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A Hidden Role of Public Subsidy in University-Industry Research Collaborations

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Abstract

Contractual and organizational characteristics of university-industry research collaboration (hereafter UIC) are keys to its success. In this respect, government can play essential roles in UIC: Public subsidy for research and development (hereafter R&D) is not only an important financial support for UIC, but may also be a useful channel to promote trust along with contractual agreements and information sharing among the members, which results in effective coordination and thus the success of UIC. However, few empirical studies investigate the latter role of public R&D subsidy in UIC. Thus, using original survey data, this paper empirically examines and find that public R&D subsidy improves coordination in UIC, including trust formation, contractual agreements, and communication quality between the partners as well as commitment by the partners.

Keywords: pubic subsidy; R&D, research collaboration; university; contract; trust

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1. Introduction

University-industry research collaboration (hereafter UIC) has been attracting increasing attention both from academia and practice as an effective means of promoting research and development (hereafter R&D) and enhancing its productivity (Chesbrough, 2003). However, performance of UIC projects varies considerably depending on its contractual and organizational characteristics (Mora-Valentin et al., 2004). Specifically, trust between and commitment by the partners are among the most important success factors, because researchers in academia and private firms often have considerably different interests, objectives, constraints and incentives, which impede an effective organization of UIC (Grilli and Milano, 2009).

In this respect, government can play essential roles in UIC: Public R&D subsidy is not only an important financial support for UIC, but also a useful channel to promote mutual trust, contractual agreements, information sharing, and commitment in UIC, which results in effective coordination and thus the success of UIC. Public subsidy may affect the coordination and organization of UIC projects through direct monitoring and evaluation by the government, administrative rules to provide contractual safeguard, and the disclosure to the public that disciplines future behavior of the recipients. However, compared to the more obvious, direct role of public subsidy, on which most previous studies have focused (Spence, 1984; Teece, 1986; David et al., 2000), its role of improving coordination has rather been ignored in the literature.

Several papers refer explicitly to the role of public R&D subsidy to promote mutual trust in UIC (Zucker et al., 1994; Das and Teng, 1998, Zucker et al., 2001; Darby et al., 2004). To the best of our knowledge, however, few empirical studies have investigated such role of public R&D subsidy in UIC. Thus, this paper empirically examines if and how public R&D subsidy affects coordination in UIC, including trust formation, contractual agreements, and communication quality between the partners as well as commitment by the partners, controlling for initial conditions and various project characteristics of UIC. In this sense, we will reveal an important role of public R&D subsidy that has been hidden thus far in both academic and practical discussion.

For the empirical analysis, we use our original survey data on Japanese firms in the fields of biotechnology, microelectronics and software that have experienced UIC during three years prior to the survey. 55% of our sample firms obtained public subsidy for UIC. Two-step GMM (Generalized Method of Moments) is employed for empirical estimation in order to control for endogeneity regarding the acceptance of public subsidy. Our estimation results indicate that public subsidy in fact has a

significantly positive and strong impact on trust formation, contractual agreements, communication quality, and commitment in UIC, even after considering endogeneity problem.

The remainder of this paper is organized as follows. In the next section, we present theoretical backgrounds of our paper and some hypotheses based on the backgrounds. In Section 3, we describe our data and variables used in the empirical analysis. In Section 4, we explain our models and estimation method. In Section 5, we report our estimation results. Finally, Section 6 concludes this paper.

2. Backgrounds and hypotheses

UIC has been regarded as an effective R&D strategy to enhance firms' productivity: an effective way to overcome the lack of internal business resources and enhance innovativeness, to achieve economies of scale and scope and synergy effects in R&D, to avoid risk and wasteful duplication of efforts, and to increase incentive for R&D investment by alleviating appropriability problem (Katz, 1986; d'Aspremont and Jacquemin, 1988; Suzumura, 1992; Combs, 1993; Hall et al., 2000)[1].

The performance of UIC essentially depends on its contractual and organizational characteristics. Specifically, mutual trust and communication quality between and commitment by the partners are among the most important success factors (Mora-Valentin et al., 2004). Furthermore, Okamuro (2007) indicated that the contractual characteristics regarding cooperative R&D, specifically the pattern of sharing costs and outcomes, affect the incentives of the partner firms and thus the project performance[2]. However, disparities (or high information asymmetries) between private firms and universities may cause serious conflicts, misunderstanding, and distrust between them, which would make it difficult to efficiently organize a UIC project (Grilli and Milano, 2009).

In this respect, government can play essential roles in UIC[3]. Traditionally,

[1] The theoretical literature analyzing the motivation for firms' engagement in UIC can be grouped into three categories: transaction costs, industrial organization, and strategic management theory (or capability theory). See Hagedoorn et al. (2000) and Lechevalier et al. (2007) for more detail.

[2] Aghion and Tirole (1994) provide theoretical foundation with regard to the effect of allocation of property rights on both frequency and magnitude of innovations in an incomplete contract framework.

[3] In general, government contributes to open innovation activities in a number of ways (Nakamura, 2003). For example, government research agencies do their own joint research with firms and universities, and they also provide funding to research projects. How these government funds are allocated and who gets involved in these research projects may have influence on a nation's economic performance. Further, government arranges legal settings and launches policies under which firms operate: for example, government usually determines the conditions under which firms are engaged in joint R&D projects and the policies for financing R&D investment and for promoting network formation

public R&D support is argued to complement private R&D (Spence, 1984; Teece, 1986). Specifically, David et al. (2000) listed the following mechanisms through which public R&D support stimulates complementary private R&D expenditures: (1) R&D support generates learning curve effects that enhance the ability of firms to obtain the latest scientific and technological knowledge (absorptive capacity). (2) Public funds provide the recipients easier access to specific research facilities that would not be feasible without public funds, and allow them to start projects with low additional costs (cost sharing). (3) Commissioned R&D from the public sector signals future demand for technologies, goods, and services diverted to the private sector (pump-priming effect)[4].

However, another important channel to stimulate private R&D is the promotion of mutual trust among cooperative players (Zucker et al., 1996; Das and Teng, 1998; Zucker et al., 2001; Darby et al., 2004). In this paper, we will test if and how public R&D subsidy affects contractual and organizational characteristics. Thus, in the following discussion, we focus on the relationship between public subsidy and coordination mechanisms of UIC.

Zucker (1986) defined trust as a set of expectations shared by all those involved in an exchange. Das and Teng (1998) also defined trust as positive expectations about partner motives. More concretely, they stress benevolence and integrity. Benevolence is the extent to which a trustee is believed to want to do what is good to the trustor. Integrity is the extent to which a trustee is believed to adhere to a set of principles that the trustor finds acceptable. In our empirical study, we adopted broader definition of trust including benevolence and integrity.

Zucker (1986) further categorized trust as three dimensions, namely process-based, characteristics-based and institution-based trust. Process-based trust is based on concrete experience concerning certain behavioral patterns. It results from the dynamics of past and future exchange processes. Each one gathers information on past transactions with which they can evaluate the other partner's trustworthiness. This argument is consistent with that of Shapiro et al. (1992) and Doney and Cannon (1997). Characteristics-based trust notices the influence of personal bonds, friendship, social norms or religion in the relationships among actors. This is similar to the discussions

among actors.

[4] As one of recent empirical studies, Czarnitzki and Ebersberger (2010) find that public R&D subsidy results in more R&D spending at the firm level in Finland and Germany. Colombo et al. (2010) examine the effect of public R&D support on the investment of new technology-based firms (NTBF) in Italy. According to their result, public finance increases the investment rate of small NTBFs, but not of large NTBFs. From these analyses, we can infer that public support to NTBFs is helpful, only if it is targeted to firms that really need it, such as small and/or young ones.

of Sako (1992) and Shapiro et al. (1992). Finally, institution-based trust covers formal social structures which are usually supported by sanctions based on the law. These include property rights, business contracts, and public support. Institutional arrangements provide the rules of the game and the actual play of the game itself (Williamson, 2000).

Trust is often produced on institutional mechanisms, including in-group preference, formal rules and procedures supported by formal organization or a third party with monitoring and enforcement (Brewer and Silver, 1978; Zucker, 1983, 1986, 1996)[5]. To the extent that collaborations within organization involve a third party, involvement of a third party would help increase the self-enforcing range, and thus induce a higher rate of collaboration within organizational boundaries (Zucker, 1996).

Absent trust in cooperative R&D, participants may take opportunistic action such as "cheating, shirking, distorting information, misleading partners, providing substandard products/services, and appropriating partners' critical resources" (Das and Teng, 1998, p. 492). To alleviate the loss generated by opportunistic behavior, control mechanism is indispensable.

Control refers to an organizational setup, a process of regulating behaviors, and an organizational outcome. According to Das and Teng (1998), there are two important concepts concerning control, i.e. control mechanisms and level of control. Control mechanisms are the organizational or regulatory arrangements designed to determine and influence the behavior of organization members, while level of control is the degree to which one believes that proper behavior of the other party is ensured. Through the establishment of proper control mechanisms, the achievement of desirable goals becomes more predictable by deterring opportunistic behaviors in cooperative R&D (Provan and Skinner, 1989; Parkhe, 1993).

Based on the above discussion, we expect government, providing public subsidy, to play an important role as a third party in government-sponsored UIC, and to promote trust among participants. In sum, the following implicit institutional or administrative designs are expected to promote effective coordination among UIC participants: (1) a third party (government) regularly monitors and evaluates participants' behavior in UIC to ensure cooperation, (2) a third party provides administrative structures and regulatory agreements as contractual safeguards in UIC

[5] Anthropologists (e.g. Geertz, 1978) state that a combination of repeated exchange and expected future exchange produce trust, when a third party is not available to monitor the exchange. As indicated by Mayer et al. (1995) and Kopczak and Johnson (2007), trust develops over time. Trustors learn about the trustworthiness of the trustee, based on the trustee's actions in situations of risk and vulnerability, through accumulated experience.

to increase confidence in successful coordination, and (3) a third party (government) sets up control mechanisms to influence the future behaviors of organization members. The outcomes and the processes of government-sponsored UIC will be reported in public, which would deter opportunistic behaviors by UIC participants. It is plausible that the participants, who desire to receive another public fund in the future, are not likely to engage in opportunistic behaviors. Moreover, in preparing for the application for a public subsidy, project members should intensely communicate each other, which may promote further communication and trust formation.

An example of the public R&D subsidy provided by METI (Ministry of Economy, Trade and Industry) may illustrate government's role to improve coordination process in UIC. METI's "Consortium R&D Project for Regional Revitalization" starting in 1997 is one of the major support programs for UIC projects[6].

This program is carried out as R&D projects contracted by METI to competitively selected research consortia, so that R&D expenditures for the projects are fully covered by the subsidy. The subsidy is paid for the contracted work, thus not at the beginning of, but after finishing the project work. Each consortium has a management organization[7] that prepares for and submits application form (project proposal). Proposals should include detailed description of research plan and commercialization plan, project schedule, budget plan, detailed information on management organization, project leader and sub-leader as well as each of other members (firms, university professors, etc.), and each member's role in the project.

Upon acceptance, management organizations of selected consortia have to conclude formal contracts with regional departments of METI to conduct the projects. Management organizations usually conclude then subcontracting agreements with project members. Project members are also requested to provide collective confirmation for the commercialization of research outcomes.

After finishing the project (basically within two years), management organization submits the project report to METI, which then reimburses the R&D expenditures of the project. Project evaluation by METI is conducted based on the final report from the management organization. In the final report and evaluation, not only the technological achievement of the project, but also the efficiency of project coordination and the effort for improving it should be taken into consideration. METI publishes information about the selected consortia including membership and the final

[6] Following information on this support program was obtained from the website of METI (http://www.meti.go.jp/).

[7] Management organization can be a private firm, university, public research institute, or public agency.

reports of these projects. Moreover, METI follows up further research and commercialization of project outcomes by the supported consortia for five years after finishing the project.

In this way, METI and its regional departments monitors and evaluates UIC projects, enforces clear mutual agreements also among the members, and make project information public. We expect such institutional background to encourage better coordination in the UIC projects.

Thus, through the social relations backed by government, collaborators in UIC can be able to relax their boundaries and extend their network for R&D[8]. In this circumstance, close contacts among researchers in cooperative R&D facilitate the transmission of novel knowledge which is often tacit in nature (Zucker et al. 1998). Further, relaxation of boundaries around the participants allows more information exchange and learning across organizational boundaries than would otherwise be the case (Zucker et al. 1996). Therefore, we provide following four hypotheses with regard to public R&D subsidy and contractual and organizational characteristics.

H1 Public R&D subsidy promotes a mutually agreeable explicit contract between a firm and a university in a UIC project.

H2 Public R&D subsidy enhances quality of communication between a firm and a university in a UIC project.

H3 Public R&D subsidy strengthens firms' commitment to a UIC project.

H4 Public R&D subsidy supports trust formation between a firm and a university in a UIC project.

Most empirical studies examine the effect of participation in public R&D support on firm performance, e.g. patent productivity (Zucker et al., 1996; Branstetter and Sakakibara, 2002; Das and Teng, 1998; Zucker et al., 2001; Czarnitzki and Hussinger, 2004; Hujer and Radic, 2005; Czarnitzki et al., 2007; Darby et al., 2004; Hussinger, 2008; Grilli and Milano, 2009; Lechevalier et al., 2010). Further, most literature is based on case studies: SEMATECH in the US semiconductor industry (Irwin and Klenow, 1996; Link et al., 1996); the VLSI Cooperative R&D Association in Japan (Sakakibara, 1981; Otaki, 1983); the Fifth Generation Computer Project in Japan (Odagiri et al., 1997); the Next Generation Projects such as the Exploratory Research for Advanced Technology (ERATO) in Japan (Hayashi, 2003); the Advanced

[8] Darby et al. (2004) support this referring to the case study of Advanced Technology Program (ATP) by U.S. Department of Commerce.

Technology Program (ATP) in the US (Jaffe, 1998; Link, 1998; Hagedoorn et al., 2000; Hall et al., 2001); the Small Business Innovation Research (SBIR) in the US (Lerner, 1999; Wallsten, 2000); the Alvey Programme for Advanced Information Technology in the UK (Quintas and Guy, 1995); the Societa di Ricerca in Italy (Tripsas et al., 1995); the Office of the Chief Scientist Program (OCS) in Israel (Lach, 2002; Trajtenberg, 2002); the EUREKA and EU Framework Programmes (Benfratello and Sembenelli, 2002) and the SESI-TSER Project (Carayol, 2003) in Europe.

They largely find positive effect of public R&D support on firm performance, but few of them empirically show why public R&D support enhances firm performance, possibly due to data constraints. To the best of our knowledge, little has been done regarding the effect of public R&D subsidy on contractual and organizational characteristics in R&D cooperation, whereas several theoretical studies suggest positive links between them. Therefore, a major contribution of this paper is to empirically examine if and how public R&D subsidy affects coordination mechanism in UIC. Thus, our findings would enable us to deepen our understanding on the success factors of UIC.

3. Data and variables

This section explains our data source and variable construction. First, we describe our original survey conducted in 2008 as the data source. Then, we present our dependent and independent variables.

3.1. Data

The empirical analyses are based on original survey data. We conducted a postal survey in 2008 for 9,882 firms in the fields of biotechnology, microelectronics, and software. We selected these three technology fields as representing major science-based industries in which UIC is especially important (Meyer-Krahmer and Schmoch, 1998). Our sample firms were extracted from the company database of Tokyo Shoko Research (TSR) and the directory of the Japan Bioindustry Association (JBA). In this survey, UIC was defined as project-based R&D collaboration between universities and companies aiming at the generation of new technologies, products, or processes. We obtained 1,732 responses, among which 277 firms have finished UIC during the preceding three years. These 277 firms comprise our sample for empirical analysis. 155 out of these 277 projects (55%) received public R&D subsidy for the

UIC project[9]. Among the projects with public R&D subsidy, its average ratio to total project budget was 45%[10].

The questionnaire asked about the characteristics of UIC projects and participating firms. The respondents are asked to provide information on the latest project if they engaged in more than one projects and on the relationship with the most important university partner if they had more than one university partners in the project[11].

Project characteristics comprise coordination mechanisms in UIC, such as trust formation, contractual agreements, and communication quality between the partners as well as commitment by the partners. Moreover, we collected the data on the ratio of public subsidy to total UIC budget, initial conditions of UIC (tie strength, technological relatedness, geographical distance between the partners, and research capability of the partner) and other aspects (the importance of public administration in finding the partner university, the university's intellectual property policy, market and technology unpredictability surrounding the UIC, the number of participants, project duration, and technological orientation). Firm characteristics include size, R&D intensity (the ratio of R&D expenditure to sales), and technological field. We used these information to construct our dependent, independent, and instrumental variables. These variables are described in detail in the following section.

3.2. Variables

In this section, we explain the dependent and independent variables in our estimation model. All variables are derived from our survey. The concrete items of the survey used in this paper are shown in Appendix 1.

3.2.1. Dependent variables

We use the following four dependent variables measured as firm's subjective evaluations on 7-point Likert scales: (1) contractual safeguards (*contract*), (2) communication quality (*communication*), (3) the strength of firms' commitment in UIC (*commitment*), and (4) trust formation (*trust*). We create the variable *contract* as the

[9] The firms (projects) that did not obtain public subsidy comprise both the firms (projects) that did not applied for public subsidy and those whose applications were rejected. From our questionnaire, we cannot distinguish between these groups. However, this would not incur severe empirical problems because we control for the endogeneity of obtaining public subsidy in the empirical estimation.

[10] No further information was available about public subsidy including its rules, targets, or processes.

[11] 40% of the projects in our sample include two or more universities. Therefore, by focusing on the most important university partner, we cannot exclude the possibility of upward bias for these projects, although we control for the number of project members and the (subjective evaluation of) research capability of the university partner in the empirical analysis,

average value of the strength of contractual safeguards in UIC regarding 1) partner's roles and responsibility, 2) partner's obligation for performance, 3) project schedules, 4) project budgets, 5) data protection and secrecy, 6) profit sharing, 7) legal procedures in troubles, and 8) the procedures in case of unpredicted events[12]. The variable *communication* is measured as the average value of four items regarding communication quality comprising timely, accurate, adequate, and complete information exchange between the partners. The variable *commitment* denotes the strength of firms' commitment to the university partner measured as the mean value of four items regarding the engagement of a key person in the firm in promoting UIC internally and in the relationship with the university partner. Finally, we construct the variable *trust* from the perceptions about the partner's benevolence and integrity.

3.2.2. Independent variables

Public subsidy

We are most concerned about how public R&D subsidy affects coordination in UIC. We provide two measures of public subsidy. The one is the dummy variable *d_subsidy* which takes on the value one if the UIC project received public funds. The other is *subsidy* which is measured as the ratio of public subsidy to total UIC budget. If public subsidy promotes contractual agreement, communication, commitment and mutual trust among cooperative partners, the coefficient of *d_subsidy* is expected to be positive. We use *subsidy* for robustness check. Okada and Kushi (2004) indicate that the investment ratio by government is positively associated with higher evaluation of the research results of the government-sponsored cooperative research. According to them, the ratio of public subsidy to project budget (*subsidy*) can be regarded as the degree of commitment by government. We expect that higher commitment by government lead to stronger monitoring and evaluation of participants' behavior in UIC for ensuring cooperation.

Initial conditions

Initial conditions of a UIC project would be also important factors affecting contractual and organizational characteristics of the UIC. We use four types of ex ante relationship factors that are determined prior to the UIC: (1) tie strength measuring the closeness of the relationship between the firm and the university partner (*tiestrength*), (2) the technological relatedness between the firm and the university partner (*tech_relate*), (3)

[12] Using these items, we measure the level of mutual understanding and explicitness of contractual agreements.

firms' evaluation of the research capability of a partner university (*capability*), and (4) geographical distance to the university partner (*distance*). The variables except for *distance* are measured on 7-point Likert scales, while *distance* is a categorical variable.

Closeness of the relationship, technological relatedness between the firm and the university partner, and the partner's research capability would promote coordination in UIC (Mora-Valentin et al., 2004). Past experience of cooperation and the higher evaluation of a partner's capability smooth the coordination in research cooperation through process-based and characteristics-based trust (Zucker et al., 1986). However, the effect of *distance* on contractual and organizational characteristics is ambiguous. Geographical closeness to a partner promote face-to-face communication and improve coordination among UIC participants (Malmberg et al. 1996; Fujita, 2007), whereas geographical distance may be associated with stronger monitoring of behavior and performance and higher communication frequency to smooth collaboration among research partners. Thus, the effect of geographical distance on coordination remains an empirical issue.

Other project characteristics

The survey collected further information on the partner university's intellectual property (IP) policy, market and technology uncertainty surrounding the UIC project, the number of project participants, project duration, and technological orientation of the project.

Among these project characteristics, we pay special attention to the IP policy of the partner university, considering the recent emergence and development of IP policy at Japanese universities[13]. We measure the firm's evaluation of the partner university's IP policy with regard to clearness, equitability, and the flexibility to the needs of partners using 7-point Likert scales and construct the variable *univ_ip* by calculating the average value of those items. We expect that the variable *univ_ip* be positively correlated with dependent variables because reasonable university's IP policy is likely to smooth coordination with the UIC project

We control for market and technology unpredictability surrounding the UIC project using the variables *unpre_mkt* and *unpre_tech* measured by 7-point Likert scales. The less predictable the market and technological circumstances, the more efforts of coordination would be necessary, because such unpredictability may give rise to opportunistic behavior of the partners (Williamson, 1975)

[13] The Japanese government enacted the Technology Licensing Organization (TLO) Act in 1998 and the Japanese Bayh-Dole Act in 1999 to promote UIC. These policy changes facilitated the Japanese firms to contract collaborative research with universities (Okada et al. 2009).

Moreover, we include the total number of UIC participants (*num_par*) in our model. We may expect that a large number of participants induce high coordination costs. In addition to project duration (*proyr*), measured by the number of months in natural logarithm, the technological orientation of the UIC (basic research, applied research, or development) may also be related with the contractual and organizational characteristics. Thus, we create dummy variables of technological orientation in these three categories (*basic research*, *applied research*, and *development*), among which the last one is regarded as the baseline reference.

4. Empirical method

4.1. Model

We employ two-step GMM estimation to analyze how public subsidy affects contractual and organizational characteristics of UIC projects, using the variables defined in the previous section[14]. The empirical specification is described as follows.

$$\begin{aligned} Y_i = {} & d\_subsidy_i + tiestrength_i + tech\_relate_i + distance_i + capability_i \\ & + univ\_ip_i + unpre\_mkt_i + unpre\_tech_i + num\_par_i + \log(proyr)_i \\ & + basic\ research_i + applied\ research_i + e_i \end{aligned}$$

where subscript *i* denotes UIC project and e_i is error term. Y_i is the dependent variable for which we use *contract*, *communication*, *commitment*, and *trust* interchangeably. Our main concern is the effect of public subsidy (*d_subsidy*). However, we assume that obtaining public R&D subsidy be endogenously determined[15]. For example, smaller and more R&D intensive firms may be more likely to receive public funds than larger and less R&D intensive ones. Further, research projects with higher quality are more likely to receive public funds, because most public funds are provided to selected applicants through competitive schemes. Unfortunately, however, we cannot obtain the information on ex ante evaluation of UIC projects from our survey, whereas we have information on the characteristics of its participants. Therefore, in order to cope with this endogeneity problem, we use some instruments on firm characteristics that would not directly affect coordination in UIC.

[14] Later we check the robustness of our estimation by redefining or reconstructing the dependent variables and using SUR (Seemingly Unrelated Regression) considering positive correlations among the dependent variables.

[15] We conducted Wu-Hausman test with regard to the endogeneity of public subsidy. The result shows that the null hypothesis that the variable *d_subsidy* is exogenous is rejected at 5% or 10% significance level.

4.2. Instruments

Our instruments for receiving public subsidy consist of some basic characteristics of firms and the means to search for the university partner.

Basic characteristics of firms

We use the number of employees (*emp*), the R&D ratio to sales (*rd_ratio*) and the dummies of firms' technology fields as instruments. The number of employees (*emp*) is a measure of firm size. The R&D ratio to sales is regarded as a measure of firms' R&D capability or absorptive capacity. We expect that R&D intensive firms are more likely to receive public funds than others, while smaller firm eagerly apply for public funds because of their limited R&D resources. Finally, dummy variables of technology fields, i.e. biotechnology, microelectronics, and software, are included in the model to control for the differences in appropriability innovation outcomes and technological opportunities.

The means to search for the university partner

How a firm found its university partner may also be an important factor for receiving public subsidy. Specifically, we expect that UIC developed through public administration (*search*) be most closely related to the acceptance of public subsidy. The variable *search* denotes the importance of public administration in finding the university partner measured by 7-point Likert scale.

We summarize the basic statistics of the dependent, independent, and instrumental variables in Table 1 comparing the firms (projects) with and without public R&D subsidy. We also provide the results of significance test on the difference of mean values.

With regard to the entire sample, the degree of contractual agreements, communication, commitment and trust are all relatively highly evaluated with the mean points ranging between 4.9 and 5.6. The sub-group with R&D subsidy has higher mean values of these dependent variables than the other sub-group. Mean values of *contract* and *commitment* are significantly different at the 5 % level. 55% of sample firms (or UIC projects) received public R&D subsidy, while its ratio to total project budget is 45% on average of the recipients. UIC projects in our sample consist of 4.6 members on average with a mean duration of 34 months. We confirm no significant differences in the mean values of project characteristics at the 5 % level. With regard to

firm and industry characteristics used as instruments, we observe that the firms that obtain public subsidy are significantly smaller and more R&D intensive than the others, while biotechnology firms are more likely to obtain R&D subsidy than those in the other technological fields.

5. Estimation results

In this section, we present the estimation results regarding four dependent variables: *contract*, *communication*, *commitment*, and *trust*. Table 2 shows the results of the second stage of the two-step GMM estimations. We include in the model all independent variables mentioned above, except for *subsidy*. Instead of the ratio of public subsidy to total budget of UIC project, we use the dummy variable *d_subsidy*, to test the effect of receiving public subsidy on contractual and organizational characteristics in UIC.

Before discussing the effects of independent variables, we mention the validity of instruments regarding the utilization of public subsidy (*d_subsidy*). We find that partial R squares are relatively high ranging from 0.194 to 0.203. The values of partial F statistics are higher than 7, but lower than 10. Therefore, we cannot reject the weak instrument problem regarding *d_subsidy*, although F-test of excluded instruments in all models reject the null hypothesis that the set of identifying instruments are weak. Hansen J test statistically supports no correlation between the instruments and the error term of the equation in the second stage.

First of all, the availability of public subsidy (*d_subsidy*) has a strong and positive impact on contractual safeguards (*contract*), communication quality (*communication*), firms' commitment (*commitment*), and trust formation (*trust*) in UIC. These results suggest that, as expected, public R&D subsidy encourages mutually agreeable contracts, information sharing, and trust formation among the participants as well as firms' commitment in the UIC through implicit institutional designs. Following our results, we can calculate that the UIC receiving public subsidy, on average, enhances 0.959 point in contractual safeguards, 0.867 point in communication quality, 1.502 point in firms' commitment, and 0.911 point in trust formation in UIC on 7-point scales.

Second, we find that several initial conditions are important factors to effective coordination in UIC. The coefficients of closeness of the relationship between the partners prior to the UIC (*tiestrength*) are positive and significant at the 1% or 5% level with regard to contractual safeguards (*contract*) and trust formation (*trust*) in UIC.

Further, the coefficient of technological relatedness between the firm and the university (*tech_relate*) is positive and significant at the 1% level regarding contractual safeguards (*contract*). The coefficient of research capability of the partner university (*capability*) is positive and significant at the 1% level regarding communication quality (*communication*). These are partly consistent with our expectation that favorable initial conditions prior to the UIC promote ex post coordination in the UIC. Different from *tiestrength*, *tech_relate* and *capability*, geographical distance (*distance*) does not significantly affect contractual and organizational characteristics. As already mentioned, geographical distance has possibly the two opposite effects which may get the impact of *distance* less apparent.

Third, if we look at the coefficients of other project characteristics, we find that the partner university's IP policy is the most effective and important factor to promote coordination in UIC. The coefficients of the university's IP policy (*univ_ip*) are positive and significant at the 1% level in all models. Therefore, the university's IP policy with regard to clearness, equitability, and the flexibility to the partners' needs contributes to desirable ex post coordination in UIC. Regarding the market and technology uncertainty surrounding the UIC, *unpre_mkt* has a positive but weak effect on contractual safeguards (*contract*). It is plausible that high level of market uncertainty surrounding the UIC induces its participants to mutually agreeable explicit contracts[16].

Table 3 presents the estimation results for robustness check, using the ratio of public subsidy to total UIC budgets (*subsidy*) which would reflect the degree of commitment by government. The other independent variables are same as in Table 2. In this estimation, we again find that public subsidy has a strongly positive effect on contractual safeguards (*contract*), communication quality (*communication*), firms' commitment (*commitment*) and trust formation (*trust*) in the UIC. Our results suggest that a 10% increase in the ratio of public subsidy to total UIC budgets, on average, leads to 0.16 point increase in contractual safeguards, 0.20 point increase in communication quality, 0.23 point increase in firms' commitment, and 0.13 point increase in trust formation in UIC on 7-point scales.

The dependent variables of our model may be positively or negatively

[16] As robustness checks, we further included in the model the variables of the importance (weight) of the UIC project in focus for the entire innovation strategy of firms and of the UIC experience in general (not with a particular university partner) that are both based on subjective evaluations measured by 7-point Likert scales. We found that the effect of public subsidy does not considerably change after including these variables, while the former variable has positive and significant effects on *contract*, *communication* and *commitment*, but the latter does not significantly affect project coordination. These additional results are available upon request from the authors.

associated each other according to the complimentary or substitutive relationship. Indeed, correlation coefficients among them (0.33–0.60) suggest the former, complementary relationship allover. Thus, we also conduct SUR (Seemingly Unrelated Regression) considering correlation among the error terms of the estimation models of these dependent variables. Table 4 presents the estimation results of SUR that are similar to those in Table 2. Therefore, we may conclude that our empirical findings are robust even considering for complementary relationship among the dependent variables.

Finally, we conduct estimations using each discrete item of the questionnaire as dependent variables (without constructing them from aggregation). The results are summarized in Table 5. To save space in the paper, we do not mention all the results in detail. However, even if we use each item as the dependent variable, we can conclude that whether a UIC project receives public subsidy or not is a key determinant of the ex post contractual and organizational characteristics in the UIC[17].

6. Conclusion

UIC has been increasingly regarded as an effective means to promote private R&D and to enhance its productivity, but the performance of UIC project depends essentially on its contractual and organizational characteristics. In this respect, government can play essential roles: Public R&D subsidy is not only an important financial support for UIC, but may also be a useful means to promote mutual trust, contractual agreements, information sharing, and commitment in UIC, which results in effective coordination and thus the success of UIC. However, despite several conceptual arguments on the latter role of public subsidy, few empirical studies have directly investigated it thus far.

Using original survey data on Japanese firms in the fields of biotechnology, microelectronics and software, this paper empirically examined if public R&D subsidy contributes to improving coordination in UIC. This is a major contribution of this paper. The estimation results by two-step GMM procedure show that public R&D subsidy has indeed a significantly positive and strong impact on trust formation, contractual characteristics, communication quality, and commitment in UIC even when considering endogeneity. That is, public R&D subsidy encourages mutually agreeable explicit contracts, information sharing, and trust relationship among the participants as well as firms' commitment in UIC. Our results also indicate that initial conditions of

[17] As another robustness check, we construct the variables *contract*, *communication* and *trust* from principal component analysis for the same regressions as Tables 2 and 3 and obtained very similar results. Further information on this additional analysis is available from the authors upon request.

UIC and IP policy of partner universities are particularly associated with contractual and organizational characteristics.

Our analysis has some restrictions that are mostly ascribed to data constraints and that should be extended or improved in future research. First, we measured the dependent variables on contractual and organizational characteristics of UIC by retrospective and subjective evaluations of managers. Future research should provide further efforts to check possible measurement bias caused by such evaluations and develop more appropriate measurement methods. Second, we have no information on the type of public R&D subsidy, i.e. its rules, targets, or processes. Considering different characteristics of public subsidies would be a promising research topic. Third, we collected data only from private firms. Thus, we have little information on university partners and no data of their evaluations of UIC's contractual and organizational characteristics. Further analyses using a matched sample of both sides of UIC would be desirable. Fourth, although 40% of the UIC projects in our sample include two or more universities and the average number of project members exceeds four, we focused on bilateral relationship between a firm and a university, i.e. its most important university partner. We expect future research to be extended to consider multilateral relationship. Fifth, we used a relatively small sample of Japanese firms, focusing on specific technology fields. Thus, it would be important to extend the sample to other countries and technology fields in future research to obtain more generally applicable findings and implications. Moreover, with regard to analytical techniques, the problem of weak instruments should be properly addressed.

As a whole, however, our results empirically reveal an important role of public R&D subsidy that has rather been ignored in the literature thus far, and suggest the effectiveness of public R&D support as an innovation intermediary. Thus, a major implication of this research is that in designing and evaluating public policy, specifically with regard to R&D subsidy, we should also consider its indirect effect on UIC projects. Previous studies show that contractual and organizational characteristics affect the success of UIC. Therefore, we may conclude that R&D subsidy is an effective means to improve coordination, information sharing, and motivation among the members in UIC, which would in turn enhance the success probability of UIC[18].

[18] Indeed, in another paper, we estimated the effects of project coordination (contract, communication, and commitment) on technological performance of the UIC project and confirmed positive and significant impact on several measures of technological success.

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Table 1 Basic Statistics (Comparison of firms with and without pubic subsidy)

	Overall			***d_subsidy* = 1**			***d_subsidy* = 0**			comparison test
	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	
Dependent var.										
contract	255	4.85	1.33	136	5.38	1.39	112	4.78	1.25	**
communication	254	5.25	1.29	135	5.32	1.19	113	5.14	1.39	
commitment	256	4.92	1.42	136	5.09	1.42	113	4.72	1.43	**
trust	244	5.58	1.25	131	5.70	1.21	107	5.35	1.28	*
Independent var.										
subsidy	256	24.40	31.80	140	44.62	30.77	—	—	—	
tiestrength	213	5.13	1.75	117	5.25	1.78	90	4.97	1.71	
tech_relate	253	4.10	1.96	135	4.19	2.04	111	3.91	1.83	
capability	254	5.16	1.63	136	5.15	1.60	112	5.14	1.64	
distance	255	3.21	1.77	136	3.10	1.87	111	3.34	1.64	
univ_ip	247	4.93	1.64	132	4.93	1.66	108	4.94	1.60	
unpre_mkt	253	4.64	1.70	132	4.66	1.69	112	4.55	1.69	
unpre_tech	252	4.70	1.58	135	4.86	1.53	110	4.53	1.56	*
num_par	244	4.62	4.74	131	4.92	4.10	107	4.16	5.32	
proyr (month)	250	34.36	21.54	136	36.02	20.86	110	31.33	21.09	*
basic research	258	0.20	0.40	139	0.22	0.41	114	0.19	0.39	
applied research	258	0.41	0.49	139	0.40	0.49	114	0.41	0.49	
Instruments										
emp	237	98.16	143.12	127	74.30	125.20	103	126.17	154.66	***
rd_ratio	236	11.25	21.88	124	13.65	25.42	107	8.17	16.11	**
biotechnology	264	0.41	0.49	140	0.47	0.50	116	0.33	0.47	**
microelectronics	264	0.29	0.45	140	0.30	0.45	116	0.25	0.43	
search	251	3.58	1.95	134	3.93	1.98	111	3.13	1.82	***

Note1: Level of significance: ***1%, **5%, *10%.

Table 2 Estimations Results (GMM) with *d_subsidy*

	contract	*communication*	*commitment*	*trust*
d_subsidy	0.959**	0.867**	1.502***	0.911***
	0.474	*0.389*	*0.585*	*0.346*
tiestrength	0.157***	0.067	0.019	0.131**
	0.061	*0.061*	*0.058*	*0.056*
tech_relate	0.195***	0.039	0.034	0.029
	0.054	*0.052*	*0.071*	*0.049*
capability	0.080	0.210***	0.067	0.086
	0.087	*0.076*	*0.095*	*0.071*
distance	0.005	−0.006	0.104	0.021
	0.055	*0.054*	*0.064*	*0.051*
univ_ip	0.211***	0.318***	0.299***	0.279***
	0.079	*0.064*	*0.083*	*0.072*
unpre_mkt	0.123*	−0.052	−0.022	0.002
	0.074	*0.075*	*0.079*	*0.078*
unpre_tech	−0.024	0.016	−0.024	−0.084
	0.074	*0.076*	*0.077*	*0.078*
num_par	0.006	−0.022	−0.020	0.009
	0.029	*0.025*	*0.030*	*0.023*
log (*proyr*)	−0.075	−0.320**	0.027	0.076
	0.166	*0.145*	*0.188*	*0.181*
basic research	0.170	0.438*	0.041	−0.201
	0.281	*0.236*	*0.322*	*0.279*
applied research	−0.117	0.139	0.550**	0.071
	0.219	*0.212*	*0.251*	*0.220*
constant	1.136*	2.850***	1.591*	2.820
	0.646	*0.747*	*0.814*	*0.890*
sample size	137	136	137	133
Log likelihood	−209.226	−199.830	−232.476	−195.617
partial R square	0.194	0.202	0.195	0.203
F-test of excluded instruments	7.20 p = 0.000	7.43 p = 0.000	7.20 p = 0.000	7.58 p = 0.000
Hansen J test	4.111 p = 0.391	6.547 p = 0.161	4.693 p = 0.320	2.671 p = 0.614

Note1: Level of significance: ***1%, **5%, *10%.

2: Robust standard errors are indicated in italics.

Table 3 Estimation Results (GMM) with *subsidy*

	contract	*communication*	*commitment*	*trust*
subsidy	0.016* *0.009*	0.020** *0.008*	0.023** *0.011*	0.013** *0.005*
tiestrength	0.154** *0.061*	0.069 *0.068*	0.022 *0.063*	0.127** *0.057*
tech_relate	0.201*** *0.056*	0.040 *0.059*	0.058 *0.081*	0.031 *0.049*
capability	0.049 *0.081*	0.207** *0.083*	0.000 *0.097*	0.084 *0.067*
distance	0.022 *0.056*	0.010 *0.060*	0.102 *0.072*	0.023 *0.050*
univ_ip	0.239*** *0.072*	0.344*** *0.070*	0.355*** *0.082*	0.288*** *0.067*
unpre_mkt	0.131* *0.077*	−0.040 *0.082*	−0.026 *0.089*	0.004 *0.080*
unpre_tech	−0.038 *0.075*	−0.013 *0.084*	−0.030 *0.089*	−0.086 *0.080*
num_par	−0.007 *0.033*	−0.033 *0.030*	−0.029 *0.038*	0.008 *0.025*
log (*proyr*)	−0.015 *0.155*	−0.217 *0.155*	0.255 *0.186*	0.106 *0.169*
basic research	0.282 *0.275*	0.529** *0.243*	0.279 *0.336*	−0.182 *0.283*
applied research	−0.223 *0.222*	−0.020 *0.251*	0.438 *0.298*	0.065 *0.221*
constant	1.026* *0.641*	2.442*** *0.849*	1.085 *0.928*	2.689*** *0.913*
sample size	137	136	137	133
Log likelihood	−208.928	−215.410	−243.349	−195.596
partial R square	0.113	0.118	0.113	0.115
F-test of excluded instruments	2.86 p = 0.018	3.09 p = 0.011	2.86 p = 0.018	2.98 p = 0.014
Hansen J test	4.164 p = 0.384	3.443 p = 0.486	5.171 p = 0.270	2.767 p = 0.597

Note1: Level of significance: ***1%, **5%, *10%.

2: Robust standard errors are indicated in italics.

Table 4 Estimation Results (SUR)

	contract	*communication*	*commitment*	*trust*
d_subsidy	0.777* *0.455*	1.008** *0.414*	1.224** *0.522*	0.785* *0.427*
tiestrength	0.152** *0.061*	0.093* *0.056*	0.057 *0.070*	0.136** *0.057*
tech_relate	0.200*** *0.058*	0.024 *0.052*	0.031 *0.066*	0.024 *0.054*
capability	0.028 *0.069*	0.247*** *0.063*	0.003 *0.079*	0.143** *0.064*
distance	−0.004 *0.056*	−0.005 *0.051*	0.052 *0.064*	0.010 *0.052*
univ_ip	0.231*** *0.065*	0.308*** *0.060*	0.370*** *0.075*	0.279*** *0.061*
unpre_mkt	0.135* *0.071*	−0.025 *0.064*	−0.066 *0.081*	0.030 *0.066*
unpre_tech	−0.037 *0.074*	0.048 *0.067*	0.101 *0.085*	−0.037 *0.069*
num_par	−0.001 *0.031*	−0.012 *0.028*	−0.010 *0.035*	−0.002 *0.029*
log (*proyr*)	0.182 *0.173*	−0.272* *0.158*	0.296 *0.199*	0.043 *0.163*
basic research	0.078 *0.27*	0.364 *0.246*	0.094 *0.310*	−0.152 *0.253*
applied research	−0.104 *0.221*	0.100 *0.202*	0.600** *0.254*	−0.038 *0.208*
constant	0.437 *0.757*	2.157*** *0.690*	0.406 *0.869*	2.129*** *0.711*
sample size	130	130	130	130
R-square	0.370	0.435	0.331	0.369
chi2	76.55***	100.18***	64.25***	76.06***

Note1: Level of significance: ***1%, **5%, *10%.

2: Standard errors are indicated in italics.

Table 5: Estimation Results on Each Item

	contract								***communication***				***commitment***				***trust***				
	a1	a2	a3	a4	a5	a6	a7	a8	b1	b2	b3	b4	c1	c2	c3	c4	d1	d2	d3	d4	d5
d_subsidy	1.07**	2.074***	1.649***	1.267**	0.499	1.407**	1.528*	1.316*	0.795*	0.736	0.993**	1.251***	1.886***	1.204*	1.668**	1.293*	0.716*	1.779***	1.035*	1.127**	0.945**
	0.536	*0.514*	*0.566*	*0.561*	*0.567*	*0.644*	*0.827*	*0.754*	*0.425*	*0.459*	*0.437*	*0.428*	*0.699*	*0.721*	*0.809*	*0.693*	*0.411*	*0.480*	*0.641*	*0.589*	*0.435*
tiestrength	0.169**	0.173**	0.158**	0.134*	0.199**	0.021	0.298***	0.258**	0.011	0.107*	0.099	0.100	0.114	−0.064	0.041	−0.017	0.018	0.024	0.115	0.197**	0.147**
	0.079	*0.084*	*0.071*	*0.082*	*0.087*	*0.085*	*0.100*	*0.106*	*0.074*	*0.062*	*0.071*	*0.071*	*0.094*	*0.09*	*0.103*	*0.086*	*0.060*	*0.068*	*0.087*	*0.091*	*0.068*
tech_relate	0.187**	0.204***	0.169**	0.239***	0.164**	0.165*	0.259***	0.361***	0.009	−0.010	0.041	0.119*	−0.018	0.031	0.057	0.044	−0.024	−0.012	0.009	0.210**	0.070
	0.073	*0.067*	*0.067*	*0.078*	*0.083*	*0.094*	*0.093*	*0.096*	*0.059*	*0.048*	*0.059*	*0.063*	*0.091*	*0.099*	*0.118*	*0.087*	*0.050*	*0.057*	*0.077*	*0.100*	*0.065*
capability	0.007	0.109	0.034	−0.066	0.059	0.067	0.068	−0.070	0.295***	0.202**	0.248***	0.111	0.184	0.045	0.016	0.007	0.174**	0.242***	0.103	0.141	0.133*
	0.085	*0.090*	*0.091*	*0.100*	*0.109*	*0.123*	*0.130*	*0.124*	*0.080*	*0.082*	*0.090*	*0.095*	*0.13*	*0.122*	*0.145*	*0.107*	*0.075*	*0.083*	*0.098*	*0.099*	*0.081*
distance	0.134**	0.109	0.080	0.097	−0.016	−0.031	0.037	−0.050	−0.037	0.025	−0.007	0.015	0.095	0.054	0.170*	0.057	0.045	0.04	0.038	0.030	0.020
	0.066	*0.073*	*0.071*	*0.076*	*0.074*	*0.078*	*0.088*	*0.087*	*0.061*	*0.056*	*0.062*	*0.060*	*0.087*	*0.079*	*0.097*	*0.079*	*0.054*	*0.067*	*0.069*	*0.074*	*0.060*
univ_ip	0.255***	0.147*	0.136	0.178*	0.205**	0.404***	0.297***	0.313***	0.427***	0.305***	0.305***	0.221***	0.433***	0.252**	0.188	0.374***	0.351***	0.115	0.283**	0.209**	0.225***
	0.087	*0.083*	*0.096*	*0.111*	*0.104*	*0.109*	*0.114*	*0.111*	*0.075*	*0.072*	*0.074*	*0.073*	*0.109*	*0.108*	*0.133*	*0.101*	*0.078*	*0.085*	*0.114*	*0.094*	*0.081*
unpre_mkt	0.016	0.047	0.051	0.195*	0.173	0.183	0.187	0.134	0.010	−0.059	−0.126	−0.064	0.067	−0.150	−0.190*	0.069	0.046	0.031	0.063	0.083	0.002
	0.103	*0.091*	*0.103*	*0.115*	*0.109*	*0.113*	*0.124*	*0.118*	*0.091*	*0.076*	*0.081*	*0.080*	*0.108*	*0.105*	*0.114*	*0.109*	*0.081*	*0.087*	*0.100*	*0.112*	*0.080*
unpre_tech	−0.110	−0.190*	−0.016	0.069	0.010	−0.223**	−0.022	−0.009	−0.009	0.096	0.012	−0.017	−0.035	0.116	−0.024	−0.085	−0.176**	−0.136	−0.146	−0.245**	−0.051
	0.090	*0.101*	*0.090*	*0.109*	*0.101*	*0.107*	*0.112*	*0.112*	*0.087*	*0.070*	*0.085*	*0.084*	*0.113*	*0.103*	*0.120*	*0.106*	*0.079*	*0.087*	*0.099*	*0.110*	*0.079*
num_par	0.053	0.020	−0.052	0.002	−0.044	−0.044	−0.038	0.062	−0.043	−0.006	−0.035	0.007	−0.083*	−0.025	0.066	−0.025	−0.013	0.013	0.001	−0.012	−0.011
	0.042	*0.035*	*0.037*	*0.045*	*0.053*	*0.040*	*0.052*	*0.041*	*0.034*	*0.028*	*0.026*	*0.032*	*0.048*	*0.042*	*0.046*	*0.041*	*0.027*	*0.024*	*0.033*	*0.036*	*0.026*
log (*proyr*)	−0.366	−0.173	−0.462**	−0.252	−0.128	0.461*	−0.422	0.051	−0.203	−0.154	−0.450***	−0.452***	0.053	0.233	0.058	0.007	0.103	−0.133	−0.306	−0.110	−0.112
	0.236	*0.243*	*0.224*	*0.249*	*0.247*	*0.253*	*0.283*	*0.219*	*0.179*	*0.158*	*0.168*	*0.161*	*0.241*	*0.237*	*0.275*	*0.216*	*0.152*	*0.194*	*0.212*	*0.286*	*0.163*
basic research	−0.079	0.258	−0.264	−0.32	0.319	0.286	0.113	0.165	0.196	0.204	0.579**	0.656**	−0.239	−0.209	0.125	0.825**	−0.267	−0.057	−0.353	0.267	0.152
	0.338	*0.365*	*0.386*	*0.399*	*0.381*	*0.419*	*0.427*	*0.418*	*0.302*	*0.232*	*0.265*	*0.260*	*0.422*	*0.419*	*0.488*	*0.418*	*0.254*	*0.298*	*0.412*	*0.399*	*0.319*
applied research	−0.063	0.095	−0.307	−0.244	−0.510	−0.033	−0.351	−0.228	0.260	−0.011	−0.075	0.277	0.490	0.398	0.711**	0.718**	0.186	−0.003	−0.019	−0.241	−0.118
	0.297	*0.277*	*0.314*	*0.331*	*0.321*	*0.288*	*0.345*	*0.318*	*0.239*	*0.227*	*0.250*	*0.243*	*0.329*	*0.321*	*0.346*	*0.331*	*0.219*	*0.257*	*0.292*	*0.335*	*0.236*
constant	2.609***	1.401	3.299***	2.040**	2.233**	−0.678	−0.499	−1.442*	2.056**	2.673***	3.196***	3.244***	−0.356	2.005*	1.641	2.282**	2.772***	3.645***	3.836***	1.520	2.964***
	0.948	*0.959*	*0.896*	*0.961*	*1.047*	*1.061*	*0.974*	*0.784*	*0.907*	*0.712*	*0.838*	*0.782*	*0.976*	*1.043*	*1.160*	*1.096*	*0.850*	*0.954*	*1.066*	*1.046*	*0.849*
sample size	134	134	134	134	134	134	134	133	137	137	136	136	137	137	135	137	133	133	131	131	133
Log likelihood	−245.494	−257.713	−256.995	−259.533	−255.691	−265.600	−277.666	−267.711	−228.175	−204.085	−219.241	−219.701	−269.144	−266.419	−276.982	−262.815	−209.517	−232.142	−246.414	−255.750	−226.731

Note1: Level of significance: ***1%, **5%, *10%.

2: Robust standard errors are indicated in italics.

3: The discrete items of the dependent variables are shown in Appendix 1.

Appendix 1 Variable constructions - The items in the questionnaire

Dependent variables

contract

How clearly were the following issues defined at the beginning of the partnership (1 = there was no mutual understanding – 4 = there was a mutual oral understanding – 7 = the mutual under-standing was exactly defined in a written document)

(a1) Roles and responsibilities of each partner
(a2) Performance obligations of each partner
(a3) Project schedules (timing and deadlines)
(a4) Project budget (how it should be used and checked?)
(a5) Data / secrecy protection, publication of the findings
(a6) Profit sharing from new products and processes etc.
(a7) Legal procedures in case a partner does not fulfill his role or obligation
(a8) Procedures in case of unexpected events

communication

Please evaluate the communication and interaction with the university research partner in the partnership (if there were more than one please refer to the most important university research partner).

Overall, the communication between our firm's and the university partner's representatives was ... (1-7)

(b1) 1 = untimely－7 = timely
(b2) 1 = inaccurate－7 = accurate [you can rely on it]
(b3) 1 = inadequate－7 = adequate
(b4) 1 = incomplete－7 = complete

commitment

Please evaluate the role of the person in your company who was most engaged in promoting this partnership internally and in the relationship with the university partner.

The person in our company who was most engaged in this partnership… (1=do not agree – 7 fully agree)

(c1) enthusiastically promoted the UIP advantages within our firm
(c2) showed tenacity in overcoming obstacles related to the UIP within the company
(c3) did not give up when others said this UIP cannot be done
(c4) secured the top level support and financing required for this UIP

trust

Please evaluate your company's relationship with your university partner in the UI partnership (1 = strongly disagree – 7 = strongly agree):

(d1) This university partner's representatives were frank in dealing with us.

(d2) Promises made by the university partner's representatives were reliable.

(d3) If problems (such as delays) arose, the university partner's representatives were honest about the problems.

(d4) The university partner's representatives made sacrifices for us during the project.

(d5) We felt the university partner's representatives were on our side.

Independent variables

Public subsidy

Please indicate the extent to which your company obtained public subsidies for the UI partnership as a percentage of the total budget for this partnership. %

tiestrength

Prior to this UI partnership, how close was your relationship with this university partner? (1=very lose – 7=very close)

tech_relate

How did your company evaluate the technological relatedness of your university partner before you entered into a UI partnership with it (1=fully disagree – 7=fully agree)?

This university partner was advancing technology in areas related to our products.

capability

How did your company evaluate the research capability of your partner university before you entered into a UI partnership with it? (1=fully disagree – 7=fully agree)

We believed they were scientifically leading in their field

distance

Please indicate the geographical distance between your company and the partner university.

(1) Less than 10 km (2) 10-20 km (3) 21-50 km

(4) 51-100 km (5) 101-500 km (6) more than 500 km

univ_ip

Please evaluate how clearly the partner university's policy on intellectual property rights was defined. (1=do not agree – 7 fully agree)

(1) University intellectual property policies were clear and easily understood.
(2) University intellectual property policies were sufficiently flexible to meet our firm's needs.
(3) University intellectual property policies were equitable in revenue and royalty sharing.

unpre_mkt, *unpre_tech*

Please respond regarding the extent of market and technological uncertainties surrounding this UI R&D collaboration (1 – 7)

(1) The market surrounding the research collaboration was very predictable and easy to forecast vs. unpredictable and hard to anticipate.
(2) The technological developments surrounding the research collaboration were predictable vs. hard to anticipate, unpredictable.

Instruments

searching for a university partner

Please rate how relevant the public administration was for finding this university research partner? (1=not relevant at all – 7=extremely relevant)