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A Study on Factors Influencing the Outcomes of University-Industry Collaborative Activities Focusing on the Faculty's Need for and Engagement in University-Industry Collaborative Activities -

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Abstract

Objectives: Prior studies failed to prove interactions between need and activity among players of university-industry collaborative activities. This study proved these interactions, based on needs, engagements, and outcomes of university-industry collaborative activities. **Methods/Statistical Analysis:** The needs are composed of network reinforcement, securing information and knowledge, and contributing to intra-/extra-mural utilization of outcomes. The engagements are composed of start-up revitalization for intellectual property creation and engagement in knowledge dissemination. And the outcomes are composed of learning about resource acquisition and clients' business process. PLS statistical tool was used for data analyses for which 44 data sample were collected. **Findings:** The study results can be summarized as following. First, the needs for securing information and knowledge have positive effects on the engagement in university-industry collaborative activities. Second, the needs for intra-/extra-mural contribution have positive effects on their engagements in knowledge dissemination. Third, the increase in engagement has positive effects on outcomes. Fourth, the increase in engagement in knowledge dissemination improves the outcomes of learning about resource acquisition and of clients' business process. **Application/Improvements:** This study found out the outcomes and their influencing factors of university-industry collaborative activities. This study can contribute to deciding which needs should be paid extra attention to by main players.

Keywords: Engagements, Intellectual Property, Needs, Outcomes, University-Industry Collaboration

1. Introduction

Most of previous studies on university-industry collaboration focused on results without empirically considering the reason for low engagement rates and the challenges arising from the university-oriented collaboration with industries. Also, prior studies were often limited to fragmentary results in examining the outcomes of university-industry collaboration from the perspectives of firms and universities, leaving much to be desired when it comes to the analysis of factors affecting the outcomes and revitalization of university-industry collaboration from a holistic perspective. Likewise, research on university-industry collaboration was largely intended to develop policy measures angled towards the process and roles of organized support systems so as to lead university-industry collaborative activities to yield substantial outcomes. Yet, such prior studies failed to establish the interactions between main agents and resultant outcomes. Hence, the present study intends to shed light on the needs for,

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engagement in, and outcomes of university-industry collaborative activities from the perspective of the faculty that serve as the main agents of university-industry collaborative activities. Ultimately, this study seeks to expand the positive outcomes of university-industry collaborative activities by identifying specific needs for such activities that should be met and specific activities that the faculty engages in more actively.

1.1 University-Industry Collaboration: Definition

University-industry collaboration refers to the interaction and collaboration between participants, i.e. industrial entities, research centers, and universities, in projects intended for research, technology development, human resource development, training programs, human interactions, and information sharing. University-industry collaboration projects aim at joint technological R&D, training programs, production support and technology transfer. As a similar term, the university-industry partnership covers a narrower scope. Waddock defines university-industry collaboration as a method of social cooperation, or a voluntary effort made by industrial entities and educational and research institutions to solve problems or issues of common interest cooperatively[1]. According to Link and Bauer, basically university-industry collaboration may refer to a joint inter-organizational agreement with intent to acquire skills and knowledge between industrial entities and universities, through which companies can improve their competitive position[2]. They argued that university-industry collaboration should be perceived not only as a simple method of technological acquisition that can be chosen by companies but also as part of management strategies for 'systematically securing and utilizing technology' including setting up a long-term technological strategies and competitive advantage. In that respect, university-industry collaboration is one of effective sources of creating future corporate value, and can be viewed as an important mechanism that facilitates knowledge transfer between universities and industries.

1.2 University-Industry Collaboration in Korea: Chronology

University-industry collaboration in Korea commenced in the 1980s with a government-led policy initiative called 'National R&D Project', followed by 'Technology Infrastructure Implementation Project' in the 1990s and the enterprise-driven 'Client-oriented University-industry Collaboration' in the 2000s, when university-industry collaboration in pursuit of innovation made great strides. Despite the quantitative growth of university-industry collaboration, the qualitative growth of outcomes as well as consistent and substantial efforts exerted by the faculty, corporate staff and researchers to create collaborative outcomes is half-fledged, which is attributable to the following. First, there has been a gap between the speed of technological change and universities' curriculum revision, i.e. companies seek to secure new technology through university-industry collaboration, whereas universities pursue the improvement of technology and students' skills. Second, even now universities' lack of technological innovation to bridge the gap, half-fledged strategic approaches to university-industry collaboration, and insufficient process and competency to support the enhancement of university-industry collaboration hinder corporate needs for university-industry collaboration.

1.3 Previous Studies

University-industry collaboration has been investigated at home and abroad by many researchers. Coursey and Bozeman defined it as "a series of activities conducted by one or more government-sponsored research institutes and private companies to jointly develop or secure technological knowledge based on formal or informal agreements"[3]. Also, Lee and Goh defined university-industry collaboration as a series of interactive and collaborative activities conducted by participants including industrial entities and universities with a view to R&D, human resource development, manpower exchange, and information sharing in the course of business operations4. Also, they categorized university-industry collaborative activities largely into technology exchange, manpower exchange and collaborative networking, as shown in Table 1[4,5].

Jo investigated university-industry collaborative activities, specifically the outcomes of technology projects, and viewed resource competency (the number of graduate students and total R&D spending), patent competency (patents applied for at home and abroad), and organizational competency (organizing a task force, special department and manpower placement) as the factors

Table 1. Typology of university-industry collaboration

Typology		Details	Policy
Technology	R&D	Joint commission, dispatch and invitation	Technology development support policy
	Technology transfer	Technology transfer, trouble shooting, technological instruction, and facility/equipment installation	Technology transfer, technology support policy and infra support policy
Manpower		Customized industrial training programs, hands-on practice of undergraduate students, Industrial in-service re-training programs, internship contracts, recruitment of adjunct professors with industrial background	Human resource development support policy
Collaborative network		Activities to build mutual trust and community culture between industries and universities	Collaboration and exchange support policy

of creating outcomes in university-industry collaboration, whilst technology transfers, returns on technology transfers, startups launched by the faculty and their revenues as the factors of outcomes[6].

In contrast, Jang and Jung referred to personnel factors (lack of skilled personnel, lack of management's interest and lack of members' awareness), technology factors (lack of technical skills, excessive technology R&D spending and concerns about disclosure of confidential information), organizational factors (immature task force and lack of facilities and equipment), and external institution factors (lack of communication, difficulties in role allocation and lack of trust) as the hindrance to revitalization of university-industry collaboration in Korea, and remarked that research administration system, financial stability, official utilization of university-industry consortia, criteria for university-industry R&D spending, and a range of infra rearrangement should be prioritized[7].

Diverse previous studies including the foregoing ones largely took objective figures including intellectual property[8], R&D spending and manpower as the input values of university-industry collaborative activities, and furthermore analyzed the outcomes in view of statistical numerical figures representing earnings and technology (patents) in order to account for the positive relations in measuring the relevance between input and output variables in university-industry collaboration[9]. Still, challenges arise in determining the relevance between intangible input and output variables because of the quantitative analysis of outcomes. For instance, the qualitative outcomes attributable to formal or informal network activities, dispositions of persons (corporate officers/staff, researchers, the faculty and persons in charge of university-industry collaboration) and the efforts they put in are hard to explain.

2. Model and Hypotheses

The present study pondered upon the university-industry collaboration in light of the main agents', or the faculty's needs for university-industry collaborative activities, the types of such activities in practice, and resultant outcomes expected and gained by the faculty ultimately to shed light on the effects of the engagement in university-industry collaboration on the outcomes. Therefore, this study surveyed the faculty in universities, and notably investigated both quantitative and qualitative outcomes. Importantly, the present findings suggest how to trigger the faculty's needs for university-industry collaboration in order to boost relevant activities and gain positive outcomes, and how to empower universities to establish and operate some support systems or processes that enable the main agents to estimate and induce such outcomes. Based on previous findings, this study set up a model concerning the effects of the needs for and engagement in university-industry collaborative activities on the outcomes from an exploratory perspective as shown in Figure 1.

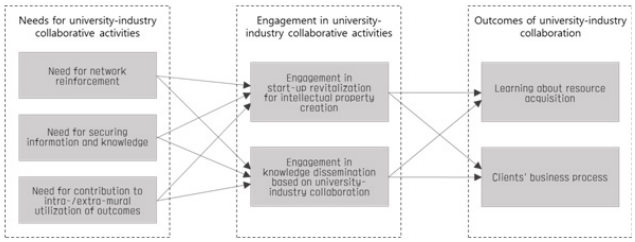

Figure 1. Research Model.

Needs for university-industry collaborative activities imply the main agents' awareness of the needs for such activities, comprising the need for network reinforcement, the need for securing information and knowledge, and the need for contributing to intramural and extramural outcomes through such activities. To be specific, first, the need for network reinforcement involves expanding the human network with relevant corporate officers and staff, researchers in relevant R&D centers, experts in relevant corporate support agencies, the faculty in other universities, and the faculty of other disciplines. Second, the need for securing information and knowledge involves perceiving the status of relevant companies or competitors as well as the latest technology, information and knowledge. Third, the need for contributing to intra-/extra-mural utilization of outcomes involves securing opportunities for continuous research on previous outcomes, supporting undergraduate or graduate students with employment opportunities, creating financial returns on technology transfers based on research outcomes, transferring or applying disciplinary knowledge and competency to industries, transferring or applying research outcomes to other organizations (companies), and raising internal and external recognition (fame).

The engagement in university-industry collaborative activities means the extent to which the main agents participate in university-industry collaboration and carry out relevant activities. The engagement in university-industry collaborative activities consists of the engagement in revitalization of start-ups for intellectual property creation and in knowledge dissemination based on university-industry collaboration. Specifically, first, the engagement in revitalizing start-ups for creation of intellectual property involves securing intellectual property rights, transaction and transfer of technology, technology instructions, support for research and project development, and startups on campus. Second, the engagement in knowledge dissemination based on university-industry collaboration involves building multi-disciplinary amity and exchange of technology, consulting and advisory support, and collaboration with corporate fields, publishing university-industry joint papers, and academic research project services.

The outcomes of university-industry collaborative activities mean the results gained by the agents participating in university-industry collaboration from relevant activities. The outcomes are sub-divided into quantitative outcomes of learning about resource acquisition and qualitative outcomes of clients' business process. To be specific, first, the outcomes of learning about resource acquisition include the number of university-industry joint research, the number of university-industry joint papers published, the number of technology transfers, the number of formal exchanges, the number of informal exchanges, the financial returns on technology transfers, the returns on project development based on technology transferred, the enrollment of graduate students, and the contribution to national economy.

Second, the outcomes of clients' business process include customized corporate university-industry collaboration, expansion of corporate network, engagement in diverse programs, increasing utilization of university-industry consortia, seamless corporate communication, improvement of university-industry collaborative business process, shorter university-industry collaboration work hours, increasing corporate trust, increasing corporate satisfaction, and increasing association with other agencies.

Based on the model, five hypotheses are set up as below from the exploratory perspective.

Hypothesis 1. Among the needs for university-industry collaborative activities, the need for network reinforcement will have positive effects on the engagement in university-industry collaborative activities.

Hypothesis 1-1. The need for network reinforcement will have positive effects on the revitalization of startups for intellectual property creation.

Hypothesis 1-2. The need for network reinforcement will have positive effects on the engagement in knowledge dissemination based on university-industry collaboration.

Hypothesis 2. Among the needs for university-industry collaborative activities, the need for securing information and knowledge will have positive effects on the engagement in university-industry collaborative activities.

Hypothesis 2-1. The need for securing information and knowledge will have positive effects on the engagement in revitalization of startups for intellectual property creation.

Hypothesis 2-2. The need for securing information and knowledge will have positive effects on the engagement

in knowledge dissemination based on university-industry collaboration.

Hypothesis 3. Among the needs for university-industry collaborative activities, the need for contributing to intra-/extra-mural utilization of outcomes will have positive effects on the engagement in university-industry collaborative activities.

Hypothesis 3-1. The need for contributing to intra-/extra-mural utilization of outcomes will have positive effects on the engagement in revitalization of startups for intellectual property creation.

Hypothesis 3-2. The need for contributing to intra-/extra-mural utilization of outcomes will have positive effects on the engagement in knowledge dissemination based on university-industry collaboration.

Hypothesis 4. Among the needs for university-industry collaborative activities, the engagement in revitalization of startups for intellectual property creation will have positive effects on the outcomes of university-industry collaborative activities.

Hypothesis 4-1. The engagement in the revitalization of startups for intellectual property creation will have positive effects on the outcomes of learning about resource acquisition.

Hypothesis 4-2. The engagement in the revitalization of startups for intellectual property creation will have positive effects on the outcomes of clients' business process.

Hypothesis 5. Among the needs for university-industry collaborative activities, the engagement in knowledge dissemination based on university-industry collaboration will have positive effects on the outcomes of university-industry collaborative activities.

Hypothesis 5-1. The engagement in knowledge dissemination based on university-industry collaboration will have positive effects on the outcomes of learning about resource acquisition.

Hypothesis 5-2. The engagement in knowledge dissemination based on university-industry will have positive effects on the outcomes of clients' business process.

3. Measures and Analysis

3.1 Measurement Method and Data Collection

The following questionnaire items in Figure 2 used to validate the foregoing model are measured on a 5-point Likert scale.

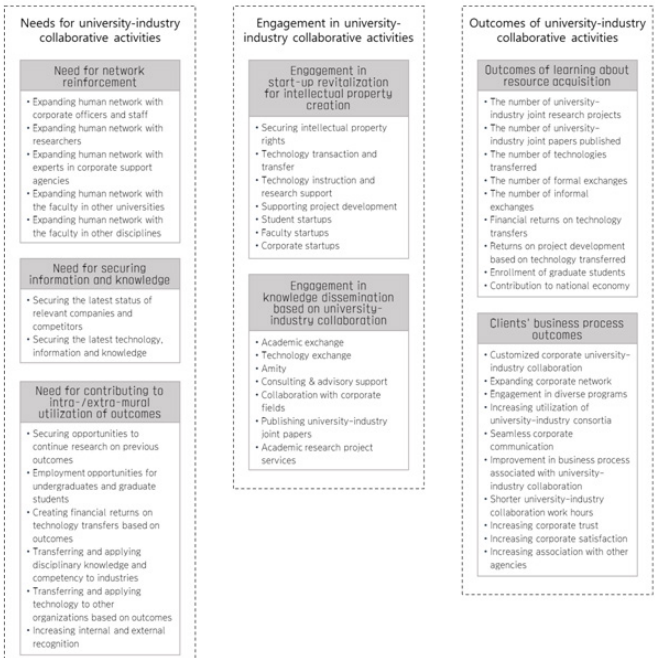

Figure 2. Survey questionnaire items.

PLS was used as the tool for analysis[10]. Data was collected for about two months with the direct questionnaire survey. Given the nature of the research, the faculties (full-time professors) serving as main agents for university-industry collaboration were surveyed. 44 out of 150 copies of the questionnaire distributed were returned and analyzed.

3.2 Reliability and Validity

Reliability was verified in terms of the internal consistency used for standardized measures comprised of Likert scales. As in Table 2, each latent variable's composite reliability and Cronbach α proved to be 0.8 or higher. Also, each latent variable's AVE (averaged variance extracted) proved to be 0.5 or higher, which is the standard value suggested by Fornell and Larcker[11]. Therefore, the present model was proved to show a high level of reliability.

The discriminant validity was tested based on whether the square roots of AVE marked on the diagonal axis in Table 3 exceeded the coefficients between the other constructs. In short, the discriminant validity of the present model was proved.

Table 2. Reliability test

Items	AVE	Composite Reliability	Cronbach's Alpha
Clients' business process outcomes	0.770	0.979	0.977
Need for network reinforcement	0.726	0.930	0.910
Engagement in knowledge dissemination based on university-industry collaboration	0.680	0.937	0.921
Outcomes of learning about resource acquisition	0.662	0.940	0.926
Need for securing information and knowledge	0.877	0.934	0.862
Need for contributing to intra-/extra-mural utilization of outcomes	0.736	0.944	0.930
Engagement in revitalization of startups for intellectual property creation	0.736	0.951	0.940

3.3 Analysis Results

The analysis of path coefficients indicated the causality between two variables as below. In brief, 7 out of 10 hypotheses were accepted, at a significance level of 5%, which is outlined in Table 4.

Table 4. Data analysis results

hypotheses	Path	Path Coefficient (Beta)	t-Value	Results
H1	H1-1	0.120	0.802	Rejected
	H1-2	0.148	1.516	Rejected
H2	H2-1	0.282	2.258	Accepted
	H2-2	0.265	2.528	Accepted
H3	H3-1	0.245	1.565	Rejected
	H3-2	0.309	2.578	Accepted
H4	H4-1	0.440	5.019	Accepted
	H4-2	0.332	3.234	Accepted
H5	H5-1	0.479	5.026	Accepted
	H5-2	0.238	2.123	Accepted

The foregoing analysis highlights the following. First, among the needs for university-industry collaborative activities in the hypothesis 1, the need for network reinforcement does not have significant effects on the engagement in university-industry collaborative activities (i.e. revitalization of startups for intellectual property creation and knowledge dissemination based on university-industry collaboration). Therefore, concerning the question items on the need for network reinforcement, the need for expanding human networks with relevant corporate officers and staff, researchers, corporate support experts, the faculty in other disciplines and the faculty in other universities is not directly related to university-industry collaborative activities.

Table 3. Discriminant validity

Items	1	2	3	4	5	6	7
1. Clients' business process outcomes	0.877*						
2. Need for network reinforcement	0.516	0.852					
3. Engagement in knowledge dissemination	0.538	0.516	0.825				
4. Outcomes of learning about resource acquisition	0.633	0.477	0.608	0.813			
5. Need for securing information and knowledge	0.436	0.570	0.549	0.545	0.937		
6. Need for contributing to intra-/extra-mural utilization of outcomes	0.435	0.703	0.584	0.482	0.647	0.858	
7. Engagement in revitalization of startups for intellectual property creation	0.628	0.453	0.628	0.648	0.509	0.512	0.858

* Square root of the AVE on the diagonal.

Second, in the hypothesis 2, the faculty's need for securing information and knowledge with regard to industry collaborative activities has positive effects on the engagement in university-industry collaborative activities (i.e. revitalization of startups for intellectual property creation and knowledge dissemination based on university-industry collaboration). That is, the need for securing the latest status of relevant companies and competitors, the latest technology, information and knowledge via university-industry collaboration leads the faculty to engage in university-industry collaborative activities, which in turn drives them to actively participate in diverse activities for securing intellectual property rights, technology transfers and transaction, technology instructions, and supports for project development. Also, such needs impact upon startups (launched by students, the faculty and companies). At the same time, the need for securing information and knowledge has positive effects on knowledge dissemination by the faculty based on university-industry collaboration, i.e. active participation in academic exchange, technology exchange, amity, corporate consulting and advisory activities, collaboration with corporate fields, publishing joint papers and academic research project services.

Third, in the hypothesis 3, the faculty's need for intra-/extra-mural contribution has positive effects on their engagement in knowledge dissemination as part of university-industry collaborative activities. That is, the faculty's need for opportunities to continue research on previous outcomes, for reinforcing undergraduate or graduate students' employment opportunities, for creating financial returns on technology transfers based on research outcomes, for transferring and applying disciplinary knowledge or expertise to industries, for utilizing research outcomes in industries via technology transfers, and for increasing personal fame and recognition internally and externally enhance the university-industry academic exchange, technology exchange, amity, corporate consulting and advisory activities, collaboration with corporate fields, publishing joint papers or academic research project services.

Fourth, the increase in the engagement in university-industry collaborative activities has positive effects on the outcomes of university-industry collaborative activities. As in the hypothesis 4, the increase in the engagement in intellectual property creation (i.e. securing intellectual property rights, technology transfer and transaction, technology instruction and research support, support for project development, and startups launched by students, the faculty and companies) improves the outcomes of learning about resource acquisition (the number of university-industry joint research projects, the number of university-industry joint papers published, the number of technology transfers, the number of formal/informal exchanges, the increase in financial returns on technology transfers, the increase in returns on project development based on technology transferred, the increase in enrollment of graduate students affiliated with companies and agencies and the increase in contribution to national economy), and facilitates the clients' business process outcomes (i.e. increase in customized university-industry collaboration, engagement in corporate networks, engagement in diverse university-industry programs, utilization of university-industry consortia, seamless inter-organizational communication, university-industry collaboration business process, shorter university-industry collaboration work hours, trust between companies and the faculty, corporate satisfaction and association with other agencies).

Fifth, as in the hypothesis 5, the increase in the engagement in knowledge dissemination based on university-industry collaboration (i.e. academic exchange, technology exchange, amity, corporate consulting and advisory activities, collaboration with corporate fields, publishing joint papers and participation in research project services) improves the outcomes of learning about resource acquisition and of clients' business process.

4. Conclusion

The present study highlights the following points. The needs for university-industry collaborative activities impact on the engagement in university-industry collaborative activities, which in turn influences the outcomes of such activities. In view of hypotheses, the foregoing results shed light on the following. First, among the needs for university-industry collaborative activities, the need for knowledge acquisition exerts significant effects on revitalization of startups for intellectual property creation and the engagement in knowledge dissemination based on university-industry collaboration. Second, the need for contributing to intra-/extra-mural utilization of outcomes has positive effects on the engagement in revitalization of startups for intellectual property creation and the engagement in knowledge dissemination based on university-industry collaboration. Third, the

engagement in revitalization of startups for intellectual property creation has significant effects on the outcomes of learning about resource acquisition and the outcomes of clients' business process. Fourth, the engagement in knowledge dissemination based on university-industry collaboration has significant effects on the outcomes of learning about resource acquisition and of clients' business process.

The present findings should be noted on the grounds that the outcomes of university-industry collaborative activities are determined based on the faculty's first-hand experience and perception and that both quantitative and qualitative outcomes of university-industry collaborative activities are elucidated.

In particular, given that the subjects of this study are the faculty engaging in university-industry collaborative activities, further studies may survey the experts participating in university-industry collaborative consortia and persons in charge of corporate university-industry collaboration based on the proposed process to investigate any differences, to select the needs that should be paid extra attention to by main agents, to identify the extent to which the faculty participate in university-industry collaborative activities, and to compare the outcomes of university-industry collaborative activities. Also, not only quantitative but also qualitative analysis of and approach to the outcomes of university-industry collaborative activities, as well as some intangible aspects behind university-industry collaborative activities (e.g. academic activities, gatherings and informal contacts) are worth investigating in conjunction with the process of creating outcomes.

Still, the present study has limitations. First, due to the focus put on the faculty as subjects in determining the outcomes of university-industry collaborative activities, this study fails to identify the outcomes of activities perceived by companies. Second, the objective explanatory power of the correlations between the faculty's responses concerning the needs for, engagement in and outcomes of university-industry collaborative activities could be increased by further analyzing the quantitative, or more objective, outcomes.

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