Information Exchange and Governance Structures in U.S. and Japanese R&D Consortia: Institutional and Organizational Influences

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***Abstract*— We examine institutional and organizational influences upon information exchange and governance structures within R&D consortia in the United States and Japan. We hypothesized that national differences in institutional environments would lead to less active governance and information-exchange activities within Japanese R&D consortia relative to their U.S. counterparts. At the consortium level, we expected that internal consortium diversity would increase information exchange and governance requirements, and that structures stabilizing relations between consortium members would reduce information-exchange and governance requirements.**

We tested these hypotheses on 39 U.S. and 54 Japanese multifirm R&D consortia, involving, respectively, 1801 U.S. member organizations and 1647 Japanese member organizations. Controlling for organizational age, size, and strategic focus, we found that internal diversity and interorganizational relations are both associated with information-exchange and governance mechanisms. Our model has much greater explanatory power for the United States than for Japan.

***Index Terms*— Governance structures, information exchange, interfirm cooperation, National Cooperative Research Act, R&D consortia, technology research associations, technology transfer.**

I. Introduction

TWO MODERN economies—the United States and Japan—are competing fiercely for global domination of expanding markets in high-technology industries. To reduce development costs, and to speed time to market, firms in each country have formally partnered with rivals and competitors in multifirm R&D consortia. Thus, in both nations, we find parallel R&D consortia with very similar technological and competitive objectives. However, the organization of their R&D consortia is strikingly different. For example, consortia technology-transfer and information-exchange efforts are considerably less active in Japan than in the United States [3], [4].

Our research on the observed national differences extends the rich, descriptive comparisons catalogued by Aldrich and Sasaki [3], [4] by using the lenses of organizational economics and institutional and contingency theories of organizations. We expected that differences in the institutional environments of the United States and Japan at the "mesolevel" of intercorporate relationships [27] would produce differences in information-exchange and governance practices within the R&D consortia of each nation. We also expected that the characteristics of member firms would generate differences in consortium practices.

Prior empirical studies have explored various pieces of this puzzle, as some researchers have examined broad institutional differences [26], [27], [43], whereas others have concentrated on more microlevel structures at the firm level [35], [36]. Some investigators have closely examined a few cases, whereas others have collected quantitative information from a large number of cases [36] or have analyzed only a single country at a time [48]. Our comparative investigation of 93 multifirm R&D consortia takes a unique middle ground by providing an explicit empirical translation of institutional- and organization-level arguments concerning consortium practices.

To provide a context, we begin with a brief discussion of multifirm R&D consortia as a relatively recent organizational form. We then develop and test two sets of hypotheses, drawing first upon organizational economics and the comparative U.S.–Japanese institutional literature and then on the contingency theory of organizations. Last, we estimate a combined model, interpret our results, and make suggestions for future research.

A. Multifirm R&D Consortia in the United States and Japan

R&D consortia constitute a subset of organizational forms involving formal interfirm cooperation among potential competitors in the same industry [20]. As an intermediate governance form between the poles of markets and hierarchies [62], consortia may be distinguished from other interorganizational alliances—such as joint ventures, technology licensing, subcontracting, etc. [14]—along three dimensions.

1) R&D consortia typically (but not necessarily) involve multifirm rather than dyadic interfirm cooperation.
2) They usually involve horizontal collaboration among direct competitors.
3) They tend to focus upon basic and applied precompetitive research on moderately long-term projects.

Japanese R&D consortia, known as technology research associations (TRA's), emerged after legislation in 1961—the

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Act on the Mining and Manufacturing Industry Technology Research Association—granted special funding, favorable tax treatment, and other advantages to these new organizational entities. TRA's bring together firms in the same industry that are willing to cooperate on collective projects. In the United States, since the 1984 National Cooperative Research Act (NCRA) first authorized their existence, participation in R&D consortia has increased rapidly [5]. A number of forces have fueled the development of this important new organizational form: competitive pressures, desires to spread risk and pool resources, moves toward the establishment of industry technical standards, and attempts to reduce the development time for new generations of products and processes [3], [20], [50]. Although the technological objectives for consortia appear similar in both countries, the larger institutional context in which they operate differs dramatically, and the mechanisms used to control and diffuse new technology within the respective consortia of each country exhibit both similarities and differences [3].

B. Critical Issues in the Management of R&D Consortia

In both nations, the transfer of technology to member firms is the *raison d'être* of R&D consortia. From a practical standpoint, the decision to coordinate research via an interfirm R&D consortium forces firms to develop explicit mechanisms for exchanging information between members. Cooperating firms also must build specific governance mechanisms (e.g., boards of directors, councils, etc.) to administer joint activity and make decisions concerning technology, goals, budget, and so forth.

Olk and Young [47], for example, explored how heterogeneous sets of members in R&D consortia select technology, set goals, and make operating decisions and budget allocations. Barnett *et al.* [5] investigated the emergence of R&D consortia as either generalist or specialist organizational forms, raising the issue of which governance mechanisms are most appropriate for each form. In their exploration of opportunistic behavior in collaborative R&D organizations, Tripsas *et al.* [5] examined the frequency of interactions among members, as well as monitoring and enforcement mechanisms. Fruin [23] has also investigated the mechanisms of control and coordination in interorganizational technology networks.

We turn now to our analysis of whether information-exchange and governance mechanisms in the R&D consortia of each nation are affected by institutional differences between the two nations. We focus on three central characteristics of interest to consortia: 1) their number of information exchange mechanisms, 2) the number of governance mechanisms they use, and 3) the intensity of their governance mechanisms.

II. Institutional and Interorganizational Influences upon R&D Consortia

Firms in the United States and Japan tend to use markedly different internal arrangements [29]–[31], [61], as well as external networks, for developing new technology [7], [21], [37], [42]. Japan's socio-political and economic environment provides a macroinstitutional level of support for stable interorganizational relations, due in part to the Ministry of International Trade and Industry (MITI)'s role in consortium formation [20], but also because a pervasive interdependency exists among many important economic actors through durably structured social and economic ties.

Organizational economics offers a theoretically grounded explanation for differences across nations [6], [8]. Economic exchange can be conceptually ordered along a continuum of "soft" to "hard" contracting, or, as Gerlach [26] has summarized it, from *relational* to *transactional* exchange. Within the context of hard, transactional exchange, autonomous parties are characterized as having arms-length relationships to one another and as pursuing individualized self-interests. Transactional exchange typically requires that each party commits to a well-specified contractual obligation that anticipates many possible contingencies.

In contrast, soft, relational contracting—as originally described by Macaulay [40] and then further elaborated by Dore [17], Macneil [41], Ouchi [49], and Williamson [62], [63]—presumes considerable overlap of interests between the parties [32] and a less rigorous and complete *ex ante* specification of mutual obligations [64, p. 361]. Under conditions of uncertainty, both parties rely on tacit social norms and on expectations of future exchange to govern and organize exchange behavior. Williamson [63, p. 238] observed:

> by contrast with the neoclassical system, where the reference point for affecting adaptations remains the original agreement, the reference point under a truly relational approach is the entire relation as it has developed through time.

When economic relationships continue over time, as is common in Japan, social sanctions constitute effective constraints upon potential opportunism.

In Japan, economic exchange among large, established firms occurs under a broad national umbrella of relational contracting, resulting in a general preference for dealing with long-term associates rather than "unreliable newcomers" [26, p. 27]. This preference apparently stems from the tightly coupled social organization of Japanese industry that facilitates broad teamwork among companies, trade associations, research institutes, and government, involving trading groups known as *keiretsu*, or "business groups" [25], [54]. Larger firms may belong to one of the major *keiretsu*, and smaller firms may be connected through regional and even local groupings, so that business partners are rarely unknown to each other [48]. The degree of embeddedness varies, but few companies are immune to or isolated from this "organized capitalism" [17], so the ties between organizational actors are highly durable over time.

A. Institutional Hypotheses

We hypothesize that the different institutional contexts for interfirm activities in the two nations have clear consequences for the organization of R&D consortia. On the theoretical continuum between "soft, relational" and "hard, transactional" contracting, we have characterized interorganizational relationships in Japan as relatively relational and those in the United States as relatively transactional. However, in our formal hy-

pothesis, we avoid constructing and comparing national straw men by examining not only broad similarities and differences *across* countries but also variations *within* countries. Our first hypothesis only applies to Japan.

I1: The more concentrated the membership of Japanese consortia, as measured by the number of keiretsu represented, the more likely they are to employ fewer information exchange mechanisms and use fewer and less intense governance mechanisms among member firms.

In Japan, MITI has for several decades provided support and wielded influence over the keiretsu and has extended this influence to R&D consortia. Controversy now surrounds claims regarding MITI's power and impact. However, even Callon [12, p. 6], who presented strong evidence that MITI's overall effectiveness has waned since the mid-1970's, argued that as other options have eroded, "consortia have claimed center stage in MITI's high-tech policies." Calder [11] identified severe limits to Japanese industrial policy effectiveness in the face of international political and economic pressures. He analyzed the competing views of Japan as strong and unitary versus internally pluralist, and opted for the middle ground.

The United States lacks a state-legitimated umbrella for interorganizational relations. As a result, individual members of an R&D consortium in the United States must rely on their own resources and experiences with intercorporate alliances to achieve stable membership. Membership stability may play a role similar to keiretsu affiliations to the extent that stability leads to a more trusting climate between nominal competitors. Trust builds up as exchange partners repeat their interactions [28], [34], [65] and undergo firm-level learning about the type and degree of transaction costs that arise when firms join multifirm R&D consortia [59]. We therefore propose the following.

I2: The more experience firms have with other consortium members, through stable membership, the more likely they are to employ fewer information-exchange mechanisms and use fewer and less intense governance mechanisms among member firms.

In both nations, firms may belong to many different consortia, through which they gain experience in alliance management as well as knowledge of specific partners. When firms within a consortium have other consortia memberships, they may serve as channels through which governance and information dissemination practices diffuse across consortia. If representatives take knowledge of such practices back to their member firms, the information may diffuse either because the same representatives participate in other consortia or because they spread the knowledge within their own firm and others pass it on when they participate in other consortia.

In the United States, we expect consortia membership "interlocks" to increase the use of the various governance and information-dissemination mechanisms because they are a fundamental mechanism of learning and diffusion of practices across consortia. By contrast, in Japan, we would expect much less of an effect because government intervention and the extensive ties already present between firms provide a foundation for the diffusion of practices [9].

I3: The greater the number of (overlapping membership) interlocks a consortium has with other consortia, the greater the use of information-exchange and governance mechanisms—with the relationship stronger in the United States than in Japan.

Our final institutional hypothesis concerns the role of government involvement in the operating decisions and funding of consortia. Consortium arrangements are often disputed because the potential for opportunism may increase markedly when competitors join together. Member firms may not be able to agree among themselves on solutions to collective action problems. Tripsas *et al.* [59] pointed out that governmental intervention may be a partial solution because governmental regulations and oversight can be a functional alternative to internal administrative arrangements for handling information asymmetry between exchange partners, protection of proprietary information, and the distribution of rewards, recognition, and profits.

In Japan, government plays a greater role than in the United States, actively using "old boy" networks to provide managing directors for consortia and providing direct financial subsidies to specific consortia. By contrast, in the United States, government offers a more remote advisory function, minimal funding, and even disincentives to consortium formation through enforcement of antitrust law and inhibiting regulations. In both countries, we expect that government involvement will reduce governance costs by reducing the need for extensive monitoring, although its effects on information exchange are not clear (and therefore we propose no hypothesis about it). We therefore hypothesize the following.

I4: The greater the involvement of government agencies, via indirect influence and direct funding, the fewer and the less intense the governance mechanisms used by consortia.

B. Organizational Influences upon R&D Consortia

Complexity and uncertainty have a direct bearing on organizational structure and strategy, a theme with a long history in the contingency literature of organizations [24], [33], [58]. In this view, organizations facing environments characterized by different degrees of uncertainty develop distinctive organizational structures to cope with the challenges of environmental uncertainty.[1] Organizations facing more varied types of environments, and hence more uncertainty, have been found to be more decentralized and differentiated.

Uncertainty and complexity lead to higher needs for information exchange and control, whether uncertainty stems from internal or external sources. Within interorganizational entities such as R&D consortia, perhaps the most salient aspect of uncertainty is that which arises from the *diversity* of organizational membership in a given consortium. A consortium composed of member firms with diverse organizational characteristics and histories may require frequent and intensive communication because members share little in common beyond the technological goals of the consortium.

Diversity of membership also raises interesting issues of trust across members, a theme in the literature on organiza-

[1] Contingency theory has been discredited in certain respects [51], yet the posited relationship between organizational form and strategy and environmental uncertainty also appears in the subsequent literature on organizational ecology [2] and organizational economics [6].

tional economics. R&D consortia with a more diverse membership may also experience greater *ex ante* fears of opportunism, which in turn may lead to greater reliance upon impersonal forms of information-exchange, monitoring, and governance mechanisms. In their study of the SEMATECH consortium of U.S. semiconductor equipment manufacturers, Browning *et al.* [10] found that cultural differences among members made cooperation more difficult than expected. Veugelers [60] analyzed 668 interfirm alliances initiated between 1986 and 1991 (primarily in European Community nations), and found that asymmetries among partners in nationality, size, and experience raised coordinating costs among partners. Differences in size may create discrepancies in organizational power and a demand by some members for more formality [56].

O1: The greater the range of organizational size and industry/institutional sectors represented among member firms of an R&D consortium, the larger the number of information-exchange mechanisms and the greater the number and intensity of governance mechanisms it will use among member firms.

Our second organizational hypothesis focuses on a consortium's strategy at its founding, following Barnett *et al.* [5], who pointed out that R&D consortia are collective action organizations. Some consortia adopt very general strategies, picking broad, ambiguously stated goals, whereas other adopt very narrow strategies, focusing on a well-defined special purpose. Barnett *et al.* [5] found a bias toward generalism in the founding of R&D consortia, with generalist consortia growing at a faster rate than specialists. Generalists' growth preempted the potential niche space of specialists and thus decreased the founding rate of new specialist—but not generalist—consortia.

Following the logic we laid out for Hypothesis O1, we would expect generalists, with their broad mandates and ambiguously defined goals, to have more problems of internal coordination and control than specialists. By contrast, specialists, with narrow mandates and relatively clearly defined goals, may have an easier time reaching consensus and thus have fewer needs for coordination and control mechanisms.

O2: Generalist R&D consortia, as compared to specialists, will use more information-exchange mechanisms and more numerous and intensive governance mechanisms among member firms.

In addition to organizational problems generated by a diverse membership, consortia also may face communication and governance problems because of the administrative arrangements they adopt for carrying out research [3], especially with regard to using a centralized facility versus decentralizing research to member firms. Each arrangement poses its own set of problems for consortium administrators. If a great deal of research is conducted in a central facility, member firms may become suspicious that their interests are not being taken into account and ask for more extensive governance mechanisms. If research is conducted within member firms, implementation of results may be easier, as there is no "not invented here" syndrome to overcome, but monitoring and control may be difficult and results may not be shared equally among all members. Smilor and Gibson [55] found that sheer physical distance between technology developers and users was inversely related to the success of technology transfer. Our research design did not allow us to probe the actual proportion of consortium resources invested in joint facilities and member firm efforts, so our hypotheses concerning the two arrangements remain tentative. We propose the following.

O3: Consortia conducting some research in joint facilities, as opposed to within member firms, will use more information-exchange mechanisms and more numerous and intensive governance mechanisms among member firms.

III. Data Analysis and Research Design

Our study began with a complete listing of all R&D consortia in the United States, and all TRA's in Japan, from the time enabling legislation was passed up until 1990. We then obtained information on their governance structures through a survey mailed to the top administrator in each consortium and from phone calls and consortium documents. We also obtained information about member organizations in the consortia from publicly available archival sources in each nation. Thus, our data collection and analysis encompass two levels: R&D consortia in each country and member firms from the consortia of each country.

A. The United States

R&D consortia have existed officially in the United States only since 1984, when the NCRA was passed. To qualify for protection against the awarding of treble damages in an antitrust case, U.S. R&D consortia must register with the Department of Justice, and the process of filing a request for exemption results in a consortium's being listed in the *Federal Register*. We prepared a mailed questionnaire that was sent in July 1990 to the administrative managers of R&D consortia named in the *Federal Register* and whose addresses we verified by telephone. The questionnaire asked about their history and operating characteristics and probed how the consortium was governed. We received 39 usable replies from the 67 R&D consortia who were eligible for inclusion in our sample, for a completion rate of 58%.

The *Federal Register* lists the member organizations in each consortium. We obtained information on all listed firms, regardless of whether we had managed to interview the consortium managers. After making corrections, 1801 cases remained. For these listings—of which 1635 were business firms—we used three sources to track down financial information on the business firms that were members: DISCLOSURE, *Ward's Business Directory,* and INFOTRAC. Because some firms belong to more than one consortium, duplications remain in the data base. However, each member firm is only counted once in the descriptive statistics for each consortium.

B. Japan

The Japanese portion of the study was carried out in 1990–1991, using the same questions as in the U.S. questionnaire translated into Japanese. The sampling list was prepared from information supplied by government agencies. Between May 1961 and September 1990, 116 TRA's were established, and many had achieved their goals and had shut down by the time of our study. Most of them—94—were under the aegis of MITI, 20 were under the Ministry of Agriculture and Forestry,

and two were under the Science and Technology Agency. We mailed questionnaires to the 69 consortia still active in January 1991 and received 54 usable replies. The 78% response rate reflects both our study's intrinsic interest to the participants and the blessing our study received from MITI and the Japan Technology Transfer Association.

We obtained a list of the member organizations in each consortium from government sources. We used *The Japan Company Handbook* to search for financial information on 1604 of the 1647 member organizations that were business firms. The *Handbook* only covers firms that are listed in the First and Second Section of the Tokyo Stock Exchange. Because some firms belong to more than one consortium, there are duplications in the data base. There are 1106 unique entries, but when we consider only those listed on the First and Second Sections, the number is reduced to 353. Most of the remaining firms are small and medium sized.

C. Measures

We created measures of information exchange and governance activities within the consortia of each country, as well as measures of interorganizational relationships and organizational diversity. Many extend or replicate those published earlier in Aldrich and Sasaki [3], [4] in papers that were primarily descriptive. Tables I and II list variable definitions and provide summary data on our measures. Because there are no precedents of similar scale and scope for some of this research, several of our measures are novel. Further information on the construction of indexes is available from the first author.

IV. Results

We used multiple regression to test each group of hypotheses separately and then constructed final equations informed by the results of the separate tests. We report unstandardized regression coefficients, so that we can focus on the *form* of the relationship between the independent variables of interest and our two sets of dependent variables. Our hypotheses posit not only nonnull regression coefficients but also the signs of the coefficients, and so we use one-tailed significance tests unless otherwise noted.

A. Initial Models

We present our hypotheses again, in shortened form, and then the results for each based on the regression results given in Tables III and IV. We are encouraged by our results. Although a number of specific hypotheses did not receive the support we anticipated, we did find solid evidence of differences between Japanese and U.S. information-exchange and governance practices. The results we present are generally consistent with our thesis that *national* differences in institutional environments lead to less active information exchange and governance activities by Japanese R&D consortia.

I1: More Keiretsu concentration predicts lower values on all three dependent variables for Japan.

a) Japan: This relationship has the expected negative sign in all three equations, and is substantial and significant for both information exchange and membership in government mechanisms. We will return to the highly significant relationship for information exchange in our subsequent discussion.

I2: More stable membership predicts lower values on all three dependent variables.

a) Japan: There was too little variance in this measure to include in our Japan models, as Japanese consortia had almost no dropouts.

b) United States: No significant relationship for any of the three dependent variables.

I3: More overlapping consortia membership interlocks predict higher values on all three dependent variables, with the relationship stronger in the United States than in Japan.

a) Japan: Positive and significant for information exchange. This is against our prediction that information structured through keiretsu processes would render variation in interlocks relatively unimportant.

b) United States: Number of interlocks is highly significant and in the expected (positive) direction for all three dependent variables.

I4: More national government involvement predicts fewer and less intense governance mechanisms.

a) Japan: No significant relationships with any of the three dependent variables for either the government-involvement or government-funding measures.

b) United States: No significant relationships with any of the three dependent variables for either the government-involvement or government-funding measures.

O1: More diversity of membership predicts higher levels on all three dependent variables.

Because of missing data for some U.S. consortia, we did not include our first indicator—employment size variation—in these models. Separate regressions (not shown) using this measure showed it to be insignificant for all dependent variables in both countries. We estimated the model including industrial and sectoral origin diversity.

a) Japan: The coefficients for the Herfindahl index (approaches maximum of 1.0 when there is no diversity) of member U.S. government standard industrial classifications (SIC's) are all negative, as predicted, but are statistically insignificant across the dependent variables. The coefficients for the index of members' sectoral origins are also all negative, as predicted, and those for information exchange and membership in governance mechanisms are significant.

b) United States: The coefficient for the Herfindahl index of member SIC concentration is negative, as predicted, for both governance outcomes, and it is significant for membership in governance mechanisms. The sector index coefficient is significant for all three outcomes. For the two governance measures, the relationship is negative, as predicted. For the information-exchange measure, concentrated sectoral origins raise information exchanges, which is the opposite of our prediction.

O2: Generalism predicts higher values on all three dependent variables.

a) Japan: As predicted, the relationship is positive for all outcomes, and the coefficients are significant for number of government mechanisms and for membership intensity.

TABLE I
OPERATIONALIZATION OF MEASURES

Information Exchange. Seven specific practices were measured: journals or articles; technical reports; newsletters; visitor programs; shareholder assignees; a shadow research project within member firms; and shareholder site demonstrations. These seven were reduced by factor analysis to a single index.

Governance. Two indicators of how consortia are governed: (1) an index for the number of governance measures, based on five possible structures -- board of directors; councils; task forces; panels; and user groups: (2) the *intensity* of the governance mechanisms, based on the extent to which members participate in the five governance mechanisms. Because this measure was highly skewed, we used the logarithm of the number involved as the dependent variable in our analyses.

Keiretsu concentration. For Japan only -- an index of membership concentration in *keiretsu,* using Herfindahl's index, which takes a maximum value of 1 if all organizations in a consortium are members of the same *keiretsu,* and has a lower bound of 1/N if all member firms belong to different *keiretsu.* Firms were coded into one of 10 categories: non-member, or a member of one of 9 national *Keiretsu,* using a reference book on Japanese *keiretsu* (*Keiretsu NoKenkyu*) which heavily emphasizes financial ties.

Membership stability. A membership stability measure was computed by dividing the number of members still in the consortium at the time of our survey by the total number of organizations that had ever been members of the consortium. In Japan, because of the manner in which consortia are founded and monitored by MITI and other government agencies, very few members ever drop out of a consortium. Of the 113 consortia founded before 1991, only four (3.5 percent) ever experienced a member dropping out. By contrast, of the 94 consortia founded before 1990 in the United States, 16 (17 percent) had experienced dropouts. Thus, only in the United States is there enough variation in this measure to permit its use in our models.

Consortium interlocks. We measured interlocks by counting all the other consortia to which a consortium was linked through a member belonging to each. Each interlock was counted only once, regardless of how many joint members two consortia shared in common Whereas the average across the U.S. consortia was about 15, the average for Japan was almost 41. Having many members with multiple memberships clearly increases a consortium's chances of being interlocked with others, but the two

b) United States: Generalist strategy is in the predicted (positive) direction and significant for all outcomes.

O3: Doing some research in joint facilities predicts higher values on all three dependent variables, and doing some research in member facilities predicts lower values on all three outcomes.

a) Japan: Using joint facilities generated the predicted positive coefficients, but none reached significance. Two of the three member facilities relationships are negative, but none is significant.

b) United States: All joint facilities coefficients are positive, as predicted, and all three are significant. Two of the three member facilities relationships are in the predicted negative direction, but only information exchange is significant.

B. Final Model

We cannot build identical summary equations for the two nations because there are two variables they do not share in common: keiretsu concentration and membership stability. We included in our final models in Table V only those independent variables that were significant at the 0.10 level for that dependent variable and country in the separate models. In this section, we highlight those variables that are significant in the final model.

TABLE I *(Continued)*
OPERATIONALIZATION OF MEASURES

measures are not equivalent. The correlation between the average number of multiple memberships held by a consortium's members and a consortium's number of interlocks is .63 in the United States and .44 in Japan.
Government Involvement. Two measures of government involvement in a consortium's activities: (1) consortium managers estimated, on a five-point scale, how much the federal (national) government was involved in their consortium, from very "in" -- coded 1 -- to very "out" -- coded 5; (2) managers estimated what proportion of their revenues came from government funding.
Organizational Diversity. Three measures: (1) a coefficient of variation for the employee size distribution for members of each consortium. We calculated the mean and standard deviation for the distribution of the number of persons employed by all members within a consortium, and then divided the standard deviation by the mean; (2) a Herfindahl index of concentration for the distribution of SIC values within each consortium. The index takes a maximum value of 1 if all the members have the same SIC; (3) a Herfindahl index for the distribution of sector origins for members within each consortium. The index takes a maximum value of 1 if all members are from the same sector. We classified members as originating from one of eight sectors: U.S. firm, overseas non-Japanese firm, association, consortium, university, federal government, state government, and Japanese company. Almost all Japanese consortium members were Japanese firms, in contrast to U.S. consortia, which drew more on foreign firms and non-business members. Thus, origin concentration is significantly higher in Japan than in the United States.
Joint and separate facilities. A dummy variable for each kind of arrangement -- joint facility (0= no, 1=yes) and member-based facility (0=no, 1=yes).
Specialism/generalism. We used the classification scheme developed by Barnett, Mischke and Ocasio (1993) to code U.S. consortia as following a specialist (=0) or generalist (=1) strategy at their founding, and applied their scheme to the Japanese consortia.
Control variables. The number of full-time members is the measure of consortium size, and age is measured in years since founding.

1) Japan: Keiretsu concentration is still highly significant and has a significant negative effect on information-exchange activities. The number of interlocks, which we expected to be overshadowed by keiretsu concentration, still has a positive and significant effect on information-exchange mechanisms. Sector concentration continues to have a negative and significant effect, and generalist strategy is positive and significant in the final model of participation in governance mechanisms.

2) United States: Interlocks are still positive and significant for all outcomes. Sector origin concentration is negative and significant for both governance outcomes, as we expected, but continues to be positive (against prediction) in its effect on information exchange. Generalist strategy is positive and significant for all outcomes. In explaining the number of information-exchange mechanisms, research in joint facilities is positive and research in member facilities is negative, and both are statistically significant.

3) Summary: Hypotheses I1 and I3 received some support. Concentration of membership in a few keiretsu has consistently strong and significant depressing effects on the number of information-exchange mechanisms and also effects governance membership intensity in the initial models. A

TABLE II
MEANS AND STANDARD DEVIATIONS OF VARIABLES

	U.S.		Japan		Total	
	Mean	SD	Mean	SD	Mean	SD
Number of information exchange practices	3.20	1.92	1.30	1.39	2.3**	1.89
Number of governance mechanisms	1.82	1.14	1.67	1.10	1.74	1.11
Number of members participating in governance, logged value	3.01	1.46	2.82	1.18	2.90	1.30
Herfindahl index of keiretsu memberships	N/A	N/A	0.16	0.11	N/A	N/A
Membership stability	0.93	0.13	0.99	0.02	0.97**	0.09
Average number of interlocks to other consortia	15.23	10.85	40.85	22.19	30.11**	22.22
Mean level of federal government involvement (1=in, 5=out)	3.6	1.4	1.9	1.0	2.6*	1.5
Average proportion of revenues from government	17.2	26.0	54.2	36.8	38.7**	37.4
Coefficience of variation in members' average number of employees	1.30	0.53	1.12	0.45	1.19	0.49
Herfindahl index of members' SICs	0.24	0.20	0.27	0.25	0.25	0.22
Herfindahl index of members' sector origins	0.80	0.21	0.95	0.09	0.89**	0.17
Joint facilities used (=1)	0.48	.51	0.17	0.38	0.30*	0.46
Members' facilities used (=1)	0.43	.50	0.89	0.32	0.70**	0.46
Generalist (=1)	0.64	0.48	0.57	0.50	0.60	0.50
Number of consortium members	2.62	32.0	17.4	12.2	21.1**	23.0
Age of consortium (years)	5.9	7.6	8.4	6.8	7.4	7.2

NA = not applicable
Significance level of differences: ** .01; * .05; + .10; NS = not significant at .10

TABLE III
INTERORGANIZATIONAL RELATIONS: EFFECTS ON CONSORTIA INFORMATION-EXCHANGE AND GOVERNANCE
REGRESSION ANALYSES: COEFFICIENTS ARE UNSTANDARDIZED REGRESSION COEFFICIENTS

	Information Exchange		Number of Govt. Mechanisms		Membership in Govt. Mechanisms	
Independent Variables	U.S.	Japan	U.S.	Japan	U.S.	Japan
Intercept	3.94	2.16	-1.12	1.94	-0.73	2.44
Herf. index keiretsu concentration	NA	-5.53*	NA	-1.81	NA	-2.35†
Membership stability	-1.72	NA	1.18	NA	1.24	NA
Number of interlocks	0.10**	0.01†	0.04**	-0.01	0.07**	0.00
Level of government involvement	-0.14	-0.17	0.06	0.07	0.13	0.07
Average % revenue from government	-0.01	0.01	0.01	0.00	0.01	0.00
Number of members	0.00	-0.04†	0.02**	0.02	0.02**	0.02
Age of consortium	0.03	0.02	0.07**	-0.02	0.06**	0.01
R^2	.36*	.18	.51*	.14	.54**	.17
N	(39)	(50)	(39)	(52)	(39)	(52)

NA = not applicable
**.01 *.05 †.10 one-tailed test

TABLE IV
ORGANIZATIONAL STRATEGY AND DIVERSITY: EFFECTS ON CONSORTIA INFORMATION-EXCHANGE AND GOVERANCE REGRESSION ANALYSES: COEFFICIENTS ARE UNSTANDARDIZED REGRESSION COEFFICIENTS

	Information Exchange		Number of Govt. Mechanisms		Membership in Govt. Mechanisms	
Independent Variables	U.S.	Japan	U.S.	Japan	U.S.	Japan
Intercept	-0.63	4.61*	1.66*	1.65	3.86**	5.33*
Herf. index of member's SICs	0.12	-0.31	-0.34	-0.03	-2.34*	-0.14
Herf. index of member's sector	2.95*	-3.08†	-1.35*	-0.76	-1.87*	-3.34†
Generalist strategy (=1)	1.37*	0.38	0.59*	0.44†	0.70*	0.63*
Joint facilities (=1)	1.08*	0.11	0.38†	0.41	0.53†	0.23
Member facilities (=1)	-1.05*	-0.81	0.07	0.26	-0.24	-0.30
Number of members	0.01†	0.00	0.01*	0.02	0.01*	0.03*
Age of consortium	0.02	0.00	0.06**	-0.02	0.04*	0.00
R^2	.38*	.11	.54**	.12	.58**	.25†
N	(39)	(47)	(39)	(49)	(39)	(49)

**.01 *.05 †.10 one-tailed test

TABLE V
SUMMARY EQUATION

	Information Exchange		Number of Govt. Mechanisms		Membership in Govt. Mechanisms	
Independent Variables	U.S.	Japan	U.S.	Japan	U.S.	Japan
Intercept	-1.18	1.60	1.28	1.53*	2.87*	4.86**
Herf. index of keiretsu concentration	--	-5.32**	--	--	--	-1.32
Interlocks	0.08**	0.02†	0.02†	--	0.04*	--
Herf. index of members' SIC	--	--	--	--	-1.06	--
Herf. index of members' sector	2.87**	0.45	-1.29*	--	-1.61*	-2.68†
Generalist strategy	0.88†	--	0.46†	0.35	0.55†	0.45†
Joint facilities	0.56†	--	0.22	--	0.32	--
Member facilities	-0.90†	--	0.08	--	-0.33	--
Number of members	0.00	-0.03†	0.01*	0.02†	0.01*	0.02†
Age of consortium	0.04	0.00	0.07**	-0.02	0.06*	0.01
R^2	.54**	.13	.58**	.09	.64**	.22*
(N)	(39)	(50)	(39)	(51)	(39)	(51)

**.01 *.05 †.10 one-tailed test

higher level of interlocks is consistently related to use of more information-exchange mechanisms and to higher levels of both governance measures in the United States. While interlocks have the effect of increasing information exchange in Japan, they do not affect governance mechanisms, contrary to our prediction. Hypothesis I2, regarding the effects of membership stability in the United States, is not supported by our analysis, nor is Hypothesis I4, predicting that government involvement would reduce the need for consortium-level governance mechanisms. In *neither* nation did we find that variation across consortia in their level of government involvement or support affected governance activities.

For Hypothesis O1, the predicted positive effect of membership industrial diversity on our outcome measures received some support in the initial, but not in the final, models. The sectoral diversity measure behaved largely as predicted in the initial models and was still a negative influence on the governance measures in the final models. However, across the models, sector concentration predicts (against our expectation) higher numbers of information-exchange activities

in the United States. A possible ad hoc explanation is that when members come from the same sector, it is easier to make use of preexisting sectoral information dissemination mechanisms. Nonetheless, this finding remains an anomaly for our theoretical perspective.

Hypothesis O2 is strongly supported for the United States across all models, as generalism is associated with higher numbers of information-exchange and governance mechanisms and with higher governance participation by members. For Japan, this hypothesis is supported for the governance measures in the initial model and for governance intensity in the final model. Administrative location of research had the effect predicted for Hypothesis O3 in the United States but not for Japan. In the United States, variations in research location are significant in explaining the number of information-exchange mechanisms.

In general, both our initial and our final models are much more powerful for the United States than for Japan, and more of our hypotheses are supported for the United States than for Japan.

V. Discussion

This study addressed a single research question: why is the organization of R&D consortia different in Japan and the United States, despite similar technological and competitive objectives? Our most striking finding is that the factors that are quite powerful in explaining variation in the United States are not at all powerful in explaining variation in Japan.

We theorize that the most general explanation for our findings is simply this: firms seeking to cooperate in the United States face an institutional environment in which they largely have to act alone in establishing workable structures and practices and generating a flow of resources, both financial and human. Few powerful institutions provide clear structural guidance or provide resources in exchange for following normative patterns. The U.S. environment for constructing R&D consortia is loosely structured on the institutional level and is very diverse on the organizational level. In our models, institutional-level factors, and some measures of organizational diversity, help to explain consortium-level outcomes in the United States. We hypothesize that this is because U.S. R&D consortia—as a group—engage in a great deal of experimentation, which results in variability, particularly in attempts to disseminate information, but also in such consortium features as membership stability and sector origin.

In Japan, more fundamental and powerful institutions, e.g., MITI and keiretsu, shape the institutional and resource environments. Japanese firms operate in a powerful preexisting institutional environment, which readily provides exemplars and even resources for forming cooperative R&D ventures. Okimoto [120] chastened those who would portray Japanese industrial policy as monolithic and homogeneously effective. Instead, he made a more subtle point, on which we draw in this study: the effectiveness of MITI, as well as Japanese industrial policy, depends upon many features of Japanese industrial organization, including: "subcontracting and subsidiary networks," "keiretsu groupings," and "inter-corporate stockholding." Okimoto [46] concluded that it

> is the dynamic combination of factors, interacting within the structure of an integrated system, that gives shape to the apparent effectiveness of Japanese industrial policy.

Firms trying to cooperate in Japan quickly learn how to behave, particularly how to disseminate information and how to gather resources. They therefore experiment less, resulting in far lower variability in some consortia characteristics, such as membership stability and sector origin, in Japan than in the United States.

Our theoretical perspective integrates contingency with institutional and organizational economics perspectives in the following way. The more that encompassing and fundamental institutions provide ready guidance and resources to embedded member firms seeking to cooperate, the less these firms need to experiment with different assortments of members and practices. This, in turn, reduces the diversity of firms that participate in R&D consortia, and therefore reduces the potential problems of coordination, communication breakdown, and opportunism. Moreover, the more that institutional actors are able to discipline consortium participants for violating expected behaviors, the less the consortia themselves need to be concerned with developing extensive rules and procedures for governance and information exchange.

We do not argue that long-term relationships and relational contracting never occur in the United States. Indeed, Carlton [13] found that the average length of purchasing relationships in U.S. industry ranged from 7 to 11 years, exemplified in Acheson's study of the Maine lobster market [1], which found evidence of relational exchange that affected pricing decisions. Another study of "soft" relational contracting in the United States found that scientists in U.S. biotechnology companies were much more likely to use social networks than arms-length, "hard" contracting to exchange scientific knowledge [34].

American industry contains many examples of sustained interorganizational economic linkages, as interfirm ties and complex webs of subcontractors characterize a diverse group of industries, from aircraft manufacturing [44] to publishing [51], construction [19], and motion pictures [52]. Furthermore, American institutions clearly exist that replicate some of the functions of Japanese business alliances, including institutional stockholding, interlocking directorates, lending consortia, and even multidivisional corporations. However, compared with historical patterns observed in the Japanese economy, less regular and predictable information exchange and social interaction occurs among the components of U.S. industry. Much of the interorganizational activity is also relatively recent in origin, and still reflects strongly cherished beliefs concerning the efficacy of solo entrepreneurial effort [10]. Indeed, heightened interest in cooperative behavior might not continue if U.S. companies regain a clear advantage over Japanese competitors. In Japan, the rich tapestry of interorganizational linkages appears to be somewhat independent of economic cycles.

The national government's role in R&D alliances differs substantially between the two nations. In the United States, government involvement rarely involves substantial financial assistance and is typically more consultative in nature. Even SEMATECH, one of the few U.S. consortia that was an ex-

ception to this pattern, saw its subsidies reduced in the 1990's. In Japan, as our data suggest, the situation is quite different, with government involvement considerably more visible and pervasive. MITI's influence is particularly significant. At one extreme, Lynn [38] and Callon [12] have argued that R&D consortia are really an elaborate system that serves the practical role of a conduit for government subsidies. Consortium directors are often "old boys" from MITI. Given that 87% of consortium managers report substantial government involvement, and two-thirds of the Japanese consortia received at least 50% of their funding from the government, it is reasonable to suspect that institutional penalties will be quite high for independent decision making about beginning or ending membership in specific R&D consortia. However, we found no evidence in our analysis that, within either nation, direct government involvement changed the way consortia were organized.

In Japan, where many interfirm alliances are rooted in pre–World War II ties, sanctions and penalties for opportunism are much more severe than in the United States. We do not rely upon an explanation of morally superior Japanese executives for this assertion. Rather, we contend, as has Gerlach [26], that short-term opportunism is reduced when business partners expect to continue their long-term relationships with others through an ongoing web of intricate business networks. As a practical matter, relatively few opportunities exist for independent trade in Japan. If you are the lead supplier to a key firm in a specific *keiretsu*, you may have an implicit obligation to join a relevant R&D consortium founded by that key firm. Your obligation will be heightened by pressures from MITI and other sponsoring agencies, who may be quite active, if not coercive, in stimulating and screening firms to join specific R&D consortia. It may be that the government plays a stronger role in encouraging horizontal collaboration, while keiretsu and other networks take the lead in encouraging vertical alliances [16]. When one is outside a network in Japan, one is truly outside. Consortium members do not drop out because, once ostracized, fewer opportunities for effective trade will materialize. Our results imply that private-sector ties are much more important in Japan than direct government involvement.

Much of what we say about consortia in Japan remains speculative. Our theoretical perspective predicts that degree of embeddedness in large-scale government and private institutions, along with variation in the role of institutional actors in apportioning resources and discipline, should explain variation both within and between the two countries. Why, then, was our model so powerful for the United States and so weak for Japan?

We suspect that other measures of the institutional environment in Japan might give us more powerful results. As one reviewer suggested, the very definition of keiretsu, unproblematic to many researchers, is empirically ambiguous, as keiretsu network patterns vary significantly, depending upon which criteria of membership one uses [8]. Perhaps other definitions and criteria would support a more powerful Japanese model. We also had no measure of the important nonkeiretsu business networks that exist, particularly among smaller organizations. The Japanese government's influence may arise from setting overall parameters for R&D consortia, rather than its financial subsidies, and the overall environment of rules and funding may be so taken for granted that the variations we measured do not particularly matter. Perhaps more subtle measures of differential government behavior would yield more powerful results.

We are very encouraged by our finding that keiretsu concentration is substantively important and statistically significant in both the initial and final models of information dissemination practices. R&D consortia are intentionally formed as a tool for developing technology and transferring it to member organizations, and therefore we believe that information dissemination, as a proxy for technology transfer, is of great practical value. Consortium governance mechanisms might be adopted largely in response to legitimacy demands [15], but we would expect consortium managers to hold more tightly to instrumental calculations in adopting information dissemination practices. In our data, technology-transfer practices are fairly independent of governance mechanisms, suggesting that choices involving the two are made somewhat independently.

VI. Limitations and Future Directions

We believe that this study represents the first time that differences in structures and processes of technological collaboration between the United States and Japan have been addressed with a truly comparative design. As far as possible, we have used similar samples, methods, and measures in the two countries.

An important limitation of our study is the restriction of our data to only two nations, whereas interesting changes in technological collaboration are also going on in many other countries [16]. Other limitations include our use of a cross-sectional approach and the omission of measurements of electronic information exchange and governance—fax, e-mail, and other on-line mechanisms—which have recently assumed great importance in both nations.

Promising areas for future research include the changing dynamics of keiretsu organization, more subtle explorations of variation in government involvement, and deeper investigation and development of measures of institutional embeddedness. In general, we need models that are more powerful in explaining variation in Japan, and we believe that such models will be built through improved conceptualization and measurement of the environmental factors that influence these cooperative organizations [2].

We strongly believe that the study of R&D consortia, as a complex form of interorganizational alliance, merits considerable attention from organizational scholars in its own right. As an organizational form, R&D consortia constitute a particularly interesting type of intermediate governance between "markets" and "hierarchy" while posing a fascinating set of tradeoffs for organizational scholars as well as managers [45]. On the one hand, this interorganizational entity constitutes a strategic vehicle for gaining access to financial, human, and technical resources, lowering development costs for individual firms under conditions of intense competition [14]. On the other hand, such arrangements are not cost free because the potential for opportunism may actually *increase* when competitors join together. Problematic areas associated with

joint R&D arrangements include the selection of problems to investigate, conflicts between scientific and career goals by executives, and equitable compensation practices for scientists [57, pp. 203–205].

Clearly, information asymmetry between exchange partners, protection of proprietary information, and the distribution of rewards, recognition, and profits can pose ruinous problems for collaborators [39], [59]. Recent evidence from Japan also suggests that if subsidies are not forthcoming, firms will be much less willing to cooperate in R&D consortia [12]. Thus, we believe that the study of R&D consortia constitutes an interesting application of comparative approaches to organizational governance.

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