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Conjoint analysis of R&D contract agreements for industry-funded university research

So Young Sohn · Mooyeob Lee

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Abstract Since the late nineteenth century, universities have been regarded as useful sources of technological development to stimulate economic activity. Therefore, many governments have encouraged research collaborations between universities and industries. A consequence of such collaboration in Korea, however, is that university researchers have difficulty claiming ownership of their technological developments. Typical contracts used in academia in Korea have biased benefits for industries. Research and development contract agreements that decrease negotiation efforts between the sectors of academia and industry are essential to increase the efficiency of industry-academia collaborations. In order to determine an optimal contract design, we use conjoint analysis of four attributes, including policies of ownership and compensation, indemnity responsibility, patent application and maintenance fees, and publication restrictions. The resulting preferences take into account the perspectives of both industry and academia. We expect our approach to contribute to increasingly healthy collaborations between industry and academia, which in turn will benefit industrial competition as well as the Korean economy.

Keywords Industry-academia collaboration · R&D contract agreements · Conjoint analysis

JEL Classification K12 · L24 · O39

1 Introduction

Since the late nineteenth century, universities have been regarded as useful sources of technological development, which in turn stimulates economic activity (Bruno and

S. Y. Sohn (✉) · M. Lee
Department of Information and Industrial Engineering, Yonsei University,
134 Shinchon-dong, Seoul 120-749, Republic of Korea
e-mail: sohns@yonsei.ac.kr

Orsenigo 2003; Mowery et al. 2001; Rosenberg and Nelson 1994). Therefore, many governments have encouraged research collaborations between universities and industries. On the other hand, issues of ownership are problematic for university researchers because industry funded research and development (R&D) contracts with universities typically permit the sponsor to retain or share the rights of R&D outcomes. This phenomenon is especially prevalent in Korea, where academic Technology Licensing Offices (TLOs) have only recently been established at individual universities, and ownership issues are not clearly stated in standard R&D contract agreements. Under such circumstances, the incentives for individual academic researchers to develop and improve technology are limited. The identification of expectations should occur early in the negotiation process and provide the driving force for the definition of specific terms, such as indirect costs, use of unrestricted funds, intellectual property rights, type of research program, and measurements of success.

Compared to many of the world's major universities, universities in Korea lag behind the trend of ensuring contractual clauses with mechanisms that lead to highly efficient R&D. The systematic management of R&D contract agreements is essential in order to increase the efficiency of industry-academia collaboration. The biggest source of conflict between firms and universities is the ownership of patents for developed technology. Other problems involve identifying which party will be responsible for indemnity due to unexpected problems occurring from developed technology, whether or not consent for publication of R&D outcomes is needed, who is to be in charge of patent applications and patent maintenance fees, and what type of compensation is given to the collaborating party that does not ultimately own the patent. Such terms should be scrutinized to rectify inefficient practices in Korea.

Therefore, minimizing inherent conflicts within R&D contract clauses by developing an optimal contract design for both parties is necessary to streamline the negotiation process for universities and industrial firms.

The main purpose of this paper is to design an optimal R&D contract agreement that takes into account the perspectives of both industry and academia in Korea. In order to determine an optimal contract design, we use conjoint analysis of the following four attributes: policies of ownership and compensation, indemnity responsibility, patent application and maintenance fees, and publication restrictions. Conjoint analysis, an important analytical tool to advance marketing research in academic fields and industries, is a way to estimate the total utility of a new product or service by presuming the relative levels of utility afforded to consumers by component attributes of the product or service. In this paper, conjoint analysis is utilized to determine clauses that a standard R&D contract should retain, and to identify how current contracts should be modified.

The results of our conjoint analysis provide guidelines for writing standard R&D contract agreements between industry and academia to achieve minimal conflicts, thereby protecting the interests of both parties and increasing the efficiency of industry-academia collaborations.

This paper is organized as follows. In Sect. 2, we examine the background of R&D contracts between universities and industries. In Sect. 3, we introduce conjoint analysis and the design of our study. In Sect. 4, our findings are discussed along with feedback information from the conjoint analysis results.

2 Background

2.1 University–industry relationships

In the past, many firms regarded internal R&D as a valuable strategic asset because internal R&D creates a formidable entry barrier for competitors in many markets (Chesbrough et al. 2006). Recently, however, the R&D patterns of many firms have changed significantly with the advent of open innovation (Chesbrough 2003a). "Open innovation is a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology" (Chesbrough 2003b, p. xxiv). This phenomenon is inevitable in industry, because open innovation speeds the R&D process and provides access to multiple technologies without heavy investment in risky R&D (Chamanski and Waagø 2001). More than ever, firms are poised to capitalize upon research results from external sources.

Such research may be originated from university research programs, government R&D laboratories, or corporate scientific and engineering efforts. Among these sources, university spillovers are disproportionately large (Dasgupta and David 1987, Jaffe 1986, Merton and Starer 1973, Zucker et al. 1998, and National Academy of Sciences 1995; Libaers et al. 2006). Therefore, many countries have implemented policies to promote and sustain university-industry partnerships (Fontana et al. 2006; Schmiemann and Durvy 2003).

For example, the United States has adopted legislation called the Bayh-Dole Act, which allows the transfer of exclusive control over government funded inventions to universities and businesses operating with federal contracts for purposes of further development and commercialization. The Bayh-Dole Act strengthens the patenting rights of universities and encourages patenting activities among university researchers.

Unlike the United States, there exists no common legislation regarding university patenting in Europe. Recently, however, many European countries have instigated important legal changes, albeit in different directions (Czarnitzki et al. 2009). Some countries (Austria, Denmark, Finland, Germany and Norway) have traditionally respected the so-called "professor's privilege," which automatically grants university employees the intellectual property rights to their inventions. However, most of these countries recently revised their legislation to assign ownership to the universities themselves (Crespi et al. 2010). Under the assumption of professor's privilege, academics have the freedom to commercialize their inventions, as well as the responsibility of dealing with the administrative tasks associated with commercializing their discoveries. When universities own patents, however, they take over the risks of the patenting procedure. Otherwise, professors receive 30% of revenues received from exploitation of their patents through the university (Kilger and Bartenbach 2002).

Industrial firms initiate collaborative R&D with universities due to motivators such as risk reduction, early access to scientific or technological knowledge, access to unique research skills and reduction of costs through delegation of selected activities (Bonaccorsi and Piccaluga 1994). According to Lee (2000), additional reasons that firms seek collaborations with universities are to develop new products and processes, to conduct research leading to new patents, to improve product quality, to maintain ongoing relationships with and network with universities, and to recruit university graduates. In sum, firms engage in research collaborations with universities in order to keep abreast of new research, rather than to focus on product development (Stern 1989; Fusfeld 1994).

2.2 R&D contracts of major universities

There are ethical and legal issues concerning collaborative R&D efforts between industry and academia, which we identify as essential clauses to include in optimal R&D contract agreements for both sectors. The problems to be solved are:

- "Who will own patenting rights on technology developed through university research?"
- "Who will be responsible for the maintenance and application fees of patents?"
- "Who will take indemnity responsibility?"
- "How should researchers be compensated?"

Discussions about these questions are already underway at the world's leading universities.

In this section, we examine the standard research contracts of major universities around the world. As seen in Table 1, major universities have contract clauses related to publication restrictions, indemnity responsibility, maintenance fees, and policies of ownership and compensation. Various details of standard R&D contract clauses are described in the following subsections.

2.2.1 Clauses related to publication of research outcomes

The right to openly and freely publish research outcomes does not appear to be a key difficulty in negotiating research partnerships between universities and firms. A compromise on this issue (usually in the form of delay in publication until intellectual property rights are secured) seems to be acceptable to researchers, universities, and sponsoring companies (Hertzfeld et al. 2007). A study by Blumenthal et al. (1996) verifies that delaying publication and restricting the sharing of information are common. Researchers generally agree to the need for restrictions regarding the publication of research results.

The world's major universities have standard contract clauses that freely permit the publication of R&D outcomes after providing the sponsor with a specific period of time to review proposed publications for patentable subject matter, and to identify inadvertent disclosures of confidential information. However, each university has a slightly different publication process, as in Table 2.

2.2.2 Clauses related to indemnity responsibility for research outcomes

Although uncommon, it is critical to make contractual stipulations regarding circumstances that occur when research outcomes cause losses of life or property. We briefly discuss clauses related to indemnity responsibility for research outcomes in the standard contracts of major universities.

Stanford University and Syracuse University include clauses related to indemnity responsibility for research outcomes that are as follows. These universities specify that sponsors agree that the university is an academic research institution having an experimental nature. Also, universities never guarantee any matters of research outcomes whatsoever. As for the University of Cambridge clauses related to indemnity responsibility for research outcomes, the sponsor must make warranties to any costs, actions, claims, demands, liabilities, expenses, damages or losses regarding any third party claim due to problems arising from the university's R&D activities.

Table 1 Standard R&D contract clauses of major universities

Standard contract	Stanford University	Syracuse University	Massachusetts Institute of Technology	University of Cambridge
Clauses related to publication of research outcomes	5. Publication	8. Publication	8. Publication	8. Publication
Clauses related to indemnity responsibility for research outcomes	7. Indemnification 8. Representations, Warranties, Liability limits	14. Disclaimer 17. Liability to third parties 18. Force Majeure	11. Dispute Resolution 13. Representations and Warranties	9. Liability and indemnity
Clauses related to ownership of research outcomes	6. Intellectual Property Rights	10. Intellectual Property	9. Sponsor Intellectual Property 10. Joint Intellectual Property 11. MIT Intellectual Property	6. Intellectual Property

Table 2 Clauses related to publication of research outcomes

Descriptions	Stanford University	Syracuse University	Massachusetts Institute of Technology	University of Cambridge
Offering period of copies of any manuscript	When a manuscript is submitted for publication	Least 30 days before the date of the proposed publication	Least 30 days before the date of the proposed publication	Least 30 days before the date of the proposed publication
Review period for the reasons of removing the Sponsor's Confidential Information or identifying a patent application to be filed regarding any of the information contained in the proposed publication (days)	30	30	30	30
The freedom to publish R&D outcomes	✔	✔	✔	
Additional review period (days)		30	60	90
The option of receiving acknowledgment in the publication	✔			
Subsequent agreement between the firm and university is required for further extension		✔	✔	

In addition, MIT specifies that the university makes no warranties regarding R&D outcomes, disclaims all warranties, and states that sponsors do not guarantee likewise.

2.2.3 Clauses related to ownership of research outcomes and compensation

Ownership of patenting rights on technology developed from collaborative research, or the question of "who will retain the right of patents from the research?" is a major issue that must be resolved between contracting parties. Therefore, the optimal R&D research contract agreement should clearly assign ownership of research outcomes. Simultaneously, equity between parties should be considered when regulating ownership of patents. Furthermore, licensing options are partially mentioned in clauses related to ownership of research outcomes.

Stanford University categorizes intellectual property rights into three issues. The first issue is ownership of research program inventions. Stanford's contract describes three different cases as follows: inventions resulting from research programs are owned by Stanford, owned by the sponsor, or owned jointly by Stanford and the sponsor.

The second issue is that of patent prosecution and expenses. "Unless the parties agree in writing otherwise, the filing, prosecution, defense and maintenance of all patents for joint inventions will be conducted jointly in the name of both parties and controlled by them jointly" (Collaborative Research Agreement, Stanford University, p. 5).

The last issue is licensing. "Each party reserves the right to license its interest in its Sole Inventions or Joint Inventions, and neither party shall have any right to compensation in connection with any such license granted by the other" (Collaborative Research Agreement, Stanford University, p. 5).

The University of Cambridge has enacted a provision for licensing intellectual property resulting from R&D, which gives sponsors three options in the standard contract agreement.

The standard version of the licensing option is as follows. The sponsor grants to the university a royalty-free, non-exclusive license to use the sponsor's background intellectual property as it relates to the research project. Also, the university grants to the sponsor a non-exclusive, non-transferable, royalty-free license and those to use results for internal research purposes during the research project.

Another version of the pre-assignment of results to the sponsor is as follows. If background intellectual property of a party is used in the R&D project, all rights to this intellectual property are retained by that party.

In the third version, where results are to be used freely in the public domain, "the University shall place all Results, as soon as they are generated, in the public domain freely and without restrictions and both Parties hereby waive all rights in the Results" (Collaborative Research Agreement, University of Cambridge, p. 12).

In the case of MIT, research outcomes, which are invented solely by MIT members, remain with MIT. Otherwise, "for any copyrights or copyrightable material other than computer software and its documentation and/or informational databases required to be delivered in accordance with Attachment A, the Sponsor is hereby granted an irrevocable, royalty-free, non-transferable, non-exclusive right and license to use, reproduce, make derivative works, display, distribute and perform all such copyrightable materials for the Sponsor's internal purposes" (Collaborative Research Agreement, MIT, p. 4).

In the case of Syracuse University, any patents, copyrights, trademarks or service marks owned by one of the parties are granted by Syracuse University to inure the benefit of either party. Also, Syracuse makes contractual mention of three cases of rights to inventions, improvements, and discoveries, whether or not patentable.

In addition, the right of first option is granted to the sponsor to negotiate for an exclusive royalty-bearing license. Under the research project as agreed, this option is to make, have made, reproduce, use, sell, and offer to sell all university inventions and all joint inventions.

2.3 Circumstances surrounding universities in Korea

As the role of universities in technology development has increased in Korea, patents submitted by universities have also increased. Universities accounted for 0.93% of patents registered in 2000, and 6.37% of registered patents in 2008 (Korean Intellectual Property Office 2008). This increase has occurred as a result of government activity formulating the intellectual property system in order to commercialize or transfer a result of research produced by universities. This system encourages university researchers to apply a patent. On the other hand, the importance of collaborative research between universities and firms has been greatly expanded. Although standard contracts associated with collaborative research are of growing interest and concern, the fact remains that contract agreements between parties are typically advantageous toward the party responsible for funding the projects. Moreover, researchers have little expertise and competence in negotiating contracts.

Under these circumstances, patent law in Korea has taken into consideration the contributions of different parties to R&D projects to clarify patent authority. Although collaborative research contracts are signed, rights to research inventions belong solely to the university under the research project initiative. Nevertheless, once the sponsor supports the funding, human property, and technology information, it is recognized that the sponsor has contributed to any given R&D project. Accordingly, Korean patent law approves partial ownership of rights to research inventions for the sponsor (Jung 2007). Nevertheless, research conducted on the guidelines for collaborative R&D contract agreements announced by the Korean Intellectual Property Office (KIPO) claims that rights for the results of collaborative efforts should be owned exclusively by the enterprise in cases where the enterprise has paid all expenses (Korean Intellectual Property Office 2010).

Although standards are available, both parties have differing points of view and interests to protect, and agreement on the recognition of ownership can therefore be difficult to reach. However, in most cases of industry funded academic research, enterprises unilaterally claim ownership of the technology or patent. Existing collaborative research contracts in Korea are vague and complicated in terms of ethical and legal issues. Therefore, in order to rectify unfair practices, it is urgent to establish a standard research contract with the consent of both parties for industry funded university research.

3 Proposed conjoint analysis

Conjoint analysis was introduced by Green and Rao (1971), and has become the primary statistical technique used in marketing research to determine how people value different features that comprise an individual product or service. Extensive use of conjoint analysis in marketing began after its initial appliance in mathematic psychology, and it became more important as an analytical tool with the development of computer software. Since it is assumed that the hypothetical product or service undergoing evaluation can be defined in terms of a few important characteristics, conjoint analysis can predict which product consumers will prefer. It is not surprising that conjoint analysis is widely applied in a number of contexts, such as the development of new products, pricing, market segmentation, advertizing and strategies for distribution. Jeon et al. (2010) utilized conjoint

analysis to predict the future development of mobile phones. Sohn and Ju (2010) used conjoint analysis to weigh components of college entrance examinations to effectively recruit science-oriented high school students. Mok et al. (2010) applied conjoint analysis to the design of standard programs for intellectual property education in universities, private, and public institutions. Kim et al. (2009a, b) utilized conjoint analysis to determine the optimal design of a luxury brand outlet mall. Kim et al. (2009a, b) used conjoint analysis to develop an optimal design for English medium instruction in order to maximize achievement for students. Song et al. (2009) used conjoint analysis to estimate customer preferences and the relative importance of service factors of IPTV.

In this study, we utilize conjoint analysis to determine contractual clauses that the optimal R&D contract agreement should have, and how current contracts should be modified to best meet the needs of both industries and universities in Korea.

3.1 Design of conjoint analysis

We first identify R&D contract clauses that can lead to conflicts between firms and universities. Representative clauses need to feasibly and properly reflect the perspectives of both industry and academia. The main objective of our analysis is to provide insight into the optimal combination of four clauses (regarding policies of ownership and compensation, indemnity responsibility, maintenance fees, and publication restrictions) in order to minimize conflicts between firms and universities. We consider these four clauses as attributes for conjoint analysis. This paper examines each attribute according to standard contract agreements of the world's major universities.

Table 3 shows the possible levels of each attribute. These levels are set to represent information covered in the background review section of this paper. In considering all possible profiles, there are a total of 240 ($=3^1 \times 4^2 \times 5^1$) possible profiles. It is impossible for respondents to rate all possible profiles. A possible fractional factorial design is $3^1 \times 4^1 \times 5^1$, but ranking even 60 profiles is burdensome. Therefore, as displayed in Table 4, we have reduced the 60 profiles to 16 by deleting combinations that are barely distinguishable from other combinations, even though this reduction does not guarantee independence among the factors.

These 16 profiles were constructed using the marketing experiment function of SAS 9.13 statistical software (SAS Institute, Cary, NC, USA). After establishing relevant attributes and their levels, the 16 hypothetical contract profiles were presented to individual respondents belonging to two groups: universities and industrial firms.

Each respondent was asked to rank the 16 contract profiles, according to their own preferences, on a scale from 16 (most preferred) to 1 (least preferred).

3.2 Results of conjoint analysis

We interviewed a total of 62 participants from academia (32, 51%) and sponsoring industrial firms (30, 49%) in Korea. The researchers included 19 university professors and 13 graduate students who had experience with industry sponsored research projects. Sponsors included managers who had experience with technology transfer or collaborative research projects with universities. The majority of university respondents were in industrial engineering (29%) and electronic engineering (22%). Industry respondents were in sectors such as manufacturing (36%), financing (24%), and consulting (13%), with other sectors comprising an additional 26%. We further categorized industry respondents according to the sizes of their companies (76% large companies, 13% mid-sized companies, and 10% small businesses) (Table 5).

Table 3 Levels of each attribute

Attribute and level	Level 1	Level 2	Level 3	Level 4	Level 5
Publication restrictions	Publication without consent of sponsor after deleting sponsor's confidential information	Publication with consent of sponsor (publication without consent of sponsor is possible after 30 days)	Publication with consent of sponsor after acknowledgment in the publication		
Patent application and maintenance fees	Individual researcher	University	Firms	Co-responsibility of both the firms and university	
Indemnity responsibility	Individual researcher	University	Firms	Co-responsibility of both the firms and university	
Ownership and compensation	Individual researcher/ non-exclusive license of royalty-free	Firms/no incentives for researchers	Firms/incentives for researchers	Both university and firms/ incentives for researchers	University/non-exclusive license of royalty-free

Table 4 Selected profiles for comparison

Profiles	Publication of R&D outcomes	Patent application and maintenance fees	Indemnity responsibility	Ownership and compensation
1	Publication without consent of sponsor after deleting sponsor's confidential information	University	Firms	Firms/no incentives for researchers
2	Publication with the consent of sponsor after acknowledgment in the publication	Firms	Firms	Firms/incentives for researchers
3	Publication with the consent of sponsor (publication without consent of sponsor is possible after 30 days)	University	University	Firms/incentives for researchers
4	Publication without consent of sponsor after deleting sponsor's confidential information	Co-responsibility of both the firms and university	Co-responsibility of both the firms and university	Firms/incentives for researchers
5	Publication with the consent of sponsor (publication without consent of sponsor is possible after 30 days)	Firms	Individual researcher	University/non-exclusive license of royalty-free
6	Publication without consent of sponsor after deleting sponsor's confidential information	Co-responsibility of both the firms and university	Individual researcher	Individual researcher/ non-exclusive license of royalty-free
7	Publication with the consent of sponsor after acknowledgment in the publication	Individual researcher	Co-responsibility of both the firms and university	Both university and firms/ incentives for researchers
8	Publication with the consent of sponsor (publication without consent of sponsor is possible after 30 days)	Co-responsibility of both the firms and university	Firms	Both university and firm/ incentives for researchers
9	Publication with the consent of sponsor (publication without consent of sponsor is possible after 30 days)	Firms	Co-responsibility of both the firms and university	Individual researcher/ non-exclusive license of royalty-free
10	Publication with the consent of sponsor after acknowledgment in the publication.	Co-responsibility of both the firms and university	University	Firms/no incentives for researchers
11	Publication without consent of sponsor after deleting sponsor's confidential information	Individual researcher	University	University/non-exclusive license of royalty-free

Table 4 continued

Profiles	Publication of R&D outcomes	Patent application and maintenance fees	Indemnity responsibility	Ownership and compensation
12	Publication without consent of sponsor after deleting sponsor's confidential information	Firms	University	Both university and firms/ incentives for researchers
13	Publication with the consent of sponsor after acknowledgment in the publication	Individual researcher	Firms	Individual researcher/ non-exclusive license of royalty-free
14	Publication with the consent of sponsor after acknowledgment in the publication	University	Co-responsibility of both the firms and university	University/non-exclusive license of royalty-free
15	Publication with the consent of sponsor (publication without consent of sponsor is possible after 30 days)	Individual researcher	Individual researcher	Firms/no incentives for researchers
16	Publication with the consent of sponsor after acknowledgment in the publication	University	Individual researcher	Both university and firms/ incentives for researchers

Table 5 Results of conjoint analysis of all respondents (significance level 10%)

Attributes of research contract	Levels	All respondents		
		Importance	Relative importance (%)	Part-worth utility (ranking)
Publication restrictions	1. Publication without consent of sponsor after deleting sponsor's confidential information	1.401	13	8.197
	2. Publication with the consent of sponsor (publication without consent of sponsor is possible after 30 days)			9.598
	3. Publication with the consent of sponsor after acknowledgment in the publication			9.598
Patent application and maintenance fees	1. Individual researcher	2.495	23	8.591
	2. University			9.598
	3. Firms			11.086
	4. Co-responsibility of both the firms and university			9.598
Indemnity responsibility	1. Individual researcher	2.381	22	7.218
	2. University			8.979
	3. Firms			9.598
	4. Co-responsibility of both the firms and university			9.598
Ownership and compensation	1. Individual researcher/non-exclusive license of royalty-free	2.035	19	9.598
	2. Firms/no incentives for researchers			8.422
	3. Firms/incentives for researchers			9.598
	4. Both university and firms/incentives for researchers			10.457
	5. University/non-exclusive license of royalty-free			9.598

In the analysis of all respondents, the responsibility for 'patent application and maintenance fees' turns out to be the most significant attribute, although the importance of 'indemnity responsibility' is similar. Moreover, all respondents prefer firms to be in charge of patent application and maintenance fees, and prefer either the firm or both the firm and the university to be in charge of indemnity responsibility. In terms of publication restrictions, respondents do not prefer 'publication without the consent of sponsor after deleting the sponsor's confidential information' in contrast with the other options. In addition, respondents prefer 'university and firms/incentives for researchers' in terms of ownership and compensation.

Thus, the optimal contract agreement for both sides can be stated as follows. Publication is possible after getting the sponsor's consent. Patent maintenance and application fees are handled by the firm. Either the firm, or the firm and university together, are responsible for problems resulting from R&D outcomes. That is, individual researchers are free from responsibility of indemnification. Ownership of patents is given to both universities and firms, while individual researchers should be compensated for R&D results in the form of incentives.

The academic TLOs have introduced a standard contract, which varies in practice at different universities. Our proposed contract agreement derived from conjoint analysis has different features from the standard contract currently being used by the majority of research universities in Korea.

According to standard contracts currently in use in Korea, any inventions resulting from research programs are owned jointly by the university and sponsor. When processes such as patent application and registration are needed for securing rights to research outcomes, these processes are conducted entirely at the sponsor's expense. The university is liable for any direct, consequential, or other damages suffered by the sponsor within the parameters of this contract.

In contrast to these current standards, the contract agreement derived from our conjoint analysis considers compensation for individual researchers. It also suggests that firms must bear indemnity responsibility, while current contracts stipulate that the university indemnifies losses of the sponsor. Our results offer a foreseeable reduction of conflict when these two terms are adopted in a more optimal standard contract agreement (Table 6).

Respondents from the university group considered policies of ownership and compensation to be more important (38%) than other attributes. On the other hand, respondents from the industrial group considered publication restrictions to be the most important attribute, probably because firms regard the confidentiality of proprietary information to be the most important issue. Although we hypothesized that firms would not want to give incentives to researchers, our results show that firms prefer to do so. Firms also prefer to be responsible for patent application and maintenance fees. If firms offer such benefits to researchers, then researchers will be more motivated to achieve higher quality R&D, which in turn leads to higher performances by firms.

1. Publication restrictions: No respondents prefer the option of publication without consent, even after firms have deleted any proprietary and confidential information. Although party-specific interests are considered for each, neither party prefers publication without consent from firms. This finding is reasonable because it shows that respondents from both groups prioritize the consideration of legal issues that may cause serious problems due to leakage of confidential information.

Table 6 Results of conjoint analysis classified by group

Attributes of research contract	Levels	University group			Industry group		
		Importance	Relative importance (%)	Part-worth	Importance	Relative importance (%)	Part-worth
Publication restrictions	1	0.930	9	9.269	1.903	29	7.055
	2			10.199			8.958
	3			10.199			8.958
Patent application and maintenance fees	1	2.379	22	9.153	1.652	25	8.958
	2			10.199			8.958
	3			11.532			10.610
	4			10.199			8.958
Indemnity responsibility	1	3.304	31	6.894	1.395	21	7.563
	2			8.900			8.958
	3			10.199			8.958
	4			10.199			8.958
Ownership and compensation	1	4.100	38	10.199	1.604	24	8.958
	2			7.766			8.958
	3			10.199			10.562
	4			11.866			8.958
	5			10.199			8.958

2. Patent application and maintenance fees: Both parties prefer the option of firms being in charge of patent application and maintenance fees. Neither group prefers individual researchers to be in charge of patent application and maintenance fees.
3. Indemnity responsibility: This result also demonstrates that individual researchers are not suited to be in charge of indemnity responsibility. In addition, university respondents have an equal preference for firms, or both universities and firms to have co-responsibility for indemnity.
4. Ownership and compensation: University researchers prefer 'co-ownership of university and sponsor/incentives for individual researchers' and do not prefer the option of 'firm/no incentives for individual researchers.' On the other hand, firms prefer to retain exclusive ownership and provide incentives for individual researchers. This result shows that researchers desire adequate compensation for their efforts, and that sponsors believe that the exclusive ownership of patents is important, and is also concerned about issues of compensation for researchers.

4 Conclusions

In the twenty-first century, where successful economies are knowledge-based, science, technology and design have been identified as premium sources of growth. This trend enables companies world-wide to intensify investments in R&D and promote cooperation with universities for optimum research efforts. Under these circumstances, the importance of a standard research contract agreement that is favorable for both collaborating parties is increasingly critical.

As the negotiation of contractual agreements has emerged as the first step for collaborative R&D efforts between universities and industries, the academic TLOs have established standard terms for a basic R&D contract. Generally speaking, however, collaborative R&D agreements are more beneficial to industrial sponsors in Korea than to researchers. Thus, we propose an optimal R&D contract agreement that effectively takes into account the perspectives of both industry and academia using conjoint analysis.

Based on the results of our empirical analysis, university affiliates tend to select contractual terms that are advantageous for them. More surprisingly, industries, which were hypothesized not to give benefits to researchers, prefer to offer incentives to researchers and to be responsible for patent application and maintenance fees. This suggests that firms anticipate high profits from the commercialization of R&D outcomes. As firms inspire researchers to engage and excel in fields related to R&D, they capture the high yields of R&D in the long run.

In addition, we derive an optimal design for standard R&D contract agreements and compare it to standard agreements currently in use. While current contract agreements state that universities indemnify all damages suffered by firms, our more effective contract design suggests that firms should have indemnity responsibility. In addition, there are no statements in current contract agreements about compensation or incentives for researchers, but the optimal contract design suggests that individual researchers should get incentives based on the performance of R&D outcomes. If the results of this study are incorporated in standard contract agreements, the quality of research will increase since researchers will be more motivated to collaborate. In turn, firms will garner better access to quality technology. Consequently, better technology will enhance industrial competitiveness as well as the wealth of the nation due to successful technological commercialization.

The results of our study are based on conventional conjoint analysis. Further studies based on more advanced conjoint analysis are necessary. Adaptive conjoint analysis (ACA) is the preferred approach when there are many attributes. Choice-based conjoint (CBC) analysis can more accurately identify the preferences of respondents than conventional conjoint analysis due to the utilization of pairwise comparisons. In addition further research needs to include mediators such as patent attorneys in data surveys. Mediators provide feedback on contracts from a neutral standpoint. These topics are left as areas for further studies.

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