new knowledge into their innovation activities, resulting in a poor innovation climate. Therefore, the authors further claim that strategic initiatives should be taken to promote the companies´ absorptive capacity for innovations.

4.5 Heterogeneity

Universities can collaborate with many industries, and these collaborations can be established at various stages of the innovation process. The innovation process consists of two separate stages: - invention and innovation. Universities are centers of knowledge creation and industries provide opportunities for commercialization. Industries can join universities from the beginning, i.e., the idea generation stage of the invention, or otherwise, they can join at the commercialization stage of the innovation process. Many studies show that the diversity of industries and the stage where they step into the innovation process affect the outcomes. For instance, Walsh et al. (2016) state that heterogeneity in collaboration generally implies a higher invention quality. The vertical collaboration during the inventing stage is more important for commercialization success than a collaboration during the implementation stage. Their study thus reveals that various forms of collaborative innovations may vary, depending on the stage of the innovation process where the collaboration is initiated. Gretsch et al. (2019) confirm that UICs are generally more supportive during the initial stages of the innovation process, i.e., during the idea generation and evaluation processes, but do not directly impact the degree of innovativeness. The study also shows that a parallel collaboration (simultaneous collaborations with multiple partners) between universities and industrial partners stimulates highly innovative front-end activities. When collaborating with multiple industries, universities must put in greater effort to enable effective and efficient management of parallel activities. However, for incremental innovations, collaboration with several types of partners is not more supportive than collaboration with a single type of partner. Meyer et al. (2019).

According to Lin (2017), the increase in the number of UICs, will increase academic innovation capacity, given that there is a manageable number of collaborations in any partnership setting. The university contribution and knowledge capacity can then empower UICs. Lin (2017) and Attia (2015) both suggest that a moderate number of industry collaborations positively influences the innovation climate up to a certain threshold, while a wider collaboration breadth has a negative effect. While many studies address the effects of quantity in collaborations, Bruno et al. (2018) suggest that the quality of the collaboration is a stronger

predictor than which universities are involved.

While universities in many countries are using heterogeneous collaboration activities, Sri Lankan universities are not showing strong evidence of conducting heterogeneous partnerships in innovative activities.

5. Factors impeding UIC in Sri Lanka

While universities and industries in many countries are benefitted by UIC, Sri Lanka is yet to address some pertaining issues to mitigate its low level of collaborations and innovation eco system. Weerasinghe (2017) claims that the prevailing culture within the universities of Sri Lanka is not supportive of UIC and that they are mostly teaching-oriented. The lack of resource availability in the universities and a frequent change of government policies also hinder successful collaboration. Small and Medium Enterprises (SME) are reluctant to visit universities for knowledge exchanges as they are unaware of the university capacities and believe that universities are unable to solve industrial problems (Weerasinghe & Jayawardane, 2018). Moreover, Wickramasinghe & Malik (2018) claim that universities and industries in Sri Lanka "*speak different languages*" and they are partly disconnected not knowing what they can offer each other. To overcome this, Esham (2008) proposes that the government should establish a "*University-Industry Community Interaction Center (UICIC)*", under the supervision of the University Grants Commission of Sri Lanka, and establish centers in each university to coordinate with UIC. However, this has neither been realized nor been incorporated in the development agendas. Wijesinghe et al. (2018) show that university faculty members are tightly scheduled for academic work only, which hampers the possibilities for the intellectuals of the country to engage in industrial collaborations. The study further suggest that the establishment of UICs could be facilitated through a common IT-based application designed to reduce some geographic proximity barriers and limitations in resource planning to partly overcome this problem.

6. Findings and Discussion

6.1 Findings

Based on the insights drawn from the literature review, the authors of the present study have arrived at several significant findings. A formal UIC management mechanism should be established with selected collaborating partners. This should build on trust and be dedicated to long-term partnerships. Emerging industries that are focused on high-tech development are more appropriate strategical partners than mature, well-established industries. When planning for the collaboration, it is necessary to consider the demand for knowledge workers, the actual use of ICTs, and the supply chain of the industry partners. The university management should organize innovative and entrepreneurial activities together with industrial partners to inculcate the innovation mindset of the university students. Furthermore, academics are often overloaded with teaching and administrative tasks, which hinders academics from engaging in UICs. The university management needs to pay more attention to academic quality and take measures to relieve the workload of academics as their contribution is an important factor for successful establishments of UICs.

The financial support received by universities for conducting research and development activities in collaboration with industries is also important. With financial support, universities can implement innovation activities such as workshops, forums, competitions, interactive sessions, and panel discussions to increase inter-disciplinary communication and overcome knowledge gaps. They should also improve infrastructure, hire resource personnel, or purchase equipment related to innovation activities. Government funding can be useful for stimulating collaborative activities, while industrial funding will be more useful for innovative activities. The source of funds may be an important factor since industries have more short-term goals and commercial orientation.

It was also established that cognitive proximity is more important than geographic proximity. Geographic proximity might nevertheless be a barrier for successful UICs and innovation ecosystems, particularly in developing countries due to poor transport infrastructure. However, geographic proximity can be substituted by cognitive proximity. Especially in scientific and technological collaborations, cognitive proximity is more important than geographic ones. When it comes to radical innovations, too, cognitive proximity is more important than geographical proximity.

Furthermore, the importance of implementing policies supporting innovation in companies and universities should be emphasized. In particular, Japanese policy implications in the 1990s, including responsiveness to social needs and a willingness to contribute to social reforms, should be ideal for Sri Lanka, especially when solving problems at the societal level. Sri Lanka needs to have a university-industry collaborative policy framework designed for minimizing various barriers for UICs with a clear focus on enabling innovations through these collaborations. The government should establish a unit to formulate a national policy for implementing research and development activities relevant to the country's socio-economic development.

Heterogeneity is a driver for high invention quality. So, policies should include incentive mechanisms promoting vertical collaborations with industries for innovative front-end successes. There must also be incentives for universities to overcome critical gaps in culture, knowledge, and experiences.

6.2 Discussion

The factors above are applicable to Sri Lanka, especially considering its socio-economic context. University managements need to initiate UICs in a formal way. UIC establishments are done in an ad-hoc manner, and the creation of such are usually driven by interested individuals. Due to the high demand for ICT graduates in Sri Lanka and all around the world, ICT industries should discuss funding opportunities and their reciprocal effects with respect to UICs. There should be a general interest in, e.g., maintaining tech labs such as robotics and IoT, to attract competent students who work in close contact with industrial partners. UIC policies should be established by the government of Sri Lanka where the geographic proximity between universities and industries is addressed. This can be facilitated through an ICT supported system. Since universities in Sri Lanka are operating according to their own schedules, industry placements, graduation, and some other events useful for the industry should be made available. Industries should join universities to disseminate ICT project ideas of industrial relevance. Most often university students are lacking ideas for research and student projects. Industrial partners could potentially provide a multitude of such, and thereby get motivated resources for their own product development. There are several institutions in Sri Lanka with the objective of escalating the innovations in the country as well as establishing collaborations between industry and academia, and establishing ICT policies. Among these institutions, Coordinating Secretariat for Science, Technology and Innovation (COSTI, 2019), established in 2013, with the aim of coordinating and monitoring science and technology, is important and the innovation activities there are assigned a prominent role. COSTI is not managed by the Ministry of Education under which all universities function. This could provide some opportunities (and challenges) when designing a vivid innovation system for development, research, and education.

7. Conclusion and Recommendations

7.1 Conclusion

We have examined some key factors for UIC innovation catalysts in Sri Lanka by employing a systematic literature survey, where 41 research papers were selected from Science Direct, Scopus, and Ebscohost. We found that management directives, financial support, policies, proximity dimension, and heterogeneity are the key factors for a successful UIC. We have also identified some relevant factors that are feasible to adopt in the Sri Lankan context for escalating its innovation ecosystem. These findings may be applicable to other countries (developing countries, in particular) depending on their political and economic environments.

7.2 Recommendations

It is clear that Sri Lankan universities are highly focused on traditional teaching, but there are some efforts towards innovation and entrepreneurial activities as well among some universities. University management should consider increasing the levels of resource deployment and the incentives for participating in innovation and entrepreneurial activities. The performance evaluation system of Sri Lankan universities should also provide some more incentives for research and development and innovation activities rather than highly focusing on teaching activities.

A university-industry collaborative ICT support system should be designed to facilitate well-established UICs dedicated to escalating ICT innovations. The system should support essential collaboration functions such as creating linkages between universities and industries, finding suitable research partners, sharing of resources and schedules, knowledge management functions such as knowledge creation, dissemination, and sharing, as well as facilitating cognitive proximity between relevant actors. The availability of funding for collaborative activities and research grants should be displayed in the system as well, and it should be used for mediating international collaborations with universities in Sri Lanka. The same system, should also contain a collaborative platform for policymaking.

Also, a properly established collaboration network for escalating collaborative innovations in the country should be established, with leading personnel or steering committee with substantial experiences from both industry and university. Since all universities in Sri Lanka are managed under the Ministry of Education, establishing a body managing UIC under another ministry may be problematic for efficient inter-ministerial communication. Therefore we recommend that the collaboration network should be managed under the suggested umbrella institution “University-Industry Collaboration Agency (UICA)”, which, in turn, could function under the Ministry of Education of Sri Lanka. This agency should consist of two divisions: one for international liaison activities, in which it can collaborate with international collaborating institutions including funding partners; and the other division focusing on local institutions, such as universities and research institutes. The latter should be connected with local innovation concerned entities, such as Lanka Angel Network (LAN), government funding institutions, and relevant industry partners. It should initiate and mediate the construction of science parks, i.e., technology parks (that are not active in the country at present). Each university should also establish a UIC center to collaborate with the local division of the UICA for executing innovation activities. Such activities can include but are not limited to, conducting UIC forums, idea contests, TEDx events, Hackathons, innovation days, facilitating co-working spaces, and offering courses in Intellectual Property (IP). The establishment of a policy framework for innovation can be prepared by the UICA and coordinated by all entities in the network. This body should also address issues at universities

located remotely from the commercial capital Colombo as well as universities with inadequate-resources for innovation activities.

References

Ankrah, S., & AL-Tabbaa, O. (2015). Universities-industry collaboration: A systematic review. *Scandinavian Journal of Management*, *31*(3), 387–408. https://doi.org/10.1016/j.scaman.2015.02.003.

Arant, W., Fornahl, D., Grashof, N., Hesse, K., & Söllner, C. (2019). University-industry collaborations—The key to radical innovations? *Review of Regional Research*, *39*(2), 119–141. https://doi.org/10.1007/s10037-019-00133-3.

Attia, A. M. (2015). *National innovation systems in developing countries: Barriers to university-industry collaboration in Egypt*. *14*(2), 113–124. https://doi.org/10.1386/tmsd.14.2.113.

Bodas Freitas, I. M., Marques, R. A., & Silva, E. M. D. P. E. (2013). University-industry collaboration and innovation in emergent and mature industries in new industrialized countries. *Research Policy*, *42*(2),443–453. https://doi.org/10.1016/j.respol.2012.06.006.

Brem, A., & Radziwon, A. (2017). Efficient Triple Helix collaboration fostering local niche innovation projects – A case from Denmark. *Technological Forecasting and Social Change*, *123*, 130–141. https://doi.org/10.1016/j.techfore.2017.01.002.

Bruno, F., Rucker, P., & Branda, B. (2018). Quality comes first: university-industry collaboration as a source of academic entrepreneurship in a developing country. *Journal of Technology Transfer*, 263–284. https://doi.org/10.1007/s10961-017-9568-x.

Calcagnini, G., Favaretto, I., Giombini, G., Perugini, F., & Rombaldoni, R. (2016). The role of universities in the location of innovative start-ups. *Journal of Technology Transfer*, *41*(4), 670–693. https://doi.org/10.1007/s10961-015-9396-9.

Chandran, V. G. R., Sundram, V. P. K., & Santhidran, S. (2014). Innovation systems in Malaysia: A perspective of university-industry R&D collaboration. *AI and Society*, *29*(3), 435–444. https://doi.org/10.1007/s00146-013-0468-9.

Cheng, H., Zhang, Z., Huang, Q., & Liao, Z. (2020). The effect of university-industry collaboration policy on universities' knowledge innovation and achievements transformation: based on innovation chain. *Journal of Technology Transfer*, *45*(2), 522–543. https://doi.org/10.1007/s10961-018-9653-9.

Cornell University, INSEAD, and W. (2019). (2019). Global Innovation Index 2019. In *Organización Mundial de la Propiedad Intelectual*. https://www.globalinnovationindex.org/gii-2016-report.

COSTI. (2019). Coordinating Secretariat for Science, Technology and Innovation. http://costi.gov.lk/index.php/en.

Esham, M. (2008). Strategies to Develop University-Industry Linkages in Sri Lanka, Research Studies on Tertiary Education Sector. *Research Studies on Tertiary Education Sector*, *4*(4).

Fan, H. L., Huang, M. H., & Chen, D. Z. (2019). Do funding sources matter? The impact of university-industry collaboration funding sources on innovation performance of universities. Technology Analysis and Strategic Management, 31(11), 1368–1380. https://doi.org/10.1080/09537325.2019.1614158.

Fernández López, S., Pérez Astray, B., Rodeiro Pazos, D., & Calvo, N. (2015). Are firms interested in collaborating with universities? An open-innovation perspective in countries of the South West European Space. *Service Business*, *9*(4), 637–662. https://doi.org/10.1007/s11628-014-0243-0.

Fukugawa, N. (2017). University spillover before the national innovation system reform in Japan. *International Journal of Technology Management*, *73*(4),206–234. https://doi.org/10.1504/IJTM.2017.083079.

Gann, D., & Dodgson, M. (2019). *We need to measure innovation better. Here's how*. World Economic Forum. https://www.weforum.org/agenda/2019/05/we-need-to-measure-innovation-better-heres-how-to-do-it.

Garcia, R., Araujo, V., Mascarini, S., Gomes Dos Santos, E., & Costa, A. (2018). Is cognitive proximity a driver of geographical distance of university–industry collaboration? *Area Development and Policy*, *3*(3), 349–367. https://doi.org/10.1080/23792949.2018.1484669.

Gretsch, O., Salzmann, E. C., & Kock, A. (2019). University-industry collaboration and front-end success: the moderating effects of innovativeness and parallel cross-firm collaboration. *R and D Management*, *49*(5), 835–849. https://doi.org/10.1111/radm.12385.

Guimón, J., & Salazar-Elena, J. C. (2015). Collaboration in Innovation Between Foreign Subsidiaries and Local Universities: Evidence from Spain. *Industry and Innovation*, *22*(6), 445–466. https://doi.org/10.1080/13662716.2015.1089034.

Handen, J. S. (2014). Redefining innovation. In *Chapter 1* (pp. 1–32). https://doi.org/10.1201/b17594

Hadidi, H. El, & Kirby, D. A. (2015). Universities and Innovation in a Factor-Driven Economy: The Egyptian Case. Industry and Higher Education, 29(2), 151–160. https://doi.org/10.5367/ihe.2015.0248

Hossinger, S. M., Chen, X., & Werner, A. (2020). Drivers, barriers and success factors of academic spin-offs: a systematic literature review. *Management Review Quarterly*, *70*(1), 97–134. https://doi.org/10.1007/s11301-019-00161-w.

Hou, B., Hong, J., Chen, Q., Shi, X., & Zhou, Y. (2019). Do academia-industry R&D collaborations necessarily facilitate industrial innovation in China? The role of technology transfer institutions. *European Journal of Innovation Management*, *22*(5), 717–746. https://doi.org/10.1108/EJIM-09-2018-0195.

Hou, B., Hong, J., Wang, H., & Zhou, C. (2019). Academia-industry collaboration, government funding, and innovation efficiency in Chinese industrial enterprises. *Technology Analysis and Strategic Management*, *31*(6), 692–706. https://doi.org/10.1080/09537325.2018.1543868.

Huang, M. H., & Chen, D. Z. (2017). How can academic innovation performance in university-industry collaboration be improved? *Technological Forecasting and Social Change*, *123*, 210–215. https://doi.org/10.1016/j.techfore.2016.03.024.

InterregEurope. (2020). UNIVERSITY INDUSTRY COLLABORATION A Policy Brief from the Policy Learning Platform on Research and Innovation (Issue January).

Jackson, P., Mavi, R. K., Suseno, Y., & Standing, C. (2018). *University-industry collaboration within the triple helix of innovation: The importance of mutuality*. *45*(December 2017), 553–564. https://doi.org/10.1093/scipol/scx083.

Jugend, D., Fiorini, P. D. C., Armellini, F., & Ferrari, A. G. (2020). Public support for innovation: A systematic review of the literature and implications for open innovation. *Technological Forecasting and Social Change*, *156*(February), 119985. https://doi.org/10.1016/j.techfore.2020.119985.

Jumakulov, Z., Ashirbekov, A., Sparks, J., & Sagintayeva, A. (2019). Internationalizing Research in Kazakhstan Higher Education: A Case Study of Kazakhstan's State Program of Industrial Innovative Development 2015 to 2019. *Journal of Studies in International Education*, *23*(2), 234–247. https://doi.org/10.1177/1028315318786445.

Kesting, T., Gerstlberger, W., & Baaken, T. (2018). A benefit segmentation approach for innovation-oriented university-business collaboration. *International Journal of Technology Management*, *76*(1–2), 58–80. https://doi.org/10.1504/IJTM.2018.10009594.

Kobarg, S., Stumpf-Wollersheim, J., & Welpe, I. M. (2018). University-industry collaborations and product innovation performance: the moderating effects of absorptive capacity and innovation competencies. *The Journal of Technology Transfer*, *43*(6), 1696–1724. https://doi.org/10.1007/s10961-017-9583-y.

Lin, J. Y. (2017). Balancing industry collaboration and academic innovation: The contingent role of collaboration-specific attributes. *Technological Forecasting and Social Change*, *123*, 216–228. https://doi.org/10.1016/j.techfore.2016.03.016.

Marrello, A. (2007). *The Five Stages of Successful Innovation*. MITSloan Magazine, Spring 2007. https://sloanreview.mit.edu/article/the-five-stages-of-successful-innovation.

Martínez-Frías, J. (2003). The importance of ICTs for developing countries. *Interdisciplinary Science Reviews*, *28*(1), 10–14. https://doi.org/10.1179/030801803225010304.

Mascarenhas, C., Ferreira, J. J., & Marques, C. (2018). University-industry cooperation: A systematic literature review and research agenda. *Science and Public Policy*,*45*(5),708–718. https://doi.org/10.1093/SCIPOL/SCY003.

Meyer, M., Kuusisto, J., Grant, K., De Silva, M., Flowers, S., & Choksy, U. (2019). Towards new Triple Helix organisations? A comparative study of competence centres as knowledge, consensus, and innovation spaces. *R and D Management*, *49*(4),555–573. https://doi.org/10.1111/radm.12342.

National export strategy of Sri Lank 2018-2022: Information Technology strategy. (2018).

Oliver, A. L., Montgomery, K., & Barda, S. (2019). The multi-level process of trust and learning in university-industry innovation collaborations. *Journal of Technology Transfer*, *0123456789*. https://doi.org/10.1007/s10961-019-09721-4.

Pearsall, J., & Hanks, P. (1998). The new Oxford dictionary of English. Oxford: Clarendon Press.

Ponds, R., van Oort, F., & Frenken, K. (2010). Innovation, spillovers, and university-industry collaboration: An extended knowledge production function approach. *Journal of Economic Geography*, *10*(2), 231–255. https://doi.org/10.1093/jeg/lbp036

Rajalo, S., & Vadi, M. (2017). University-industry innovation collaboration: Reconceptualization. *Technovation*, *62–63*(December 2015), 42–54. https://doi.org/10.1016/j.technovation.2017.04.003

Ranga, M., Mroczkowski, T., & Araiso, T. (2017). University-industry cooperation and the transition to innovation ecosystems in Japan. *Industry and Higher Education*, *31*(6), 373–387. https://doi.org/10.1177/0950422217738588.

Rantala, T., & Ukko, J. (2018). Performance measurement in university-industry innovation networks: implementation practices and challenges of industrial organisations. *Journal of Education and Work*, *31*(3), 247–261. https://doi.org/10.1080/13639080.2018.1460655.

Rybnicek, R., & Königsgruber, R. (2019). What makes industry-university collaboration succeeds? A systematic review of the literature. *Journal of Business Economics*, *89*(2), 221–250. https://doi.org/10.1007/s11573-018-0916-6.

Shi, X., Wu, Y., & Fu, D. (2020). Does University-Industry collaboration improve innovation efficiency? Evidence from Chinese Firms. *Economic Modelling*, *86*(February 2019), 39–53. https://doi.org/10.1016/j.econmod.2019.05.004.

Sjöö, K., & Hellström, T. (2019). University-industry collaboration: A literature review and synthesis. *Industry and Higher Education*, *33*(4), 275–285. https://doi.org/10.1177/0950422219829697.

Spencer, J. W. (2003). Firms' knowledge-sharing strategies in the global innovation system: Empirical evidence from the flat panel display industry. *Strategic Management Journal*, *24*(3), 217–233. https://doi.org/10.1002/smj.290

Steinmo, M. (2015). Collaboration for Innovation: A Case Study on How Social Capital Mitigates Collaborative Challenges in University-Industry Research Alliances. *Industry and Innovation*, *22*(7), 597–624. https://doi.org/10.1080/13662716.2015.1105127.

Striukova, L., & Rayna, T. (2015). University-industry knowledge exchange: An exploratory study of Open Innovation in UK universities. *European Journal of Innovation Management*, *18*(4), 471–492. https://doi.org/10.1108/EJIM-10-2013-0098.

Subramonian, H., & Rasiah, R. (2016). University-industry collaboration and technological innovation: sequential mediation of knowledge transfer and barriers in automotive and biotechnology firms in Malaysia. *Asian Journal of Technology Innovation*, *24*(1), 77–99. https://doi.org/10.1080/19761597.2016.1151177.

Sutton, R., & Staw, B. (1995). What theory is not. *Administrative Science Quarterly*, *40*, 371–384.

Szücs, F. (2018). Research subsidies, industry-university cooperation, and innovation. *Research Policy*, *47*(7), 1256–1266. https://doi.org/10.1016/j.respol.2018.04.009.

Temel, S., & Glassman, B. (2013). Examining University-Industry Collaboration as a Source of Innovation in the Emerging Economy of Turkey. 5(1), 81–88.

The World Bank. (2017). University-Industry Collaboration In Research & Development. https://tcdata360.worldbank.org/indicators/h4247b4d7?country=LKA&indicator=604&countries=BTN,IND,PAK,BGD,NPL,MDV,AFG&viz=line_chart&years=2007,2017&indicators=944&compareBy=region.

The World Bank in Sri Lanka. (2020). https://www.worldbank.org/en/country/srilanka/overview.

Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review. In the *British Journal of Management* (Vol. 14, Issue 3, pp. 207–222). https://doi.org/10.1111/1467-8551.00375.

Tseng, F. C., Huang, M. H., & Chen, D. Z. (2020). Factors of university-industry collaboration affecting university innovation performance. *Journal of Technology Transfer*, *45*(2), 560–577. https://doi.org/10.1007/s10961-018-9656-6.

UGC (2020), Universities and Higher Educational Institutions established under the purview of the University Grants Commission. https://www.ugc.ac.lk/en/universities-and-institutes/list.html.

Walsh, J. P., Lee, Y. N., & Nagaoka, S. (2016). Openness and innovation in the US: Collaboration form, idea generation, and implementation. *Research Policy*, *45*(8), 1660–1671. https://doi.org/10.1016/j.respol.2016.04.013.

Webster, J., & Watson, R. T. (2002). Analyzing the Past to Prepare for the Future: Writing a Literature Review. *MIS Quarterly*, *26*(2), xiii–xxiii. https://doi.org/10.1.1.104.6570

Weerasinghe, R., & Jayawardane, A. K. (2015). Innovation and Absorptive Capacity: An Empirical Study of Manufacturing SMEs in the Western Province of Sri Lanka. Journal of Small Business and Entrepreneurship Development, 3(1), 85–92. https://doi.org/10.15640/jsbed.v3n1a8.

Weerasinghe, R.N. (2017). Systematic View of Innovation: Role of Universities in National Innovation System of Sri Lanka. *SSRN Electronic Journal*, 772–786. https://doi.org/10.2139/ssrn.2910246.

Weerasinghe, Rukmal Nishantha, & Jayawardane, A. K. (2018). University-Industry Partnerships for Innovation: Sri Lankan Experiences. *Annals of Spiru Haret University. Economic Series*, *18*(1), 25–45. https://doi.org/10.26458/1811.

Wickramasinghe, V., & Malik, K. (2016). Exploring motivations for university- industry collaboration in Sri Lanka. R & D MANAGEMENT CONFERENCE 2016 From Science to Society: Innovation and Value Creation, July, 1–8.

Wickramasinghe, V., & Malik, K. (2018). University-Industry Collaboration in Sri Lanka-A Developing Country Perspective. *International Journal of Innovation and Technology Management*, *15*(4). https://doi.org/10.1142/S0219877018500323.

Wijesinghe, C., Hansson, H., & Colomboge, R. (2018). University-Industry Collaboration for ICT Innovation in Sri Lanka. *Proceedings of E-Learn: World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2018*, 407–412. https://www.learntechlib.org/p/185008.

Wolfswinkel, J. F., Furtmueller, E., & Wilderom, C. P. M. (2011). Using grounded theory as a method for rigorously reviewing literature. *European Journal of Information Systems*, *November 2013*, 1–11. https://doi.org/10.1057/ejis.2011.51

Wynn, M. G. (2018). Technology transfer projects in the UK: An analysis of university - Industry collaboration. *International Journal of Knowledge Management*, *14*(2), 52–72. https://doi.org/10.4018/IJKM.2018040104.

Yoon, J. (2015). The evolution of South Korea's innovation system: moving towards the triple helix model? *Scientometrics*, *104*(1), 265–293. https://doi.org/10.1007/s11192-015-1541-6.

Zhang, Y., Dong, J., Cao, Y., & Cantwell, J. (2017). The double-edged sword of government role in innovation systems: A case study in the development of policy-led University Science Parks in China. *2017 IEEE Technology and Engineering Management Society Conference, TEMSCON 2017*, 7–12. https://doi.org/10.1109/TEMSCON.2017.7998346.

Appendix 1

Table 1: Analysis of Results

	Authors	Findings/ Method	Country	Situation in Sri Lanka	Recommendation/ critics
1	(Huang & Chen, 2017)	UIC management mechanism has a significant effect on university innovations. Government funding significantly affects UIC regulations and support for the innovative climate. **Method:** Quantitative methods are used to analyze the survey data obtained from 141 Taiwan universities and colleges.	Taiwan	Mainly Government funding	UIC regulations are not formally present
2	(Bodas Freitas et al., 2013)	Collaboration with emergent firms is more productive than collaboration with mature industries. The national research system on its own cannot foster the emergence and growth of technological capabilities. If firms do not collaborate with each other they are unlikely to collaborate with universities **Method:** Qualitative study with 24 face to face semi-structured interviews with universities and research organizations	Brazil	Collaboration with any types of firms is not systematically done	Emerging software companies will be more interesting to collaborate with universities
3	(Striukova & Rayna, 2015)	Universities can work as a trusted intermediary or open innovation hub. Long-term partnerships are the best which implies partners should be selected carefully. **Method:** Exploratory study based on in-depth semi-structured interviews of Pro-Vice-Chancellors (or equivalent level) of a variety of British universities.	UK	Coordinating Secretariat for Science, Technology, and Innovation (COSTI)	Universities can work as innovation hubs
4	(Hou, Hong, Wang, et al., 2019)	Research institute collaboration increase innovation efficiency, UIC adversely associated with innovation efficiency **Method:** they have constructed the research model according to the knowledge production function, and the hypotheses are verified using pooled ordinary least square regression. Data used is the panel data of China's Statistics Yearbook on Science and Technology Activities of Industrial Enterprises ((CSYSTAIE)	China		RIs are having less administrative works than University academia. This has lessened the academia's involvement in R&D activities in China.
5	(Hou, Hong, Chen, et al., 2019)	Research Institutes (RI) are more effective collaborators than universities. R&D Collaboration between RI is positively related to innovative outputs. Intermediaries do not play a catalytic role in all academia-industry cooperation **Method:** Quantitative methods are used to analyze the panel data of China's Statistics Yearbook on Science and Technology Activities of Industrial Enterprises (CSYSTAIE) in 30 provinces (except for Tibet, Hong Kong, Macao, and Taiwan due to missing data) from 2009 to 2014.	China		

6	(Szücs, 2018)	Innovation outcomes strongly depend on the funding received and the number of participants. University ranking has a significant effect on innovation indicators. Innovation benefits of government-funded research are large. **Method:** Quantitative methods are used to analyze the data obtained from the two data sources as the European commission's CORDIS database on EC research projects and EPOs PATSTAT database which contains patent applications and indicators. Then complimented them with data obtained from van Dijk's Orbis database and the Webometrics university rankings.	Austria		The government can fund researches value for national requirements
7	(Jackson et al., 2018)	Firms collaborate with clients, suppliers and each other are more likely to collaborate with universities. **Method:** Data is collected from OECD and two hypotheses are tested with quantitative methods	Australia	This type of collaborations is very weak in Sri Lanka	A good indication when selecting partners for collaboration
8	(Temel & Glassman, 2013)	Building awareness, Building trust and exposure, Transitioning companies to full research projects **Method:** the study method is not very clear; they have used a sample of 202 companies for surveys and interviews.	Turkey		Since UIC in Sri Lanka is conducted in an ad-hoc manner and limited to preliminary activities, the First and the second findings are recommended
9	(Fernández López et al., 2015)	High tech companies are more interested in engagement with universities, Independent firms are less like to cooperate **Method:** semi-structured interviews are conducted from January to October 2009 with 375 firms from the 3 countries Spain, Portugal, and France. Indicate that more innovative firms tend to be more collaborative with universities	South West European Space (Spain, Portugal, France)	Very few high-tech companies exist, and the majority of industries are SMEs. High tech companies are interested in collaborations	Opportunity for learning best practices in the industry especially for university students
10	(Kesting et al., 2018)	Larger company size and the conduction of own internal R&D are the most influencing factor for collaboration with external research suppliers. **Method:** questionnaire filled by 254 companies from the textile industry using a web survey	Germany, Belgium, Netherlands	Industry-level internal R&D activities are not highly practiced.	Improving internal R&D, companies can identify the local requirements and innovate new products matching the real requirement
11	(Rajalo & Vadi, 2017)	Motivation and absorptive capacity are indeed relevant in UIC. **Method:** Multiple case study with 12 cases	Estonia		Identify the motivation gap, develop the ability and willingness to acquire, assimilate, transform, and exploit external knowledge
12	(Oliver et al., 2019)	Initial trust based on the professional reputation and shared background is an important factor as it reflects the confidence at the outset.	Israel		Trust, develop as a practice, careful decision making, consistency, openly

		Method: Qualitative analysis of thirty interviews from government-funded four case studies			participation, honesty, helpfulness are key factors
13	(Brem & Radziwon, 2017)	Strong problem orientation, networking win-win situations ensure higher innovation diffusion success. **Method:** a combination of two qualitative methods, case study, and autoethnographic analysis.	Denmark		Need to build an innovation strategy and align with suitable business strategies
14	(Kobarg et al., 2018)	Absorptive capacity and innovation competency should be considered in UIC innovation activities **Method:** Quantitative methods are used to analyze the data obtained through a survey of 2061 German companies	Germany		The innovation competency model can be developed by the university including components such as Creativity, Enterprising, integrating perspectives, forecasting, and managing the challenge
15	(Fan et al., 2019)	Government funding has a greater impact on implementing UIC regulations, and industrial funding has a greater impact on building UIC management mechanisms. Only industrial funding has an impact on innovations climate **Method:** a survey is conducted with a sample of 146 from Taiwanese universities	Taiwan	Universities mainly receive government funding	The National Science Foundation's Technology grant scheme is available for universities and companies
16	(Cheng et al., 2020)	The relationship between UIC policy and achievement transformation was an inverted U shape. Government funding has a greater effect on knowledge output than funding from industries. **Method:** Quantitative data analysis is conducted with panel data obtained from 363 items from government and related websites	China	Universities mainly receive government funding	The government can fund researches value for national requirements
17	(Tseng et al., 2020)	UIC funding is directly instrumental in the university's technology innovations. UIC management mechanism and innovation climate support UIC funding. Incentives and rewards for university researchers affect technology innovations. **Method:** A mail survey of 145 responses is used to collect primary data from Taiwan universities. Data analysis is done with quantitative methods	Taiwan	University researchers can receive a salary bonus of 35% for publishing in journals or symposiums	There should be a mechanism for the implementation of important research findings
18	(Ranga et al., 2017)	Strong entrepreneurial spirit and culture, effective intermediaries, high absorptive capacity, cross-boundary mobility of the workforce are important factors. These can be supported by; financial support for universities, entrepreneurial support, early development stage of intermediary support mechanisms, and resources for fostering innovation **Method:** UIC policies in Japan since the mid-1990s are examined within a multidimensional innovation policy framework.	Japan		Require a significant culture shift in many organizations. Decision-making processors and approvals should be simplified. A bloated bureaucracy and unnecessary policy stifles creativity, freedom, and entrepreneurial spirit
19	(Garcia et al., 2018)	Geographical proximity can be substituted for cognitive proximity and it can stimulate long distanced collaboration when partner firms have a high absorptive capacity. Design policies that strengthen and	Brazil		An online facility can connect more cognitively closed partners located geographically distanced

		stimulate UI linkages while providing mechanisms to collaborating firms to benefit from the externalities that arise **Method:** Data is collected from a database of the Brazilian Ministry of Science and Technology and analyzed			
20	(Calcagnini et al., 2016)	University spillovers are positively correlated with innovative startups, Industrial districts are more attractive for innovative startups, the presence of human capital significantly influence the location of startups, third mission activities have a weak impact on locational choice. Policies should support both innovation and regional productive systems **Method:** dataset contains observations from variates obtained from several sources and three hypotheses are derived for testing	Italy	Similar in Sri Lanka. Western province is more attractive for startups	Most of the startups are located in the commercial capital Colombo and it is less likely to find startups in other districts.
21	(Ponds et al., 2010)	Knowledge spillovers from R&D occur over long geographical distances. Policies should be implemented in the Netherlands to stimulate spillovers covering national or international scale and not covering geographic regions **Method:** data has been collected from seven science-based technologies in the Netherlands and the patents received by the European Patents Office between 1999-2001. The data collection method is not very clear	Netherlands	No mechanism to capture knowledge spillovers	Knowledge spillovers can be converted to knowledge sharing through a properly designed knowledge Management system dedicated to UIC activities
22	(Arant et al., 2019)	Radical innovations benefit from UIC. Overcoming geographic distance is easier than overcoming cognitive distance for collaborators. Policymakers should support collaborative R&D. **Method:** They have built a dataset combining firm, patent, and subsidy data consisting of 8404 firms that patented between 2012 and 2014.	Germany		An online facility can connect more cognitively closed partners located geographically distanced
23	(Shi et al., 2020)	Pertinent policies are required to facilitate UIC and its role in improving innovation in different stages. UIC affects innovation efficiency differently across two stages. UIC is detrimental at the beginning but benefitted when engagement deepens **Method:** Survey balanced panel of 443 innovative firms between 2008-2011	China		Can be facilitated through a UIC liaising office established in universities
24	(Chandran et al., 2014)	Fewer incentives are available for industries to establish R&D collaborations. A policy drive to correct the mismatch and upgrade industrial R&D is needed. Demand-driven R&D should be conducted in universities. **Method:** Interviews are conducted with industries and universities and also used multiple data sources including the author's datasets.	Malaysia	Tax deductions are available for industries	Industries can benefit from the tax deductions provided for R&D expenditure for universities or research institutes
25	(Steinmo, 2015)	The development of cognitive and relational social capital at an organizational, individual, and alliance level is crucial. Common goals and understandings and personal relationships help mitigate	Norway		Can be facilitated through a UIC liaising office established in universities

		collaborative challenges stimulate cohesion, and realize the goal of creating the innovations **Method:** Qualitative multiple-case study design			
26	(Guimón & Salazar-Elena, 2015)	Policy perspective- a collaboration between foreign subsidiaries and local universities can develop mechanisms to link national innovation system with global innovation networks **Method:** Survey questionnaire received from 89 firms are used to address the related suggestion	Spain	Policy 32: Getting Research into Practice. (National Education Commission Sri Lanka, 2009)	Can establish an international liaison office under the apex body UGC Sri Lanka to coordinate and receive foreign funds to the country.
27	(Zhang et al., 2017)	Policy implications- equity allocation for researchers when commercializing intellectual properties, encourage university researchers to work part-time to start companies. **Method:** A case study method with a Science park	China	Available with little differences (Mendes, 2015)	Though the legal provision is available the real practice is slow.
28	(Jumakulov et al., 2019)	Kazakhstan's State Program of Industrial Innovative Development 2015-2019 (SPIID-2) functions as a catalyst for UIC based on "industrial innovative development" and producing graduates as agents of innovation within those industries. Industrial policies should be to raise the demand for skills, SPIID-2 has created the demand for postgraduate researchers. **Method:** A case study on Kazakhstan's SPIID-2 Findings are based on content analysis of policy text and interviews with university representatives	Kazakhstan	Government policies for UICs are available	Sri Lanka mainly focusing on skills for the demand, but SPIID-2 suggests, demand for skills. Needs to be checked for applicability. We also can develop such programs based on the national requirements
29	(Rantala & Ukko, 2018)	Industrial SMEs are interested in performance measurement of societal level outputs by UICs **Method:** two single case studies are conducted to explore the implementation practices and challenges of performance measurement in UICs	Finland	Policy 1 of higher education policy (National Education Commission Sri Lanka, 2009)	Suitable to address many burning problems in the society which are not addressed elsewhere in Sri Lanka
30	(Subramonian & Rasiah, 2016)	Factors that help university technology innovations are the right perception of the university, knowledge transfer channels, and managing barriers.	Malaysia	No proper mechanism for technology transfer or	Suggest establishing technology transfer office (TTO) in universities, and IT-based solution to manage barriers such as geographical distance.

		Method: Data is collected through a questionnaire in the year 2009 from a sample of 198 firms from the automotive and biotechnology firms in Malaysia.		managing barriers	
31	(Fukugawa, 2017)	Suggest having technology diffusion programs to improve the absorptive capacity of small firms. Intermediaries are more important than the mediation of networking **Method:** study is conducted with the regional panel data in the period of 1983-1997 on industrial innovations, industrial R&D, university research, and university-industry collaborations. Data is analyzed with quantitative methods	Japan	Firms do not use technology diffusion programs to improve absorptive capacity	Policies and strategic initiatives should be promoted to improve absorptive capacity promoting them for innovation
32	(Hadidi & Kirby, 2015)	Integrated innovation policy that includes higher education is needed. A recognition of the universities in the innovation process, a linkage between university, industry, and the government should be created. Factors lacking for innovation are nature, quality and amount of research, mistrust between university and industry, lack of physical and human resources. **Method:** Qualitative study with eighteen interviews with Egyptian experts from government, non-governmental organizations, and academia.	Egypt	Linkages between universities and industries are very weak and ad-hoc	Linkages between university and industry should be strengthened and formalized. Policies are supportive for sharing of resources between universities and industry
33	(Yoon, 2015)	There should be more policy considerations to strengthen UIC collaborations with SMEs. Policies can include, both GRIs and universities should work as a facilitator for KT and commercialization to stimulate innovations in SMEs. **Method:** bibliographic information of 18,097 invention patent applications jointly filed by university, industry, and government between 1980 - 2012 has been used to map the network of collaborations	South Korea	Higher Education Policies are supportive (National Education Commission Sri Lanka, 2009)	Policies are supportive but there should an action plan to implement. An action plan can be implemented by the university considering the nature of the university.
34	(Walsh et al., 2016)	Heterogeneous collaboration drives higher invention quality, vertical collaboration at the inventing stage is more critical for commercialization **Method:** used a survey of 1919 inventors in the US	US	No different forms of collaborations are evident	The impact of different forms of collaborative innovations may vary depending on the collaboration stage.
35	(Gretsch et al., 2019)	Simultaneous collaborations strengthen front end success for more radical innovations. **Method:** the questionnaire is collected from a sample of 166 R&D individuals from a single large multinational company.	Germany		Simultaneous collaborations can be more facilitated with the right collaboration software
36	(Meyer et al., 2019)	Setup with a high level of autonomy, integrate large technology-focused networks, adopt interaction practices with heterogeneous partners, act as a neutral place, act as a hub for intermediary and innovation activities.	Finland		Autonomy is required in universities due to its complex nature of studies. Can consider the university as a hub for innovations

		Method: interviews are conducted with 16 stakeholders having good experiences with user-driven research and innovation environments			
37	(Lin & Yang, 2020)	Firms with more collaboration breath, collaboration experience, network centrality, and collaborative proactiveness with universities are more innovative **Method:** based on 2914 firm-year cases of top 200 US R&D firms and estimates are obtained from quantitative techniques	US		Firms need to be more aware of the mutual benefits of collaboration. This can be done by a central authority
38	(Attia, 2015)	Relationship drivers and business drivers support the UIC. Orientation related barriers hinder the UIC. **Method:** Quantitative data analysis is conducted with data obtained through a questionnaire from 162 companies in industrial and free zone areas of Egypt	Egypt		Most of the collaborations are existing with relationship drivers and business drivers.
39	(Lin, 2017)	University contribution and knowledge capacity strengthen the benefits and lessen the cost of innovation. In the long run, wider collaboration breadth has a negative effect on the number of collaborations and academic innovations **Method:** Quantitative study with data obtained from the National Bureau of Economic Research-Rensselaer Scientific Papers Database covering 110 leading research universities in the US	US	Not exists in large	Collaboration breadth can be limited to a manageable quantity
40	(Bruno et al., 2018)	Content of the collaboration is a strong predictor than which universities are connected or the number of universities connected **Method:** Quantitative methods are used to analyze data obtained from 462 knowledge incentive academic-related entrepreneurial projects and patent data from 126 universities and research institutes	Brazil		The previously suggested online system can include a collaborative filtering mechanism or recommender system allowing partners to view matching institutions for the content
41	(Wynn, 2018)	Using new technology to innovate internal processors and services is more successful than projects on new product development **Method:** qualitative case study approach is adopted focusing on three companies reviewing fourteen technology transfer projects.	UK	There is a recent trend	Internal competitions, idea contests, events like TEDx, Hackacom, innovation day, FabLabs, Coworking, CoLearniing spaces, Training design thinking