**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]](#footnote-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]](#footnote-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]](#footnote-3). Traditionally, 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]](#footnote-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 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]](#footnote-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). 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, and (2) a third party provides administrative structures and regulatory agreements as contractual safeguards in UIC to increase confidence in successful coordination. Furthermore, government sets control mechanisms up 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.

 Through the social relations backed by government, collaborators in UIC can be able to relax their boundaries and extend their network for R&D[[6]](#footnote-6). 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 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 received public R&D subsidy for the UIC project.

 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.

 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, and geographical proximity between the partners) and other aspects (the importance of the ways of searching for 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 age, size, technological field, R&D intensity (the ratio of R&D expenditure to sales), experience of UIC, and top managers' education. 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 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[[7]](#footnote-7). 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 by a single item. 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 three types of ex ante relationship factors that are determined prior to the UIC: (1) tie strength measuring the closeness of the relationship between a firm and a university partner (*tiestrength*), (2) the technological relatedness between a firm and a university partner (*tech\_relate*), and (3) geographical proximity 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 and technological relatedness between a firm and a university partner would promote coordination in UIC (Mora-Valentin et al., 2004). 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[[8]](#footnote-8). 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)

 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. The empirical specification is described as follows.

*Y*i = *d\_subsidy*i + *tiestrength*i + *tech\_relate*i + *proximity*i + *univ\_ip*i

+ *unpre\_mkt*i + *unpre\_tech*i + *num\_par*i + log(*proyr*)i

　　　　　　+ *basic research*i + *applied research*i + *e*i

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[[9]](#footnote-9). 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 and university characteristics that would not directly affect coordination in UIC.

**4.2. Instruments**

Our instruments for receiving public subsidy consist of some basic characteristics of firms, top managers' educational background, the means to search for the university partner, and firms’ evaluation on the university partner’s research capability.

*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.

*Top managers' education*

We distinguish between different educational levels and backgrounds of top managers using five dummy variables: (1) graduates of junior or senior high schools (who do not have university degrees), (2) bachelors in the human or social science (*univ\_soc*), (3) bachelors in the natural science (*univ\_nat*), (4) those with graduate degrees in the human or social science (*grad\_soc*), and (5) those with graduate degrees in the natural science (*grad\_nat*). Among them, we use the first dummy (top managers without university degrees) as baseline reference. Top manager’s educational level and background represent technological and managerial capability of small firms (Colombo et al., 2006). Moreover, top managers can signal their own (and their firms’) capability to potential partners and thus attract them to cooperate with their firms (Fontana et al., 2006). Thus, top managers’ education may be correlated with the probability of receiving public subsidy, if the firms with higher capability and better partners have higher probability to receive it. Therefore, we expect that top manager's education be positively associated with the acceptance of public subsidy.

*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. We classified the means to search for the university partner into eight categories: (1) personal network of firm’s managers (*search\_pn*), (2) academic meetings (*search\_am*), (3) academic publications (*search\_ap*), (4) university-industry transfer centers at the university (*search\_uit*), (5) trade associations or chambers of industry and commerce (*search\_ta*), (6) business partners (*search\_bp*), (7) public administration (*search\_pa*), and (8) contact or initiative by the university partner (*search\_cp*). Among them, we expect that UIC developed through public administration (*search\_pa*) be most closely related to the acceptance of public subsidy.

*Partner university’s research capability*

Finally, we introduce firms’ evaluation on the research capability of its partner university such as the level of scientific research (*science*). If UIC including a university with higher research capability is more likely to receive public subsidy, then the variable would be positively correlated with the acceptance of public subsidy[[10]](#footnote-10).

We summarize the basic statistics of the dependent, independent, and instrumental variables in Table 1.

**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 0.246 to 0.263. The values of partial F statistics are higher than 5, 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, commitment, and trust formation among the participants in the UIC through implicit institutional designs. Following our results, we can calculate that the UIC receiving public subsidy, on average, enhances 0.763 point in contractual safeguards, 0.638 point in communication quality, 0.842 point in firms' commitment, and 0.665 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 a firm and a university prior to the UIC (*tiestrength*) are positive and significant at the 1% level with regard to contractual safeguards (*contract*), firms' commitment (*commitment*), and trust formation (*trust*) in UIC. Further, the coefficients of technological relatedness between a firm and a university (*tech\_relate*) are positive and significant at the 1% level in contractual safeguards (*contract*) and 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* and *tech\_relate*, geographical distance (*distance*) does not significantly affect contractual and organizational characteristics except for firms' commitment (however, the significance level is only 10%).

 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% or 10% level for all dependent variables. 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 positive effect on contractual safeguards (*contract*), but negative effect on firms' commitment (*commitment*). It is plausible that high level of market uncertainty surrounding the UIC induces its participants to mutually agreeable explicit contracts. However, it is difficult to interpret the negative sign of *unpre\_mkt* on *commitment*. Higher uncertainty in future commercialization may discourage firms' commitment to the UIC.

 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 0.23 point increase in contractual safeguards, 0.12 point increase in communication quality, 0.12 point increase in firms' commitment, and 0.11 point increase in trust formation in UIC on 7-point scales.

 Finally, as another robustness check, we conduct estimations using each discrete item of the questionnaire as dependent variables (without constructing them from aggregation). The results are summarized in Appendix 2. 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.

**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, commitment, and trust relationship among the participants in UIC. Our results also indicate that initial conditions of UIC and IP policy of partner universities are particularly associated with contractual and organizational characteristics.

 Our analysis has a couple of 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 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. Third, 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.

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Table 1



Table 2



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

2: Robust standard errors are indicated in italics.

Table 3



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

2: Robust standard errors are indicated in italics.

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

During the UI partnership,…

　　(b5) the staff of our company and partner university had email contact (1=once or

　　　　twice a year – 3=once a month – 5=once a week – 7=almost every day)

　　(b6) the staff of our company and partner university had telephone contact (…)

　　(b7) the staff of our company and partner university held project meetings (…)

　　(b8) the staff of our company worked at the site of the university partner, or vice

　　　　versa (1=not at all – 7=a lot)

*commitment*

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).(1=strongly disagree – 7=strongly agree)

　　We were very committed to this university partner

*trust*

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

　　(c1) This university partner’s representatives were frank in dealing with us.

　　(c2) Promises made by the university partner’s representatives were reliable.

　　(c3) If problems (such as delays) arose, the university partner’s representatives

　　　　were honest about the problems.

　　(c4) The university partner’s representatives made sacrifices for us during the

　　　　project.

　　(c5) 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.

*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**

*uic\_exp*

Prior to this UI partnership, how often did your company work on R&D projects with universities in general? (1=never – 7=very often)

*search of a university partner*

Please rate how relevant the following items were for finding this university research partner? (1=not relevant at all – 7=extremely relevant)

　　(1) Personal network of your firm’s managers

　　(2) Academic meetings

　　(3) Academic publications

　　(4) UI transfer centers at the university

　　(5) Trade associations / Chambers of industry and commerce

　　(6) Business partners

　　(7) Public administration

　　(8) Contact/initiative by the university partner

*science*

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.

Appendix 2



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.

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 Lechevalier et al. (2007) for more detail. [↑](#footnote-ref-1)
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. [↑](#footnote-ref-2)
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 among actors. [↑](#footnote-ref-3)
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. [↑](#footnote-ref-4)
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. [↑](#footnote-ref-5)
6. Darby et al. (2004) support this referring to the case study of Advanced Technology Program (ATP) by U.S. Department of Commerce. [↑](#footnote-ref-6)
7. Using these items, we measure the level of mutual understanding and explicitness of contractual agreements. [↑](#footnote-ref-7)
8. 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). [↑](#footnote-ref-8)
9. 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. [↑](#footnote-ref-9)
10. It is noteworthy that this variable is measured as subjective evaluation, and thus does not necessarily reflect objective levels. [↑](#footnote-ref-10)