

Information Flows and State-led Technological Innovation in Korea and Taiwan

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Abstract

This paper adds existing attempts to determine the effects of the government on the research sector, considering whether government intervention increases cross-sector (public-private) information flows. The analysis is focused on public and private recipients of government research funds in Korea and Taiwan, and the primary purpose is to determine how public fund-instigated R&D collaboration and research entity-instigated R&D collaboration impact the transfer of information. With a variance on Jaffe's (1998) information transfer structure and a maximum of 248 responses of public and private respondents from the KORTAI R&D dataset, application of the instrumental variable method (to address omitted variables) shows that the effects of public R&D programs in Korea and Taiwan have markedly different effects upon information transfers. Government intervention in Taiwan appears to have found a niche with several methods of information transfer. In Korea, on the other hand, public funding is simply ineffectual in generating greater information transfers as opposed to self-instigated R&D collaboration.

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Introduction

This paper adds existing attempts to determine the effects of government intervention into the research sector. Several studies approach this issue from the perspective of firm-based R&D expenditures, noting whether government funds are coupled with increases or decreases in a firm's research and development (R&D) investments.¹ In this scenario, when government subsidies/grants for research are followed by a decrease in firm research expenditures, one may conclude that government funds simply replace private funding. Yet, government subsidies can also generate increases in private firm R&D expenditures. From strictly a position of economic efficiency, expenditure analysis is useful; however, if one is interested in alternative forms of efficiency, the analytical structure must be modified.

Other studies analyze the effects of government subsidies for R&D upon a number of productivity measures but overlook the importance of information transfers, which many claim are important. D'Aspremont and Jacquemin (1988) use information transfers as an output, and Griliches emphasizes how information transfers lead to increases in R&D productivity.² There is, however, a general neglect of the source and nature of such transfers. This lacuna is representative of a private research sector focus, where knowledge transfers levy significant costs to the research engaging firm, making appropriability issues paramount.³ Rather than simply approaching the subject from the private sector perspective, we consider how government intervention increases cross-sector (public-private) information flows, which are expected to generate even greater R&D productivity.⁴ This discussion, thus, offers contributions to both the spillover literature and the literature on government involvement in research.

The analysis here is focused on public and private recipients of government research funds in Korea and Taiwan. Government grants and subsidies in both countries are provided to generate unique and commercializable research results, a funding condition which is established both implicitly and explicitly.⁵ Given this dual emphasis on the development of R&D results

¹ See Lach (2002), Wallsten (2000), and Branstetter and Sakakibara (1997).

² In his survey of the literature, Griliches (1998) considers the content of information transfers, but not the method of transferring information. We focus on the latter.

³ There is also a literature which show a correlation between decreasing costs and increasing information transfers. (For details, see Bernstein and Nadiri [1988: 429].)

⁴ For the duration of this discussion, "sector" refers to the public and/or private research sectors, as opposed to industrial sectors.

⁵ The details of the funding programs are not provided here, but there is an alignment with their stated goals and the overarching national R&D programs.

with long-term effects and commercializability, public-private R&D collaboration often occurs.⁶ In this way, science and technology policies affect information transfers, but indirectly through public-private R&D collaboration. That is, policies are not expressly oriented towards increasing information transfers between sectors, but such transfers are undoubtedly going to arise as an externality of public-private R&D collaboration. How public fund-instigated R&D collaboration and research entity-instigated R&D collaboration impact the transfer of information is the general research question posed here.

The data utilized in this discussion is sourced from the Korea-Taiwan (KORTAI) R&D database, which was compiled by the author.⁷ The particular focus of the data and sample alleviates many of the sample selectivity issues which might arise. In this way, this study attempts to adhere to the sampling methods of Sakakibara (1994), Branstetter and Sakakibara (1997), and the bulk of quantitative studies surveyed in Ruegg and Feller (2003), all of whom focus on specific government research funding programs.

Literature Review & Hypothesis Development

Information transfers are important in a number of ways, primary of which is the potential for generating greater returns to R&D. This is ideal, from both the perspective of the R&D engaging entity as well as the public fund-granting agency, and is best described in terms of the private and social components of R&D returns, presented in Fig. 1. The combination of private and social returns to R&D presents, we believe, the most compelling case for maintaining a high degree of R&D effort. Based on Jaffe's (1998) study of the U.S. Advanced Technology Program (ATP),⁸ knowledge originates in either the private or public research sector and is transferred to other research entities' through publications or patents, indicated by χ_1 . One research entity's efforts to create returns – whether reputation effects (A_1 , public sector) or profits (A_2 , private sector) – is able to generate additional returns through research entities' reputation effects (D_1) or profits (D_2) and customer benefit (E). The researching entity, public or

⁶ "Public" encompasses government research institutes (GRIs) and universities; "private" refers to private firms.

⁷ For this paper, a maximum of 107 public and private sector respondents from Korea and 141 public and private sector respondents from Taiwan are taken from the KORTAI R&D database. This dataset was collected in the winter and spring of 2005-06, following field research and interviews by the author with public and private research directors in Korea (summer 2005) and Taiwan (winter 2005). The averaged response rate for both countries and all sectors is just under 50 percent. Please contact the author for additional details about the KORTAI R&D database.

private, can generate income from patent licensing (B), determined in part by a functioning technology transfer office or office of technology licensing. Ultimately, one research entity's attempts to create private returns (A_1 , A_2 , or B) leads to greater social returns (C, D, and E.), when information transfers along χ_1 .⁹

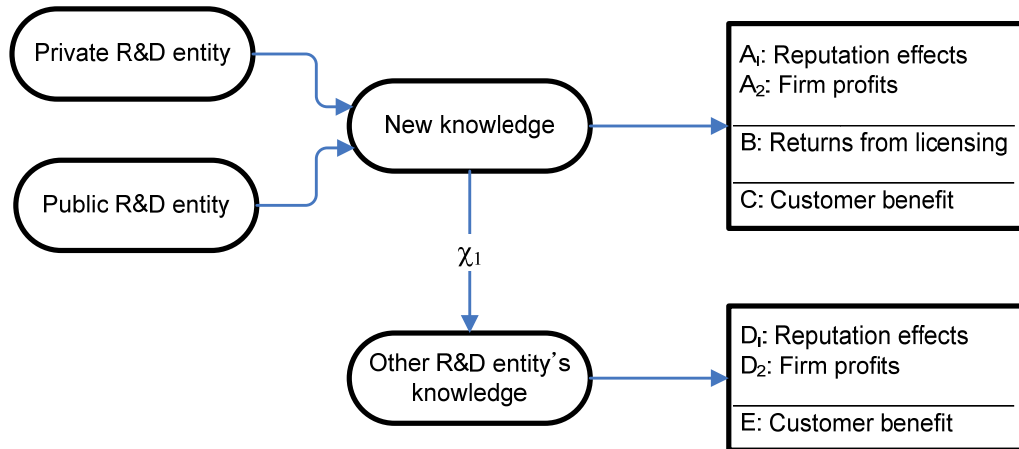


Fig. 1 Returns to R&D and information channels without collaboration

Fig. 1 exemplifies the need for the government to prioritize and support projects which promise large information transfers, but the structure is ill-equipped to deal with the specifics of information transfers within a public-private R&D collaborative framework. There is simply no allowance for R&D collaboration between the public and private research sectors, and only three forms of information transfer are considered (patents, publications, and licenses). These limitations shall be addressed in turn, with acknowledgement of the literature.

Hall, et al.'s (2000) ATP program study looks at the relations between universities and firms in R&D, qualitatively measuring how research entities from the public and private sectors interact. They conclude that universities enhance research efficiency by deepening and expanding the research of ATP fund recipients (i.e., firms). While Hall et al. (2000) do not speak specifically to the issue of knowledge transfers, Adams, et al. (2001), in their analysis of the U.S. Industry-University Cooperative Research Centers (IUCRCs), conclude that there are indeed

⁸ The ATP, incidentally, is the basis for several of the research funding programs in Korea and Taiwan from which the KORTAI R&D database is drawn.

increased knowledge transfers. They assign importance, particularly, to the function of faculty consultants, the tendency to coauthor papers across sectors, and the hiring of former graduate students. These transfers are unidirectional, however, focusing only on public to private information flows.

The limited consideration of alternative forms of information transfer in Fig. 1 has been addressed in a number of studies which delineate between formal and informal networks between researchers.^{10, 11} Formal networks include licensing and cooperative alliances, while meetings/conferences and consultations are considered more informal. Conferences and consultations, it should be noted, are identified by Cohen, et al. (2002) as important for public-to-private transfers.

Fontana, et al. (2003) also provide interesting observations about different channels of communication between sectors but as an explanation for why public-private R&D collaboration occurs. We, on the other hand, hypothesize that knowledge transfers are influenced by public-private R&D collaboration. This is but a small indication of the endogeneity issues with which the following analysis is faced.

In response to these suggestions of the literature and in-depth interviews conducted between the author and research directors in Korea and Taiwan, Fig. 2 presents the structure of private and social returns to R&D and information channels in the context of public-private R&D collaboration. Essentially, public and private research entities collaborate on a number of levels and at different stages of a research project. Fontana, et al. (2003) point out that ideas do not need to originate in either sector. The initial stage of public-private R&D collaboration represented by δ_1 in Fig. 2, involves the bidirectional sharing of ideas about commercialization and project feasibility.

Information transfers along δ_1 are expected to occur through conferences/meetings as well as dialogue about each collaborators previous research results, possibly documented in patent or publication form. After determining goals, new knowledge is created and each sector works to complete their specified tasks with hopes of bringing the new innovation to market. Public research entities develop prototypes or conduct experiments and tests while the private

⁹ We do not consider the appropriability issues, mentioned earlier, such as the negative effect of information transfers upon firm profits A_2 . It is assumed that this will be offset by high returns from licensing (B), or, from the policymakers view, greater overall social returns (A to E).

¹⁰ See the survey article of Pouder and St. John (1996).

sector prepares its manufacturing facilities for new production. All the while, research entities from the public and private sector are in consultation, conference, and possibly engaging in research exchange. The information transfers occurring at this stage of the project are presented as δ_2 .

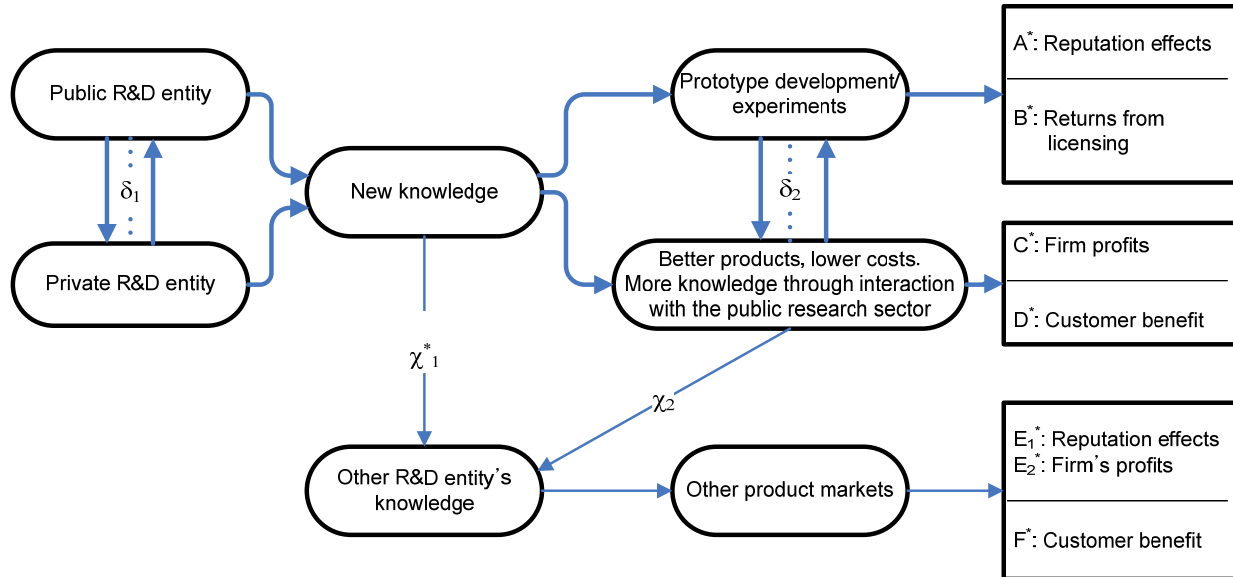


Fig. 2 Returns to R&D and information channels with public-private collaboration

In Fig. 2, χ^*_1 is no different from χ_1 in Fig. 1 except for the fact that it is followed by more consultation between the public and private research entities, indicated by χ_2 . This can generate one of two results. For one, the content of the knowledge being transferred through patents and/or publications (χ^*_1) is more limited than that of non-collaborative instances (χ_1). The private partner might become involved in the publications process, making certain that important information is not revealed in the article. The patent process may not even occur at this stage, as well, especially if collaborators are not able to predict whether manufacturing will occur. Alternatively, the knowledge transfer indicated by χ^*_1 may not happen at all, if collaborators are focusing primarily on the commercialization process, or they can occur after the finished product is manufactured, and other research entities attempt reverse engineering.¹²

¹¹ For our purposes, “networks” are a parallel construct to information transfers.

¹² From an organizational perspective, other research entities can also witness and reflect on the benefit of engaging in cross-sector R&D collaboration.

The private and social returns present in Fig. 2 are close approximations to those of Fig. 1, and are indeed larger than those offered in the non-collaborative case. Returns strictly for the collaborating research entities are A^* (public), B^* (public), and C^* (private). Beyond transfers through χ_1^* and χ_2 , the social returns are much greater here (A^* to F^*) than in the non-collaborative case. This is the result, we claim, of bridging the two research sectors and the resultant information transfers.

Method & Data

The following empirical analysis will help determine whether government intervention is necessary to promote R&D efforts, specifically R&D collaboration between the public and private research sectors. The significance of cross-sector (i.e., public-private) R&D collaboration in its impact upon information transfers between sectors has already been established, but there is still much uncertainty as to whether government funding and incentivization of such collaboration is necessary.

It is hypothesized here that salient government programs, in light of the importance of information transfers, should positively affect information transfers between sectors. There may, however, still be variance between types of information transfer, based on the discussion surrounding Fig. 2 in the preceding section. First of all, we must analyze the impact of public-private R&D collaboration, regardless of the degree of government involvement. After determining the significant presence of cross-sector R&D collaboration upon information transfers, we will make a secondary test for its source, either government-instigated or self-instigated. This will, in large part, satisfy the research question of this discussion.

There are a number of other factors possibly affecting the degree of information transfers between sectors, along with public-private R&D collaboration. Geographic proximity, frequency of interaction, and the effectiveness of the in-house technology transfer organization are the explanatory variables selected here. The inclusion of these three factors is absolutely necessary for presenting a realistic model of information transfers. Intuitively, we can expect that all three variables will have a positive effect upon information transfers, with variance by information transfer type. Transfers through licensing, for example, should be positively predicted by the technology transfer office.

A third examination of the structural model described in Fig. 2 is necessary along country and sectoral lines. We have decided to divide the data into country-level subsets to show particular differences between Korea and Taiwan. For sector-level differences, however, we have opted for the inclusion of a private dummy variable (0 = public sector, 1 = private sector). This will help establish which of the eight methods of information transfer are predicted by public or private sectoral affiliation and which are not different between the two.

The dependent variable is information transfer, in all of its varied forms, necessitating a series of regressions to determine the how each type of transfer is affected by our explanatory variables. As Cohen, et al. (1998), Fontana, et al. (2003), and Cohen, et al. (2002) have shown, information transfers are not uniform, but may occur in a variety of ways. Accounting for this variance in information transfers, the KORTAI R&D dataset contains eight separate measures of the extent to which useful information is received by the respondent from the opposing research sector. On a 7-point Likert scale, 7 being greatest, each public (or private) respondent assigns a number to measure how much useful information is received from the private (or public) sector through a particular method. Rather than use an over-generalizing principal components measure, individual analysis of the effects of government intervention will be more revealing. The eight methods of information transfers considered here are patenting, publications, hires, conferences, licenses, contract research, consultations, and personnel exchange.

In its most basic form, Eq (1) describes the relationship between information transfers and the explanatory variables mentioned above.

$$\text{info transfer} = f \left(\begin{array}{l} \text{public fund instigated collaboration,} \\ \text{self instigated collaboration,} \\ \text{frequency of interaction,} \\ \text{duration of TTO,} \\ \text{government intervention} \end{array} \right) \quad (1)$$

Public fund-instigated collaboration and self-instigated collaboration are both 7-point Likert scale measures, 7 being greatest. The degree of interaction is measured here by the frequency with which members of the respondent's institute interact with the partner from the opposing research sector. Taking form as a 5-point Likert scale score with unequal distances between

values,¹³ higher values indicating greater frequency, this variable is important in establishing a basis for efforts which are assumed to be separate from government intervention. The duration of technology transfer organization (TTO) measure captures the degree of institutionalization of technology licensing and transfer. This variable is also measured along a 5-point Likert scale with unequal distances between values, higher values indicating greater duration.¹⁴

Government intervention in research is the variable in question, which is expected to lead to increased transfers when done appropriately. Due to the absence of a valid measure of government intervention in research, it must be omitted from Eq (1). This omission implies that government intervention is captured by the error term, ε , shown in the following linear equation:

$$\begin{aligned} (\text{info transfer})_{ik} = & \beta_0 + \beta_1 (\text{public fund instig. coll.})_i + \\ & \beta_2 (\text{self instig. coll.})_i + \beta_3 (\text{frequency})_i + \\ & \beta_4 (\text{TTO form})_i + \varepsilon_i, \end{aligned} \quad (2)$$

for research entity i and method of information transfer k . As government intervention is now part of the error term, there are ramifications for other explanatory variables with which it might be correlated, primarily the propensity to engage in cross-sector R&D collaboration as a result of receiving public funds. It is assumed that a greater degree of public fund-instigated cross-sector R&D collaboration results from greater intervention by the government to generate commercializable and long-run-oriented research results. This is an expressed goal of the Korean and Taiwanese funding programs from which the KORTAI R&D dataset is drawn. Single-stage regression estimates of public fund instigated R&D collaboration, thus, reflect some of the effect of market correcting efforts, creating a positive bias.

The solution to this omitted variable problem is the instrumental variable (IV) approach, which can yield consistent estimates of cross-sector R&D collaboration through public fund instigated R&D collaboration, in spite of the problems discussed above. The following empirical analysis consists of two stages. In the first stage, our instrumented variable (which is correlated with the omitted measure of government intervention in research) will be regressed upon two

¹³ Frequency is measured as follows: “1”, less than once a month; “2”, 1-3 times a month; “3”, once a week; “4” 2-3 times a week; “5” almost everyday.

¹⁴ “1” represents no licensing office at all, “2” for 0-2 years duration, “3” for 2-5 years duration, “4” for 5-8 years duration, and “5” for over 8 years duration.

instruments. The instrumented variable, once again, is a measure of the degree to which the receipt of public funds instigates public-private R&D collaboration. The instruments which have been selected from the KORTAI R&D dataset for the degree of public fund instigated R&D collaboration are including in the right-hand side of the following equation:

$$z_i = \gamma_0 + \gamma_1(\text{gov.oversight})_i + \gamma_2(\text{proximity})_i + \mu_i, \quad (3)$$

where z is the degree of public fund instigated R&D collaboration. In Eq (3), both government oversight and proximity are expected to be positively correlated with the degree of public fund-instigated public-private R&D collaboration. Government oversight is measured here along an ordered, unequally spaced 7-point Likert scale. Higher values correspond with greater government oversight, specifically measured by the number of times per year in which the respondent has to report his/her findings to an evaluating committee as a condition of receiving funding.¹⁵ It is expected that greater oversight will lead to a greater amount of public fund-instigated cross-sector R&D collaboration, as it will insure that the research fund recipient is following the plans outlined in the original fund proposal, and that he/she is working towards innovative results with long-run and commercializable implications.

Proximity effects are also a function of the degree to which public-private R&D collaboration occurs and are also scored on a 7-point Likert scale, 7 being greatest.¹⁶ Santoro and Gopalakrishnan (2001) conclude that geographic proximity facilitates technology transfers, similar with Lerner (1999), who determined that firms in the U.S. SBIR program located in productive zip codes have greater growth in employment and sales. Finally, Mansfield (1995) shows that geographic proximity is more important when applied R&D is emphasized. When research is more basic nature, proximity plays a much less important role.¹⁷ On an intuitive level, both government oversight and proximity are uncorrelated with the dependent variable of the second stage regression (information transfers). They are also expected to have a positive effect

¹⁵ The spacing of the Likert scores is as follows: “1” corresponds with meeting zero times per year, “2” corresponds with 1 time per year, “3” with 2-3 times per year, “4” with 4-5 times per year, “5” with 5-7 times per year, “6” with 8-10 times per year, “7” with more than 10 times per year.

¹⁶ Respondents were asked to score the following statement: “Geographic proximity to a [private firm/public institute] positively influences our decisions to collaborate.”

¹⁷ This is an interesting observation which may be addressed in future research, as the KORTAI R&D database includes measures for research emphasis.

on the degree of public fund-instigated R&D collaboration, which is consistent with existing research.

The second stage of the IV approach estimates the structural equation presented in Eq (2), with the predicted variables from Eq (3). In other words,

$$\begin{aligned} (\text{info transfer})_{ik} = & \beta_0 + \beta_1 \hat{z}_i + \beta_2 (\text{self instig. coll.})_i \\ & + \beta_3 (\text{frequency})_i + \beta_4 (\text{TTO form})_i + \varepsilon_i, \end{aligned} \quad (4)$$

where \hat{z} are the predicted values of public fund instigated public-private R&D collaboration.

This will satisfy both the omitted variable issues regarding the measure of government intervention as well as the potential endogeneity problems mentioned by Fontana, et al. (2003).

Results

The summary statistics for cross-sector information transfers in Korea and Taiwan, presented in Tables 1 and 2, respectively, illustrate some of the compelling differences and similarities between the public and private research sectors. A vertical box plot is also presented in Figs. 3 and 4 to graphically present distributions by sector according to a 7-point Likert scale (y axis). The rectangular boxes in each figure represent those responses between the twenty-fifth percentile (lower hinge) and the seventy-fifth percentile (upper hinge). The median is found directly in the middle of the box. Lines (or “whiskers”) extending from the box are capped with adjacent values, beyond which are outside values, represented by small circles.¹⁸

For the Korean case, shown in Table 1, there are some notable patterns between research sectors. For instance, public sector respondents state that the greatest information from the private sector flows through conferences/meetings, consultations, and contract research. The next greatest method of receiving information from private firms in Korea is through personnel exchanges and publications, followed by information received through patents, hiring former private firm researchers, and the licensing of intellectual property.

¹⁸ Adjacent values are calculated by multiplying the interquartile range (the difference between the first and third quartile values) by 1.5, and adding or subtracting it from the upper or lower hinges, respectively.

Table 1 Summary statistics for information transfers (7-point Likert scale): Korea

Information Transfer Method	Mean	Std. Err.	[95% Conf. Interval]	
patenting				
Korea public	2.580247	.0573177	2.467848	2.692646
Korea private	3.297297	.0970627	3.106958	3.487636
publications				
Korea public	2.91358	.0602975	2.795337	3.031823
Korea private	3.513514	.0761556	3.364173	3.662854
hires				
Korea public	2.382716	.0560321	2.272838	2.492594
Korea private	2.486486	.0761556	2.337146	2.635827
conferences				
Korea public	4.814815	.0524502	4.711961	4.917669
Korea private	4.648649	.0701399	4.511105	4.786192
licenses				
Korea public	2.024691	.0483675	1.929843	2.11954
Korea private	2.243243	.0630359	2.11963	2.366856
contract research				
Korea public	3.197531	.0718998	3.056536	3.338526
Korea private	3.216216	.0876027	3.044428	3.388004
consultations				
Korea public	3.91358	.0600156	3.79589	4.03127
Korea private	4.135135	.0734796	3.991042	4.279228
personnel exchange				
Korea public	2.925926	.0655735	2.797337	3.054515
Korea private	2.324324	.0766165	2.17408	2.474569

The ranking of information transfer from the public to the private sectors resembles that of the Korean public sector respondents. Conferences and consultation are both ranked highly, as are transfers through publications. Transfers through hire and licenses are both ranked towards the bottom, and contract research towards the middle. The most noticeable differences are with patenting and publications, with knowledge flowing to a greater degree from the public to the private sectors. The proximity and similar ranking of mean scores between the two sectors in Korea raises the possibility that the institutional apparatuses for information transfer in Korea have created channels of knowledge flows which work for both public-to-private and private-to-public directions.

Table 2 Summary statistics for information transfers (7-point Likert scale): Taiwan

Information Transfer Method	Mean	Std. Err.	[95% Conf. Interval]	
patenting				
Taiwan public	1.857143	.0733295	1.713344	2.000941
Taiwan private	2.494845	.0601717	2.376849	2.612841
publications				
Taiwan public	2.047619	.0727944	1.90487	2.190368
Taiwan private	2.701031	.0573635	2.588542	2.81352
hires				
Taiwan public	2.404762	.0737487	2.260141	2.549382
Taiwan private	2.309278	.0550918	2.201244	2.417313
conferences				
Taiwan public	3.333333	.0896759	3.15748	3.509187
Taiwan private	2.896907	.0535959	2.791806	3.002008
licenses				
Taiwan public	2.02381	.0749621	1.87681	2.170809
Taiwan private	1.917526	.0463023	1.826727	2.008324
contract research				
Taiwan public	3.880952	.0842553	3.715729	4.046176
Taiwan private	3.639175	.064544	3.512605	3.765745
consultations				
Taiwan public	4.190476	.0865008	4.020849	4.360103
Taiwan private	4.082474	.0616366	3.961606	4.203343
personnel exchange				
Taiwan public	4.166667	.0862658	3.9975	4.335833
Taiwan private	3.360825	.0617354	3.239762	3.481887

Turning now to the Taiwanese case, the results of which are presented in Table (2), the pattern among mean responses reveals that, like the Korean case, information transfers similarly for both the public and private research sectors. Taiwanese public sector respondents strongly indicate that information transfers from the private sector through consultations, personnel exchange, and contract research. Ranked lowest are the degree of information flows through patents, publications, and licenses. Taiwanese private firms show a pattern of information flows from the public sector through consultation, contract research, and personnel exchange, corresponding with the public sector mean values. Transfers through hires and licenses were ranked on the lower end in both sectors in Taiwan.

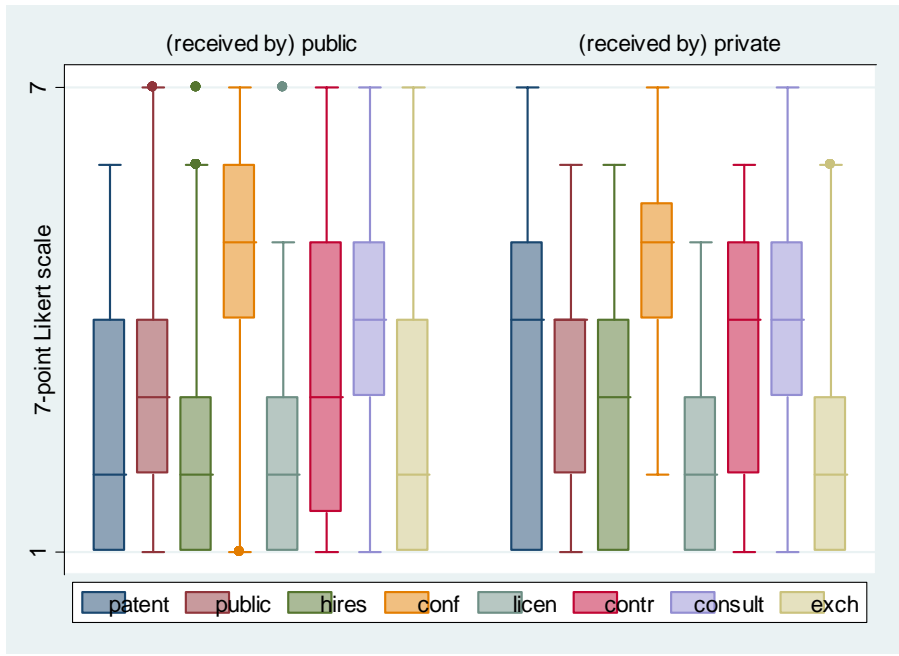


Fig. 3 Summary statistics for information transfers by sector: Korea

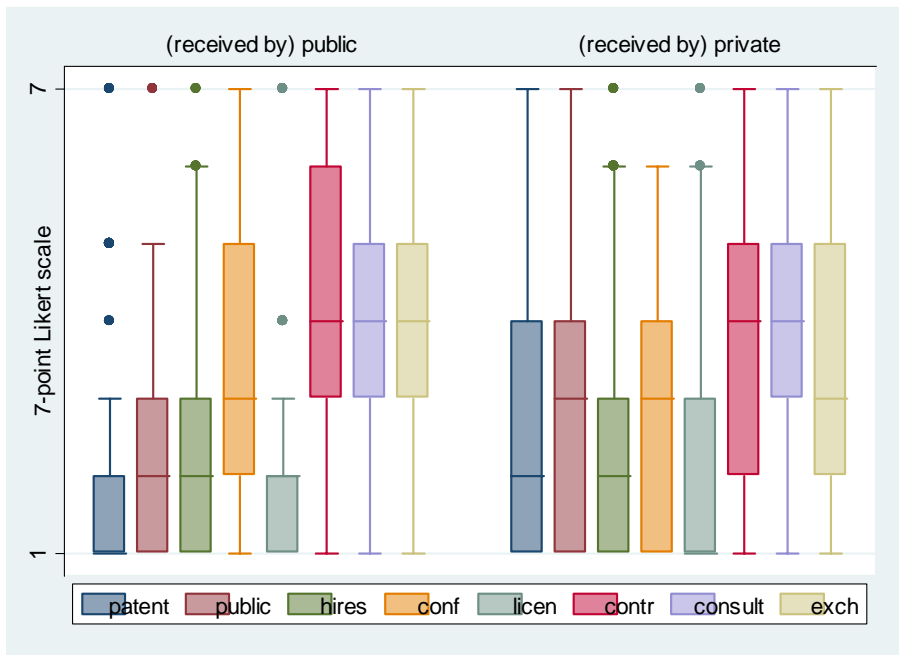


Fig. 4 Summary statistics for information transfers by sector: Taiwan

Comparing the two countries, there is a general similarity between information flows between the public and private research. Patenting and publications are ranked similarly, and the public sector in both countries receives more information through personnel exchange. Two notable differences between Korea and Taiwan, on the other hand, are the higher mean values for transfers through contract research and the lower mean values of conferences in Taiwan, vis-à-vis Korea. For all Korean sub-samples, the highest average values were assigned to conferences/meetings as a source of information. Taiwanese respondents indicated that conferences are a clear source of information transfer from sector to sector, but they are ranked below a number of other methods of information transfer.

The instrumental variable (IV) results for the Korean and Taiwanese cases, based on Eq (4), are presented in Tables 3 and 4, respectively. Before identifying some of the more general observations of these results, it is necessary to take each country in turn. Beginning with Korea, public-private R&D collaboration has an effect on a number of methods of information transfers, but in no case is intervention by the government a factor. Indeed, where public fund-instigated R&D collaboration shows a semblance of predictability, such as for information transfers through patenting, publications, licensing, and consultations,¹⁹ the coefficients have negative values. This indicates that government intervention – as we have defined it – actually decreases the amount of information transfers for these methods. The only method of information transfer exempt from this pattern is conferences.

Despite the fact that government intervention has a limited, if not debilitating effect upon information transfers in Korea, we cannot conclude that public-private R&D collaboration is ineffectual in the absence of public funding. When self-instigated, such R&D collaboration has a positive and statistically significant effect upon the amount of cross-sector R&D information transfer, in the cases of publications, licensing, and contract research.

In terms of our other explanatory variables, frequency of interaction is positive and statistically significant in all cases. The duration of a TTO, however, has a positive and significant effect upon more formal information flow methods, confirming Pouder and St. John (1996). Sectoral differences, measure by the private dummy variable, show that information transfer via patents and publications is predicted by the private sector, while transfers through

¹⁹ None of these results, however, are significant at any reportable (i.e., 10, 5, or 1 percent) levels.

personnel exchange are predicted by the public sector. This is consistent with the descriptive statistics presented in Tables 1-2 and Fig. 3-4.

Table 3 IV results for Korea

	<i>patents</i>	<i>publi- cations</i>	<i>hires</i>	<i>confer- ences</i>	<i>license</i>	<i>contract research</i>	<i>consul- tation</i>	<i>person exchange</i>
Program instig.	-.218 (.311)	-.143 (.290)	.003 (.317)	.438 (.307)	-.131 (.261)	.102 (.363)	-.500 (.332)	-.088 (.348)
self instig.	.175 (.111)	.258** (.101)	.159 (.108)	.114 (.107)	.177** (.089)	.269** (.126)	.180 (.115)	.196 (.123)
freq.	.307** (.140)	.303** (.128)	.276** (.134)	.411*** (.135)	.191* (.111)	.363** (.157)	.294** (.147)	.344** (.151)
TTO Form	.287** (.132)	.292** (.121)	.155 (.123)	.023 (.128)	.226** (.103)	.309** (.144)	.222 (.138)	.219 (.138)
private dummy	.870*** (.331)	.664** (.300)	.124 (.307)	-.008 (.317)	.242 (.258)	.222 (.362)	.231 (.343)	-.691** (.347)
const.	1.806 (1.487)	1.483 (1.393)	.924 (1.453)	1.324 (1.474)	1.131 (1.210)	.261 (1.700)	4.509*** (1.595)	1.593 (1.597)
F-stat	4.11***	5.09***	1.99*	3.19***	2.87**	3.90***	2.34**	3.34***
R2	.171	.217	.092	-	.112	.181	-	.140
N	106	107	105	107	105	106	107	105

Standard errors in parentheses.

*, **, and *** indicate significance at the 10, 5, and 1 percent levels, respectively.

Instrumented: program instigated cross-sector R&D collaboration (program instig.)

Instruments: government oversight, effect of geographic proximity upon cross-sector R&D collaboration, self-instigated cross-sector R&D collaboration, frequency of interaction, duration of TTO, private dummy.

The Taiwan case exhibits more variation between the effects of public fund-instigated and self-instigated public-private R&D collaboration. Government intervention is a positive and significant predictor for information transfers through publications, conferences, and personnel exchange. Transfers through patenting and contract research are also positively predicted by public fund-instigated R&D collaboration. Self-instigated R&D collaboration significantly and negatively predicts information transfers through licensing. It is generally concluded that self-instigation of public-private R&D collaboration is ineffectual in transferring information between sectors.

As is true for the Korean case, frequency of interaction is a positive, significant determinant of information transfers, but the duration of TTOs is not. This is particularly surprising, especially the absence of any effect upon transfers through licenses. In Taiwan, it will be useful to focus on TTOs' institutionalization at the national and institute levels.

Table 4 IV results for Taiwan

	<i>patents</i>	<i>publi- cations</i>	<i>hires</i>	<i>confer- ences</i>	<i>license</i>	<i>contract research</i>	<i>consul- tation</i>	<i>person exchange</i>
program instig.	.425 (.325)	.581** (.297)	.257 (.307)	.529* (.289)	.242 (.270)	.338 (.294)	.140 (.333)	.731** (.316)
self instig.	-.094 (.124)	-0.99 (.110)	-.111 (.114)	.002 (.113)	-.201** (.100)	.002 (.112)	.026 (.109)	-.105 (.127)
freq.	.398*** (.141)	.217 (.139)	.322** (.139)	.376*** (.127)	.150 (.123)	.342** (.132)	.379*** (.125)	.381** (.149)
TTO form	.082 (.107)	.041 (.103)	-.009 (.099)	.034 (.097)	.070 (.088)	.100 (.106)	-.036 (.097)	.030 (.118)
private dummy	.855*** (.326)	1.075*** (.323)	.169 (.316)	-.148 (.310)	.198 (.283)	.131 (.319)	.396 (.307)	-.414 (.360)
const.	-.865 (1.246)	-1.038 (1.175)	.817 (1.175)	-.356 (1.104)	1.136 (1.034)	1.167 (1.188)	2.379* (1.328)	.052 (1.303)
F-stat	3.76***	3.96***	1.67	4.34***	1.26	2.59**	2.39**	3.61***
R2	.031	-	.025	.016	-	.079	.093	-
N	139	138	130	138	131	141	141	140

Standard errors in parentheses.

*, **, and *** indicate significance at the 10, 5, and 1 percent levels, respectively.

Instrumented: program instigated cross-sector R&D collaboration (Program instig.)

Instruments: government oversight, effect of geographic proximity upon cross-sector R&D collaboration, self-instigated cross-sector R&D collaboration, frequency of interaction, duration of TTO, private dummy.

Conclusion

The R&D programs instituted in Korea and Taiwan have similar goals, but their effects upon information transfers between sectors are markedly different, based on a cross-national analysis. Government intervention in Taiwan appears to have found a niche with several methods of information transfer. In Korea, on the other hand, public funding is simply ineffectual in generating greater information transfers, as opposed to self-instigated R&D collaboration. In most cases, there is a negative effect of government involvement upon information transfers. If the fund providing agency does not assign more emphasis to information transfers, either directly or indirectly, it will be left entirely to the research entity to receive and send information through public-private R&D collaboration. We prescribe stronger, more explicit policies, given coordination and incentivization problems with developing cross-sector relations.

Despite the ineffectiveness of government intervention in Korea, it has been shown that public-private R&D collaboration in both countries is largely a predictor of information transfers from sector to sector. More importantly, and perhaps most revealing of all, public fund-instigated

and self-instigated public-private R&D collaboration tend to carry different coefficient signs when predicting the degree of information transfers from sector to sector, particularly patenting, publications, licensing, and personnel exchange.²⁰ Why this is the case has yet to be determined, but it is not believed that these contrasting effects are a reflection of government research funding crowding out research entity-level efforts to collaborate across sectors. If crowding out were occurring, coefficients for self-instigation would be negative and statistically significant with greater frequency.

Bibliography

- Adams, James D., Eric P. Chiang, and Katara Starkey. "Industry-University Cooperative Research Centers." *Journal of Technology Transfer* 26, no. 1-2 (2001): 73-86.
- Branstetter, Lee, and Mariko Sakakibara. "Japanese Research Consortia: A Microeconomic Analysis of Industrial Policy." *NBER Working Paper No. 6066* (1997).
- Cohen, Wesley M., Richard Florida, Lucien Randazzese, and John Walsh. "Industry and the Academy: Uneasy Partners in the Cause of Technological Advance." In *Challenges to Research Universities*, edited by Roger G. Noll. Washington, D.C.: The Brookings Institution, 1998.
- Cohen, Wesley M., Richard R. Nelson, and John P. Walsh. "Links and Impacts: The Influence of Public Research on Industrial R&D." *Management Science* 48, no. 1 (2002): 1-23.
- D'Aspremont, Claude, and Alexis Jacquemin. "Cooperative and Noncooperative R&D in Duopoly with Spillovers." *American Economic Review* 78, no. 5 (1988): 1133-37.
- Fontana, Roberto, Aldo Guena, and Matt Mireille. 2003. Firm Size and Openness: The Driving Forces of University-Industry Collaboration. In, A report commissioned by the OST-DTI, SPRU, University of Sussex, Brighton, <http://www.sussex.ac.uk/Users/prff0/mainpages/home.html>. (accessed).
- Griliches, Zvi. "The Search for R&D Spillovers." In *R&D and Productivity: The Econometric Evidence*. Chicago: University of Chicago Press, 1998.
- Hall, Bronwyn H., Albert N. Link, and John T. Scott. "Universities as Research Partners." *NBER Working Paper No. 7643* (2000).
- Jaffe, Adam B. "The Importance of 'Spillovers' in the Policy Mission of the Advanced Technology Program." *Journal of Technology Transfer* 23, no. 2 (1998): 11-19.
- Lach, Saul. "Do R&D Subsidies Stimulate or Displace Private R&D? Evidence from Israel." *Journal of Industrial Economics* 50, no. 3 (2002): 369-90.
- Lerner, Josh. "The Government as Venture Capitalist: The Long-Run Impact of the Sbir Program." *Journal of Business* 72, no. 3 (1999): 285-318.
- Mansfield, Edwin. "Academic Research Underlying Industrial Innovations: Sources, Characteristics, and Financing." *Review of Economics and Statistics* 77, no. 1 (1995): 55-65.
- Pouder, R., and C.H. St. John. "Hot Spots and Blind Spots: Geographical Clusters of Firms and Innovation." *Academy of Management Review* 21 (1996): 1192-225.

²⁰ Complementarity was also evident for consultations in Korea and for hires in Taiwan.

- Ruegg, Rosalie, and Irwin Feller. "A Toolkit for Evaluating Public R&D Investment: Models, Methods, and Findings from Atp's First Decade." edited by U.S. Department of Commerce: National Institute of Standards and Technology, 2003.
- Sakakibara, Mariko. "Cooperative Research and Development: Theory and Evidence on Japanese Practice." Doctoral Dissertation, Harvard University, 1994.
- Santoro, Michael, and Shanthi Gopalakrishnan. "Relationship Dynamics between Univesity Research Centers and Industrial Firms: Their Impact on Technology Transfer Activities." *Journal of Technology Transfer* 26, no. 1-2 (2001): 163-71.
- Wallsten, Scott. J. "The Effects of Government-Industry R&D Programs on Private R&D: The Case of the Small Business Innovation Research Program." *Rand Journal Of Economics* 31, no. 1 (2000): 82-100.