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Does Culture Matter in Inter-Firm Cooperation? Research Consortia in Japan and the USA

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Collaborative research consortia allow firms to pursue scale and scope economies in research, finance large costly proposals, share risks, avoid unnecessary duplication, internalize the externalities created by research spillovers, and allow the use of firm-specific complementary skills and resources. In this study we examine the evolution of cooperative research organizations in the USA and Japan. We explore the factors which influence the emergence of alternative forms of cooperation. Specifically, we examine the role of culture and the institutional environment in molding the organization of cooperation between firms in R&D and the consequences of such cooperation. © 1997 by John Wiley & Sons, Ltd.

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INTRODUCTION

The nature of the process of technological innovation has changed significantly in the past three decades. Innovations have become more complex, often requiring the integration of advances in several technologies and the use of knowledge derived from multiple disciplines. Product and process life cycles of innovations have been shortened, considerably increasing the competitive pressures on firms to innovate. Shorter life cycles also mean increased risks of investment in innovation while reducing the time through which firms can capture rents accruing from innovation. Market failures characterizing R&D investments have therefore become more pronounced, leading governments and firms to seek new ways to organize and finance innovation processes. Research consortia provide new forms of organization which evolved internationally to cope with market failures associated with innovation. These forms of cooperation allow firms to pursue scale and scope economies in research, finance large costly proposals, share risks, avoid unnecessary duplication, internalize the externalities created by research spillovers and allow the use of firm-specific complementary skills and resources (Tripsas, Schrader and Sobrero, 1995).

The concept of research association emerged in the UK mainly to overcome underinvestment in R&D among small firms. Japan adopted and adapted the UK model, focusing on enhancing innovation among large firms. The Mining and Manufacturing Technology Association Law was enacted in 1961 to allow the Japanese Ministry of International Trade and Industry (MITI) to directly subsidize research associations (Japanese government-supported re-

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search consortia) for specific research projects jointly set up by private-sector firms. MITI took a strong central role in fostering consortia development. MITI viewed the research association as an important tool in its effort to create new profiles of comparative advantage for Japan through technological innovation. The VLSI project provides an example of the strategic use by MITI of a research association (Hayashi, Hirano and Katayama, 1989; Okimoto, Sugano and Weinstein, 1994; Yamamoto, 1994). The VLSI project was established in response to the dominance of IBM and the threat that was perceived from its dominance to the Japanese computer industry. The stimulus provided by the project has facilitated a rapid transformation in the competitive position of Japanese firms. While in 1972 Japan was not represented in the top ten dynamic random-access memory chip manufacturers, within a decade Japanese firms occupied six of the top ten spots.

Recognizing a threat in Japan's rise to dominance in semiconductor and other industries, the US Justice Department softened its insistence on strict antitrust laws and their enforcement towards research consortia. In 1984, the US introduced the National Cooperative Research Act (NCRA) to reduce the legal risk of consortia formation, and signal the US business community that it endorsed R&D consortia formation for increasing US competitiveness.

One unexpected outcome of NCRA was the evolution of some new forms of organizations as well as new patterns of strategies and actions among US firms. In this study we examine the evolution of cooperative research organizations in Japan and the US. We explore the factors which influence the emergence of alternative forms of cooperation. Specifically, we examine the role of culture and institutional environment in molding the organization of cooperation between firms in R&D and the consequences of such cooperation. Our analysis is informed by a conceptual model we have derived from cooperation theories.

A CONCEPTUAL MODEL OF COOPERATION

In a review of cooperation research, Smith, Carroll and Ashford (1995) identified five types of theories of cooperative behaviour. These included theories of exchange, social learning, power and conflict, attraction and structure. Exchange theories involve the calculation of economic and psychological benefits which will be gained by cooperation, net of transaction costs and risk premiums. The expected benefit of future interactions is also calculated.

We use the exchange framework as the backbone of our conceptual model. Social learning is incorporated into such a model as a process which reduces costs of search (i.e. increasing the identification of cooperation opportunities), risks and transaction costs. The exercise of power is expressed through its impact on barriers to cooperation (removing or imposing barriers), focusing attention on specific cooperation opportunities in the identification stage and through its indirect impact on cost and benefit structures. Conflict or threat of conflict are expressed through their consequences in terms of risks and costs. Attraction and structure influence the costs of search of cooperation opportunities as well as risks, transaction costs and the non-financial benefits of cooperation.

The starting point of our framework is the problem of definition stage (box 1 in Fig. 1). This is the stage where decision problems are articulated as a consequence of perceived threats or opportunities or as a result of an internal organizational evaluation process in which it is recognized that some organizational goals are not met satisfactorily. A search process starts where alternative options (solutions) are identified (box 2). Cooperation with other firms as a solution may be perceived if there are no high barriers to such cooperation, if goals are shared at least to a degree (e.g. if firms face a common threat) or if external forces such as a government or other firms encourage the firm to consider cooperation. Attention is more likely to focus on cooperative solutions if underlying societal values encourage cooperation or if the organization has as a part of its repertoire of actions and standard operating procedures cooperative strategies. Thus, for example, past experience with cooperation may lead to social learning and incorporation of cooperative strategies in the organizational standard programs of action. All feasible alternative solutions are evaluated.

The evaluation process considers the expected present value of the stream of benefits (box 3) and the expected present value of the stream of costs associated with the cooperation (including the transaction costs of reaching and implementing the cooperative arrangement (box 4)). Net expected benefits are adjusted to reflect risk premia (box 5) and the options associated with the highest adjusted expected net present value are chosen (box 6).

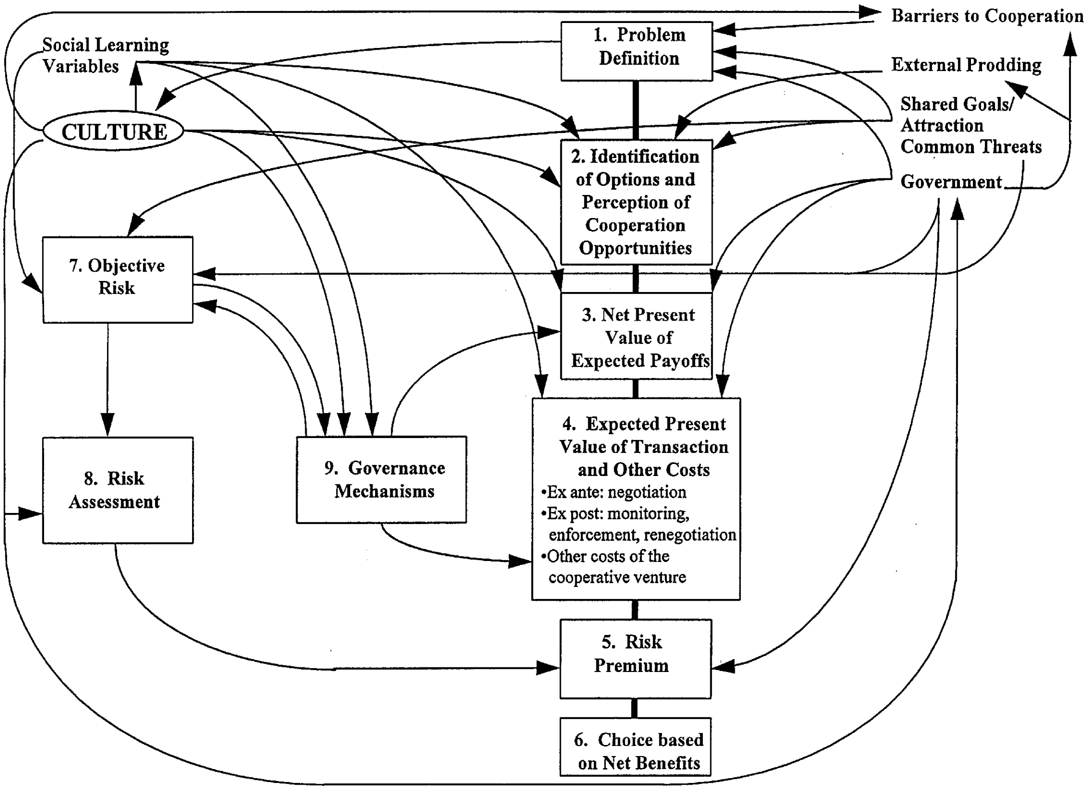

Figure 1. A conceptual model of cooperation.

The objective risks associated with each option (box 7) are assessed by the organization and evaluated (box 8) to determine the premium that the organization requires to compensate for the risks involved. The specific organizational form which is established to govern the cooperative venture (box 9) affects the share of benefits and costs of each member.

Focusing on cooperation, we assume that the following are some of the important variables that affect the different stages of the evaluation process and thus affect the chances of cooperation.

Governments play critical roles in imposing or removing barriers to cooperation between firms. Governments may provide incentives, use moral suasion, provide the means for social learning, shape the framework for cooperation and thus reduce or increase the transaction costs of cooperation and provide enforcement and insurance mechanisms to reduce risks associated with cooperation (Tripsas, Schrader and Sobrero, 1995).

Shared goals with other firms are more likely to draw attention to opportunities for joint actions, particularly when facilitated by common threats. *Attraction* may stem from similarities or complementarities between firms. It can also reflect the consequences of identification and status. The presence of a potential partner who is attractive may be considered an opportunity which may trigger a search of options to cooperate with that potential partner. Successful past experiences with cooperation are likely to result in learning and inclusion of cooperative strategies as part of the standard response programs of an organization and thus receive higher attention in the search process. When successful models of cooperative behaviour are visible, *social learning* may occur even without direct experience, reducing the transaction costs of cooperation, increasing the salience of cooperative solutions in the option identification process and reducing the risks of cooperation.

Culture affects value systems and attitudes toward cooperation and thus the predisposition of organizational members to cooperate. Culture also affects the acceptability of different modes of cooperation and the way cooperation is organized.

We use the four dimensions proposed by Hofstede (1980) for comparing national cultures in terms of their broad value differences: power distance, uncertainty avoidance, individualism–collectivism, and feminity–masculinity.[1] The first dimension, power distance, reflects the extent to which inequality (hierarchy) is seen as an irreducible fact of life. A higher power distance may facilitate disciplined cooperative arrangements between dominant and dominated firms but create difficulties in arrangement of equals unless the hierarchy is established by the presence of a dominant third party such as government.

Uncertainty avoidance is the lack of tolerance for ambiguity and the preference for formal rules. A strong uncertainty avoidance may stimulate formal well-regulated and highly focused partnerships with short time horizons. Individualism is associated with individual calculative behaviour and collectivism with placing a high value on meeting the objectives of a group even when specific behaviours may harm individuals within the group. Within a group, cooperative arrangements in highly individualistic societies are stable if they meet the objectives of all members. Members who find it more advantageous to leave the group (and, for example, join rival groups) will do so without the imposition of social sanctions or stigma. In collectivistic societies cooperative arrangements within a group are stable even when requiring sacrifices by individual members. The boundaries of the group are sharp and indeed there is tendency for factionalism. Thus cooperation across group boundary lines is more difficult in a collectivistic society than in an individualistic one (where coalitions are flexible to form and dissolve depending on individuals's incentives). The formation of group identity is a barrier that must be crossed in a collectivistic society, but once a group identity is established the arrangement is more stable and suffers from lower threats from opportunistic behaviour.

The masculinity/feminity dimension provides among other distinctions the difference between cultures which emphasize competition and achievement (masculinity in Hofstede's terms) and cooperation and nurturance. Masculine cultures will foster cooperative arrangements if such arrangements are conducive to higher achievements while feminine societies will encourage cooperation for its own sake.

Thus culture plays a multi-faceted role in shaping cooperation. Culture affects the attention paid to cooperative solutions and determines in part the social barriers to cooperation and the social sanctions imposed on non- cooperative behaviour. Culture by promoting or inhibiting opportunistic behaviour affects the risks associated with cooperation. Culture affects risk taking and thus influences the risk premia used in the evaluation of options. Perhaps most importantly, culture as we have outlined above affects the governance mechanism used in the cooperative arrangement, which in turn affects the risks and transaction costs of cooperation.

The governance mechanism is the way in which the parties organize their relationship with each other. Successful governance structures maximize outcomes, minimize transactions cost, and suppress opportunistic behaviour, thereby minimizing risk. Important attributes of governance design include: considering processes as well as structural dimensions (Zaheer and Venkatraman, 1995); and the function of structural versus social components in determining the level of trust between parties. Trust substantially influences the choice of inter-organizational governance structure (Madhok, 1995). Governance structures for inter-organizational relationships are classified into the categories according to the trust level underlying the structure: weak form trust, where the transaction allows minimal opportunities for opportunism, semi-strong form trust, where contractual and governance mechanisms limit opportunism, and strong form trust, where parties are heavily invested in principles, and opportunistic behaviour would violate these principles (Barney and Hansen, 1994).

Weak form trust is problematic in R&D cooperative arrangements, since opportunism is quite likely due to information asymmetries, uncertainty, and asset specificity (Tripsas, Schrader and Sobrero, 1995). Strong form trust may cause some difficulties in that all parties to the consortia must be invested in strong-form trust in order to reduce the risk of opportunism, and finding these trustworthy partners may be difficult. However, there are variations between the two that cannot be fully appreciated by the use of the single category of semi-strong form trust. Institutional trust (Zucker, 1986; Williamson, 1993) is derived from embedded social practices; and relational governance, in which exchange partners have 'significant relationship-specific assets combined with a high level of interorganizational trust' (Zaheer and Venkatraman, 1995).

In our analysis we will use the following classifications progressing from the least trusting to the most trusting governance structure: economic cooperation, structural cooperation, relational governance, and strong form trust. *Economic cooperation* exists where the costs of defecting are higher than the benefits. It can be created by agreement or coercion, and can feature interdependency, hostages, intense monitoring, and coercive enforcement. It is only effective as long as there is a credible threat which one party can use against another. In situations of asymmetric power, the weaker party is likely to have little say. Cooperation with coercion can be hollow: the weaker party goes through the motions, but does not fully commit to the cooperation. The weaker party is motivated to cheat as much it can without getting caught. With R&D consortia, cheating is easy due to information asymmetries: creative thoughts can be withheld and innovations can be hidden. The transaction costs of economic cooperation can be very high. *Ex-ante* costs involve making a highly specific enforceable agreement, and *ex-post* costs include monitoring, investments in coercive power and enforcement through the courts or informal means.

Early cooperation among competitors is likely to be of the economic variety until parties learn cooperative skills. Differences in social learning variables such as observation of models, practice, and social reinforcement of cooperative behaviour will affect the pace at which firms move from economic cooperation to governance structures which require more trust.

Structural cooperation prevails where everyone knows the rules of the game and follows them. Structural cooperation is similar to institutional trust, and relies on an established social system with a trusted, stable framework that minimizes uncertainty for all parties. Predictability is a key. Boundaries are tightly defined and standard operating procedures are followed within the boundaries. While this framework minimizes transaction costs by limiting the negotiation space and minimizing the need for intense monitoring and enforcement, it creates other problems. The use of standard operating procedures minimizes the ability to react to non-typical situations and limits adaptation to small incremental changes (Allison, 1971). The price of structural composition in R&D consortia is a constraint on the ability to make 'breakthrough innovations'.

Relational governance allows the parties to manage the relationship such that partners will not take advantage of each other. Variables such as trust of the partner, shared goals, attraction, long time horizons, and cooperative norms are important. Relational governance requires investments in initial and ongoing negotiations, but limits the necessity for monitoring and enforcement. Up-front investments are also required to establish trust between the parties; this may take both time and practice. Because the focus is on the relationship between the parties, and not on the contract, the contract need not be very specific, and boundaries need not be tight. While loose boundaries increase uncertainty, predictability comes from trust in the other party, and thus risk is minimized. Without a strict contract and tight boundaries, the collaboration can be more innovative and more flexible. Breakthrough innovations are more likely to take place than in either economic or structural cooperation.

Strong form trust exists where the parties have internalized the value of trustworthiness. Parties will not act opportunistically because it would be against their nature and principles to do so. (Barney and Hansen, 1994.) Investments in strong form trust are up-front and ongoing reputation investments. Strong norms and culture are likely to grow within organizations that invest in strong form trust, minimizing the need for monitoring and enforcement. As with relational governance, boundaries are not required to be tight, therefore uncertainty can be high. Risk is low, however, since the other parties are deeply trusted. Innovation is unconstrained.

The selection of a governance mechanism will depend on the nature of the risk, social learning variables (how aware of or practiced firms are in the various governance mechanisms), and culture. Returning to the conceptual framework shown in Fig. 1, we can see that governance structures have a reciprocal relationship with risk: although risk impacts the selection of the governance mechanism, the selected governance mechanism will in turn impact the degree of risk, and eventually, the risk premium assigned to the cooperation opportunity.

The governance structure can also impact the expected payoffs, depending on its effects on inputs of participants to the joint venture and the share of outputs they are expected to receive. A low trust environment will tend to limit expected payoffs from the collaboration unless mechanisms exist to enforce agreements. Economic cooperation, with the lowest possible trust, is best suited for cost-sharing tasks which occur far from the end user. For example, a number of competitors may get together to improve the safety or environmental performance of their products, especially when required by legislation. The costs are shared and no competitive advantage is created. However, if supported by a sophisticated effective legal and institutional framework economic cooperation provides a flexible form of governance that can accommodate a broad range of contingencies and opportunities to cooperate. Structural cooperation is best suited to incremental improvements, and higher trust governance structures are better suited for long-term high-uncertainty processes of innovation aiming at achieving breakthrough innovations.

Table 1 provides assessment of each governance structure in terms of its outcomes potential, transaction costs, risk management, degree of uncertainty, and the type of task for which it is most suitable.

MODEL PREDICTIONS

What does the model predict about the likely evolution of inter-firm R&D cooperative arrangements in Japan and the US?

The macro-institutional environment determines to a large degree whether cooperation between firms in any specific domain is legal and/or feasible. It also determines some of the transaction costs and risks involved in such cooperation. A strong antitrust legislation in the US historically prevented the evolution of inter-firm cooperation. Modification of the environment to permit cooperation in R&D has removed some of the risk involved and is likely to foster continued growth of cooperative ventures in the USA.

In Japan a tightening of anti-monopoly regulations is likely to favour existing established forms of cooperation and reduce the already low tendencies of Japanese to experiment with new forms of cooperation. Differences in the structure and role of government between the US and Japan suggest a higher degree of government intervention in Japan in all economic matters, including the initiation of research consortia.

General macro-institutional governance structures reflect to a degree a national culture. Our working hypothesis is that differences of national cultures between the US and Japan are an important factor in explaining differences in organizational forms, strategies, activities and outputs of cooperative inter-firm R&D activities between the two countries. Hofstede (1980) found the US culture to be a relatively small power distance, low uncertainty avoidance, individualistic culture relative to Japan whose scores indicated a high power distance, strong uncertainty avoidance collectivistic culture. Both cultures were highly masculine, but the Japanese culture was relatively more so than the US one.

These profiles lead to the following conjectures. The Japanese culture profile is compatible with highly structured focused cooperative arrangements (designed to reduce ambiguities and uncertainties). Cooperation between unequals will emerge within established business groups such as vertical *keiretsu* with a clear hierarchy. Cooperative arrangements between rivals of equal or similar status will arise only with the active participation of the government as the dominant partner. Cooperation in such cases will be established by appealing at least temporarily to the national identity of participants invoking a common threat or alluding to important national values. Given the collectivistic tendencies of the Japanese, cooperation with foreigners will be low. Outside such cooperative arrangements factionalism and rivalry are likely to prevail and cooperators may engage in other domains not covered by the arrangement, in fierce competition. Maintenance of discipline and suppression of opportunistic behaviour by the government within the cooperative arrangement will, however, accrue relatively low costs. A collectivistic

Table 1. Comparison of Governance Structures on Various Dimensions

Dimension/ governance structure	Economic cooperation	Structural cooperation	Relational governance (trust in a specific relationship)	Strong form trust (generalized trustworthiness)
Transaction costs (*ex ante*/*ex post*)	High/high	Moderate/moderate	High/moderate	High/low
Outcome potential	Low	Moderate	High	High
Risk management	Poor	Good	Good	Excellent
Uncertainty	High	Low	High	High
Task suitability	Cost cutting	Incremental improvement	Breakthrough innovation	Breakthrough innovation

tradition is likely to enhance learning and ensure efficiency of the operation once the cooperative arrangement is implemented and a group identity established. The most likely governance structure is therefore the one of structural cooperation.

The tendency in a culture with a strong uncertainty avoidance to search for options which reduce ambiguity and uncertainty is likely to lead to a relatively low level of experimentation with new forms of cooperation. Uncertainty avoidance is likely also to focus Japanese research consortia on incremental improvements of technologies. The focus on achievement influenced by a high masculinity culture is likely to result in demands by Japanese firms for a high level of outputs (for example, patents) from joint research consortia and dissolution of the cooperation once the output peaks.

The individualistic nature of US culture and the low uncertainty avoidance will favour economic cooperation. Low power distance allows a diversity of participants including partnership of equals without necessarily evolving the organization into an hierarchy of dominance. Government is likely to play a limited role in the formation of research cooperatives. The scope of objectives for cooperation is likely to be diverse and reflect shared economic interests. Sizes of groups are likely to be highly diverse (reflecting economic opportunities and risk-sharing concerns), memberships may vary over time and foreign membership may be welcome. Transaction costs and opportunistic behaviour are likely to be high. Successful partnerships, however, are likely to endure. Over time, inter-firm relationships may evolve and lead to ‘higher trust’ forms which reduce the transaction costs and risks of cooperation.

In the following sections we examine the models of cooperative R&D which evolved in Japan and the US. We then interpret the differences in tems of our conceptual model of inter-firm cooperative behaviour and the predictions derived from the model. We start with the institutional environment and the role of government in each country as the differences in the legal barriers to collusion between firms affect significantly the feasibility and risks of all forms of cooperation.

INTER-FIRM COOPERATIVE RESEARCH IN JAPAN

Joint research among competing firms has been a prevalent business practice for many years in Japan. Such joint research arrangements involve, for example, collaboration of private-sector firms or private-sector firms and government research laboratories. Other potential participants in such arrangements are universities and non-profit organizations. Many of the significant joint research projects involving firms and MITI take the form of research associations discussed above. These research associations are set up by some selected large firms and MITI to deal with specific research topics and are dissolved as soon as their initial objectives are met or are found to be unachievable. Member firms of research associations are eligible for direct government subsidies and various favorable tax treatments.

Institutional Framework for Joint Research Activities

The Japanese government played a central initiating and enabling role in research association formation through MITI.[2] By emphasizing foreign threats, MITI helped articulate common goals among Japanese firms. This focus on Japanese national competitiveness was reinforced by restrictions on foreign firms’ participation in joint research projects which involve the government sector.[3] There are also other types of arrangements by which the Japanese government provide support to R&D projects involving private-sector firms. Various types of research contracts involving government R&D agencies and firms may involve no explicit transfer of money except the participation in the project by relevant government researchers from properly equipped laboratories. Such contracts may also explicitly involve subsidies. Depending on their topics and types of arrangements, joint research arrangements outside of contracts may also be entitled to receive subsidies from the Japanese government. The forms of such subsidies include, among other forms, favorable tax and equipment depreciation treatments and direct financial subsidies to the research project.

Government policies consider, however, a variety of public interest issues. Some of the most important policies that affect inter-firm cooperation include those relating to anti-monopoly laws and the protection of intellectual property rights.

Issues Related to Anti-monopoly Laws The effects of joint research projects on competition are mixed. On the positive side, they allow the adoption of certain types of R&D activities (for instance, large-scale risky development projects) which individual firms are unwilling to undertake. Joint research may also speed up the completion time of socially worthwhile research projects even if some individual firms are willing to undertake them. These effects of joint research could potentially stimulate competition in the marketplace. For example, rapid development of new technologies may bring competitive pressure to a market which is dominated by entrenched existing firms. New firms may enter the market as a result.

On the negative side, some firms' participation in joint research projects may exclude other competing firms from benefiting from the outcome of successful projects, which in turn leads to lesser competitive behavior in markets. If participating firms are from different industries involving, for example, manufacturing and buying firms, and assembler and supplier firms, then anti-monopoly issues may arise regarding whether or not such joint research activities unduly constrain the business activities of the participating firms. Inter-industry joint research is not uncommon in Japan where horizontal inter-firm relationships exist.

The following practices are typically followed by the Japanese Fair Trade Commission (FTC). Joint research between a single firm and government research facilities and/or university facilities generally causes no anti-monopoly problems. In addition, until the late 1990s joint research projects involving government (including research associations and other government-subsidized joint R&D projects) were not thought to cause any anti-monopoly problems even though they involved multiple private firms. The stated reason for this was that the government in general supported basic research projects which were too difficult for individual firms to undertake due to their excessive risk and/or cost characteristics (Fair Trade Commission in Japan, 1990, p. 19). In its more recent guidelines (1993, p. 21), however, the Japanese FTC states that so long as multiple firms participate in them, joint research projects involving government, regardless of the type of support, are subject to anti-monopoly considerations. The 1993 (but not the 1990) Japanese guideline seems consistent with the US antitrust interpretations of joint R&D activities among private-sector firms. The earlier legal framework looked far more favourably on joint R&D than that of other countries such as the USA.

Issues Related to the Protection of Intellectual Property Rights Certain types of intellectual property rights issues arise in joint research settings. While participant firms can retain their ownership rights to their R&D findings from joint research, the Japanese FTC (1993) specifically notes that in case joint research findings provide the *de facto* industry standard to a particular line of business, potential anti- monopoly problems would arise if the joint research participants refused to license their jointly developed technologies to third parties (other competitors). Furthermore, the Japanese government can order licensing of technologies of national importance as well. Antitrust issues arising from the non-licensing actions of firms with dominant (industry standard) technologies are also well known in both the US and European Union.[4] Nevertheless, more emphasis is placed on the diffusion of new technologies in Japan than in the US or EU (Nakamura and Vertinsky, 1994, Ch. 4; Saxonhouse, 1983, p. 295).

MITI's National Research Institute Laboratories MITI operates a number of laboratories (see Appendix). These laboratories own a significant number of patents which they encourage firms to license (Table A2). In 1993 these patents were licensed to 594 firms (MITI, 1994, p. 559) for a total fee of 144 million yen (i.e. 270 000 yen per patent). These numbers are relatively stable every year. Over the 22-year period between 1972 and 1993, the total patent revenues for these laboratories were approximately 6.203 billion yen. These figures appear quite small even though no specifics regarding the licensed patents are available. This is, however, consistent with one of their missions: to disseminate scientific findings. In fact, all joint research contract agreements between the MITI Labs and private-sector firms (or other partners) contain a clause regarding the patents which have been obtained as a result of joint research that states that: (1) all patent co-holders (joint research partners) must agree before these patents can be licensed to third parties; and (2) *despite (1) above*, the Director of the National Industrial Research Institute can instruct jointly held patents to be licensed to third parties when the public interest is thought to be severely damaged should such licensing be denied (MITI, 1994, p. 558).

Issues Related to Firms in Vertical (Capital) *Keiretsu* One common form of joint research in Japan is joint product development involving a large assembler firm such as Toyota and its supplier firm(s). Since the supplier firm usually sells its products to and also becomes engaged in joint R&D

projects with more than one assembler firm, it is important for government policies to be specific about how the ownership rights of technologies jointly developed are handled. The FTC (1993) rules state that it is, in principle, illegal for an assembler firm to restrict sale to a third party (another assembler firm) of a supplier's product embodying the results of the assembler firm's joint research with the supplier firm, though it is legal for the joint research participants to ask third-party buyers to pay licensing fees for the technologies jointly developed by the supplier and participant assember firm.[5] The FTC also allows for exceptions, however, when the joint research results involve a know-how to be protected. In such exceptional cases it is legal for the assembler firm to restrict the sale of a supplier's new products jointly developed with the supplier and produced by the supplier firm to itself for some period. The length of such a period is set equal to the length of the period after which the commercial value of developed know-how becomes zero as a result of competitors' reverse engineering efforts or new availability of relevant raw materials or parts needed to reproduce the developed products.

Similar rules apply when it is the supplier firm which wants to protect its technologies that were developed jointly by itself and an assembler firm. In principle, the assembler firm is free to buy parts embodying the results of the joint research from third-party suppliers provided that the latter pay the licensing fees. However, where the joint research resulted in know-how to be protected, the assembler may procure only from the supplier with whom the technologies were developed for as long as the know-how retains its commercial value. Japan's clear directives regarding intellectual property have the effect of reducing transaction costs by minimizing the negotiation space for research associations.

Japanese Joint Research Experience

The Japanese Fair Trade Commission (1990) conducted a survey on joint R&D activities of Japanese firms listed in the first section of the Tokyo Stock Exchange in 1988. This survey reveals that many (65%) of the 790 firms which responded to the survey are engaged in joint research with other firms. This is a significant fraction of the firms which conduct R&D. In comparison, 79% of these firms conduct R&D on their own as well. The firms spend about 10% of their total R&D expenditure on joint research (667 million yen per firm on average). The number of joint research projects per firm is about 30. The most active sectors in terms of number of joint projects per firm are utilities (171), electrical machinery (49), chemicals (46), steel (37) and transporation machinery (37).

The proportions of research projects focused on basic research, applied research and new product development are: 16%, 27% and 58% for all industries; 19%, 29% and 52% for manufacturing industries; and 4%, 21% and 75% for non-manufacturing industries. The average number of patent applications based on joint research is 20 per firm, which constitute 7.4% of the firms' total numbers of patent applications.

Total R&D expenditures as well as the expenditures for joint research are rising and this pattern seems particularly prevalent for large firms (MITI, 1994). The number of joint projects increases with firm size for both manufacturing and non-manufacturing industries. No clear relationship is observed between firm size and type of research. The largest proportion of basic research projects is conducted by the second-largest firm size group for both manufacturing and non-manufacturing firms.

Joint research is more frequently focused on the margins of related product lines (45%) and new business line areas (24%) than on existing product lines (31%). Shares of firms' own research are 41%, 12% and 47%, respectively. The relatively larger use of joint research in new product line may reflect firms' desire to diversify the risk and financial burden associated with new product development. It may also reflect attempts by firms to prevent leakage of proprietary information and protect their own primary markets by limiting involvement of others in core areas of proprietary knowledge.

There is a substantial variation among industries in the average research expenditure per patent application between joint and non-joint R&D patent applications. However, excluding an outlier (General Machinery), there seems to be no reason to think that joint research is more costly than individual research, on average, to produce patent applications. Table 2 shows firms' expenditures, patent applications, and average expenditure per patent application for both joint and non-joint R&D.

Table 3 shows the distribution of organizational forms for firms' joint research for manufacturing and non-manufacturing firms. Most firms conduct joint research with other private firms, universities, and public research institutes. They also do contract research for government. Relatively few joint projects

Table 2. Expenditures for Joint Research and Patent Applications

Industry	Non-joint *R* exp. per firm (million yen)	Non-joint *R* pat. applic. per firm	Non-joint *R* exp. per pat. applic. (m. y.)	Joint *R* exp. per firm (million yen)	Joint *R* pat. applic. per firm	Joint *R* : exp. per pat. applic. (million yen)
Mfg	3738	205	18	330	14	24
Food	1936	42	46	627	9	70
Sd., fds, tabaco	604	22	27	50	5	10
Textiles	2802	345	8	445	43	10
Apparels	—	—	—	—	—	—
Lumber, wood	170	35	5	10	5	2
Furniture	390	45	9	10	5	2
Pulp, paper	1306	85	15	31	9	3
Printing	—	—	—	—	—	—
Chemicals	7569	132	57	338	15	23
Oil, coal	1330	12	111	300	4	75
Plastic	649	33	20	46	1	46
Rubber	2359	113	21	278	15	19
Pottery	1714	64	27	164	8	21
Steel	932	72	13	97	15	6
Nonferrous m.	4808	617	8	365	86	4
Metals	457	53	9	40	6	7
Machinery	2577	256	10	950	8	119
Elec. mach.	5066	420	12	193	10	19
Transp. mach.	5101	340	15	218	15	15
Precision	6625	533	12	182	21	9
Other	4057	339	12	306	30	10
Non-mfg	3790	66	57	1042	8	130
Fishery	874	16	55	57	8	7
Mining	453	4.7	96	47	0.3	—
Construction	1982	50	40	701	6	117
Utilities	6114	19	322	9455	73	129
Trsp., commun.	49 306	716	69	1006	10	101
Whls., ret., rest.	327	40	8	135	3	45
Finance, ins.	132	0.1	—	539	0	—
Real estate	274	0	—	20	0	—
Service	946	3	315	59	1	59

Source: Compiled from MITI (1990).
Note: Non-joint and joint R&D expenditures per firm and per patent application are in million yen.

Table 3. Organizational Forms of Firms' Joint Research in Japan

Partner	Manufacturing (%)	Non-manufacturing (%)
Universities	22.8%	10%
Foundations	1.2	3.0
Gov. institutes	3.2	6.0
Gov. contracts	3.2	3.0
Other firms	67.3	75.0
Joint ventures	1.8	3.0
All	100	100
Firms from:		
Same industries	19.6	17.7
Same and different industries	18.8	23.9
Different industries	61.7	58.4
All	100	100

Source: Compiled from MITI (1994).

are set up as joint ventures in part because of the limited scope and short-term nature of joint research topics.

Firms participate in joint research with government for somewhat different reasons than they do with other firms. The most common reasons for joint research with both are strengthening firms' own research capabilities, expanding technology levels for lines of products in the margins of the current product mix and entry into new business lines. The additional reasons which are relevant for joint research with other private-sector firms are shortening R&D time to completion, request for joint research from other firms, and expansion of the market and distribution channels. Cooperation with government institutions is motivated by the opportunity to obtain basic and state-of-the-art technologies, and establish common standards for technologies.

Table 4 shows the specific objectives of government and private-sector based joint research projects. While product improvement, new product development and development of manufacturing methods are important objectives in both private-firm- and government-based joint research, the first two are particularly important for private-firm-based joint projects while the third is particularly important in joint projects involving government. Developing new uses of materials is important for both private sector and government projects, while the search for new materials is only important in government-based joint research. The government role is greater where the potential for market failure is greater, thus government-based joint research is focused on earlier stages in the innovation cycle, providing enabling innovations instead of innovations which are profit-generating in their own right.

Whether government- or private sector-based, manufacturing or non-manufacturing, the lion's share of joint research activity is devoted to new product development, which is in the midrange of the innovation cycle (Felker, 1984). The categories of 'new use of material' and 'product process development/methods improvement' would also fall into this midrange, which involves the translation of new ideas into products and processes, as opposed to the generation of new ideas themselves. These can be deemed 'incremental improvement' as opposed to 'breakthrough innovation'.

The most common problems encountered in joint research projects include defining research areas and roles (56.9%, 34.3% for private sector-based manufacturing consortia and public sector-based manufacturing consortia respectively), determining ownership of joint research results (35.4%, 43.8%), practice of joint research results (29.4%, 19.8%), and the sharing of costs and facilities (14.2%, 19.1%). The presence of government as a participant in joint research appears to have impacts on the types of problems encountered but this may be at least in part due to the types of research topics and objectives which define the joint projects involving government. The fact that the largest problems faced by consortia are defining research areas/roles and ownership of joint research results indicates that even in a highly evolved, stable form of cooperation, these issues are still problematic.

The lengths of more than 60% of joint research projects are between 1 and 3 years. The outputs of joint research belong largely to all participants but the usage rates by participants of joint research findings differ depending on whether or not the projects involved firms from different industries. The usage rates are highest when only firms from the same industries are involved in joint research projects. This may be explained by firms' attempts to protect themselves by gaining at least as much from the project as competitors, or it could indicate that vertical *keiretsu*-based joint projects such as auto assembler-supplier consortia produce more immediately usable

Table 4. Objectives of Joint Research Projects

	Search for new material	New use of material	Product improvement	New product develop.	Management of prod.	Management of info.	Prod. methods improv.	Prod. methods develop.	Prod. process improv.	Prod. process develop.	Other
Private-sector based											
Manfg	6.0	26.7	40.9	87.0	0.5	1.6	5.7	19.9	1.6	3.5	0.5
Non-manfg	1.8	13.4	33.9	73.2	1.8	8.0	9.8	26.8	8.0	11.6	3.6
Existing lines of bus.	6.1	18.9	43.9	83.1	1.4	2.7	8.8	16.2	4.7	7.4	0.7
Extension of exist. bus.	5.1	22.3	41.4	81.9	0.5	3.7	6.5	22.8	3.3	4.7	1.9
New lines of bus.	3.5	31.9	29.2	88.5	0.9	2.7	4.4	25.7	0.9	4.4	0.9
Government based											
Manfg	35.2	36.4	16.2	47.4	0.6	4.3	4.3	34.9	2.1	4.6	4.3
Non-manfg	14.5	22.9	18.1	48.2	1.2	3.6	13.3	34.9	9.6	13.3	7.2
Existing lines of bus.	25.6	26.4	20.7	52.9	0.8	3.3	6.6	32.2	5.0	8.3	7.4
Extension of exist. bus.	30.1	35.2	17.6	43.2	1.1	5.1	6.8	34.7	4.5	7.4	5.1
New lines of bus.	37.5	38.4	10.7	49.1	0	3.6	4.5	38.4	0.9	2.7	1.8

Source: compiled from MITI (1994).
Note: numbers are in percent; up to two answers per question were allowed.

results. The latter explanation is not inconsistent with Kotabe and Swan's (1995) finding that inter-industry cooperation produces more innovative results than intra-industry cooperation in their sample of US, Japanese and European collaborations. A higher degree of innovation often restricts the ability of firms to immediately utilize their inventions.

Interpreting Japanese Government Involvement in Research Associations

Consistent with the predictions of our conceptual model the role of government in Japan in initiating and establishing research associations as a tool for cooperative R&D is critical. Competition and intellectual property protection laws were set and implemented to facilitate inter-firm cooperation. Furthermore, government has played an important role in providing the normative basis for cooperation by invoking the nation as a threatened collective, overriding the collectivistic inclination for groupism or factionalization. Once in a legitimate group, members refer to collectivistic traditions and values and maintain the discipline of cooperation without constant threats of opportunism. However, tendencies of groupism can resurge if the legitimacy of the cooperative joint venture is challenged. For example, Japanese firms often do not send their best scientists to work in collaboration at government research labs as they use consortia as a competitive tactic instead of a cooperative tactic (Porter, 1990). They conserve their best talent in house, and obtain competitive information from consortia involvement.[6] Relations among members in Japanese government-based research associations remain at arm's length and researchers from competing companies rarely work together on the same technical problem. This is likely the reason why there are few joint laboratories (Gover and Gwyn, 1994). MITI seems to provide the glue that holds research associations together. A proactive application of government authority is facilitated by a 'high' power distance collectivistic culture. On the other hand, private sector cooperative ventures typically involve members of business groups with established group identities and linkages.

Government involvement was not limited only to the option-identification stage. It modified the payoff function by providing direct incentives (for example, subsidies), by reducing transaction costs, and, more importantly, by reducing risks. The stable, legal and organizational framework which has emerged from MITI's initiation and involvement reduced transactions costs and uncertainty for partners. The form of cooperation molded by MITI is familiar, homogeneous and well known, thus negotiation can be limited. The distribution of intellectual property rights is relatively defined, again limiting negotiation space. The consequences of (or sanctions on) opportunism are known and apt to be significant, especially when the same firms are likely to be involved in repeated collaborations. MITI's involvement in multiple projects is also a deterrent to opportunism, since MITI can act as a conduit of reputation information and minimize a firm's options to participate in future research associations (Tripsas, Schrader and Sobrero, 1995). MITI's presence also minimizes the risk of prosecution under anti-monopoly laws.

Japanese research associations are also stabilized by their tight boundaries defined by specific research topics with most dissolving within 1–3 years of formation. These tight boundaries, initially established by MITI, have the effect of reducing negotiation space as well as limiting the risk of research spillovers.

The tight boundaries, minimization of uncertainty, reduced transaction costs, homogeneity of form, and stable social framework in operation in Japan define a governance structure for most Japanese research associations as being one of structural cooperation. Referring to Table 1, we see that the type of activity predicted by this structure is incremental improvement as opposed to breakthrough innovation. Indeed, the objectives of Japanese research associations are focused on incremental improvement activities (see Table 4). These observations do not apply, however, to research consortia involving only private-sector firms.

ADOPTION OF R&D CONSORTIA FORM IN THE USA: COMPARISON WITH THE JAPANESE EXPERIENCE

In view of the Japanese success in joint research, the US government revised its policies to allow consortia development. Collaborative research is a much more recent, but a rapidly growing, phenomenon in the US. In this section we compare US research consortia with their counterparts in Japan and interpret these differences in terms of our model.

US Institutional Frameworks for Joint Research Activities

While many of the important Japanese consortia have been initiated by MITI, US consortia were largely initiated by the private sector. Where MITI took the central role in planning and aggressively facilitating collaborative R&D in Japan, the US government, from the early 1980s to the early 1990s, generally did not intervene, other than to register consortia for legal reasons and monitor them for potential antitrust violations.

In 1992, however, the American Technology Preeminence Act was passed, initiating a more proactive role for government in consortia development and funding. The Act aims to affect prices through subsidies and provide information rather than take a major role in management of the joint enterprises. The National Institute of Standards and Technology's (NIST) Advanced Technology Program (ATP)[7] was substantially changed as follows:

(1) ATP could no longer provide direct funding to independent research organizations.
(2) Joint research and development ventures within the ATP had to be industry-led.
(3) Foreign participation in projects which involved ATP funding was prohibited.
(4) Patents developed within ATP projects became the property of the for-profit businesses involved. There was no further requirement for royalty-sharing with the federal government. Universities and other organizations which do not fit the legal definition of 'US company' are excluded from sharing in intellectual property rights from patents.
(5) The selection criteria and selection process for ATP funding were simplified and clarified.[8]

While these changes seem to limit the role of ATP, in fact a significantly greater role for ATP emerged. The percentage of new consortia reporting government funding averaged less than 1% prior to 1993, but rose to a high of nearly 25% in 1995.[9] The increase in funding is directly attributable to increased ATP involvement. Both the Defense Advanced Research Projects Agency[10] (DARPA), and the ATP[11] provide funding up to a maximum of 50% of costs to some consortia. ATP provides funding up to the laboratory prototype/technical feasibility stage, and does not involve itself in any aspect of commercialization.

Although the USA restricts foreign participation in government-funded research ventures, as does Japan,[12] the fact that few ventures have been funded by the government prior to 1993 has meant that foreign participation has been minimally restricted. One major consortium, SEMATECH, refused $90 million in federal government funding in 1994, while announcing that same year that they would consider adding Japanese members (Anonymous, 1995).

Antitrust Considerations Prior to 1984, US antitrust legislation severely constrained any type of cooperative arrangement between competitors. In 1984 the US enacted the National Cooperative Research Act (NCRA) which defines legally the types of allowable research joint ventures. This act was revised and became the National Cooperative Research and Production Act (NCRPA) of 1993, which deals with joint research as well as joint production ventures. The US government's involvement in R&D consortia, however, still seems limited compared to the Japanese counterpart.

Firms registered under the NCRPA of 1993 (or the NCRA of 1984) are exempt from the standard penalty of treble damages (but not from actual costs) in the case of antitrust prosecutions. Prosecution of registered consortia has been limited to a single case, however.[13] The NCRA was established with specific reference to the need for cooperative arrangements among firms conducting research and development in order 'to promote innovation, facilitate trade and strengthen the competitiveness of the United States in world markets.[14] The Act prohibits parties to consortia from sharing cost or price information, splitting up markets, or restricting sales/purchases in any way unless it involves innovations developed within the consortium. Where the Act is vague, interpretation is left to the courts.

Intellectual Property Rights In contrast to the fairly defined set of intellectual property rights which exists in Japan, no such regulations are in place in the US. The government takes a non-interventionistic approach, providing antitrust policies are not contravened. It is up to each research consortium to develop its own terms of reference and intellectual property rights arrangements. Attempts to define property rights can consume considerable managerial resources and add to transaction costs.

As noted earlier, the Japanese government can order licensing of technologies which it considers of national importance. The US does not have this standard of 'national importance'; however, stiffer antitrust legislation in the US could potentially result in similar technology diffusion.

US Joint Research Experience

There are currently about 670 research consortia[15] registered with the US Department of Justice. Of these, 326 have been registered since 1993, with the remaining being registered between 1984 and 1993. Although the NCRPA Act of 1993 expanded possible joint ventures to include production ventures, only about 40 of the 670 registered consortia are registered as production ventures. Well-known consortia include Microelectronics Computer Technology Corporation (MCC) and SEMATECH (semiconductor manufacturing technology). In the USA there is considerable diversity in the size, purpose, nature of participation, objectives and funding of research consortia.

US consortia data were generated by reviewing Federal Register filings since the inception of the NCRA. Six hundred and thirty non-duplicated original filings were analyzed to determine membership characteristics and sectors involved. Next, a stratified random sample was drawn of 10 consortia per year for the 12 years from 1985 to 1996, which were then grouped into three shorter periods, 1985–8, 1989–92, and 1993–6. This sample was used to analyze organizational forms, and the purposes and objectives of consortia.

Consortia Participants US consortia participants are composed of firms of all sizes. Membership consists of primarily private firms (78%), though some universities (11%) and government organizations (11%) are also involved. Figure 2 shows the percentage of consortia each year which include university, government and foreign members. Membership size ranges from two members up to 389, with a mean of 8.4 and a standard deviation of 12.9.[16] Approximately 27% of US consortia from the period 1985–96 included foreign members. Since the American Technological Pre-eminence Act introduction in 1992, the percentage of new consortia with foreign participants has dropped off, though it increased again in 1996.

Sectors Involving Consortia The sectors which have been most active in consortia formation include telecommunications, computers, petroleum, automotive and chemicals. Bellcore, itself a telecommunications consortia of 12 members, has engaged in 99

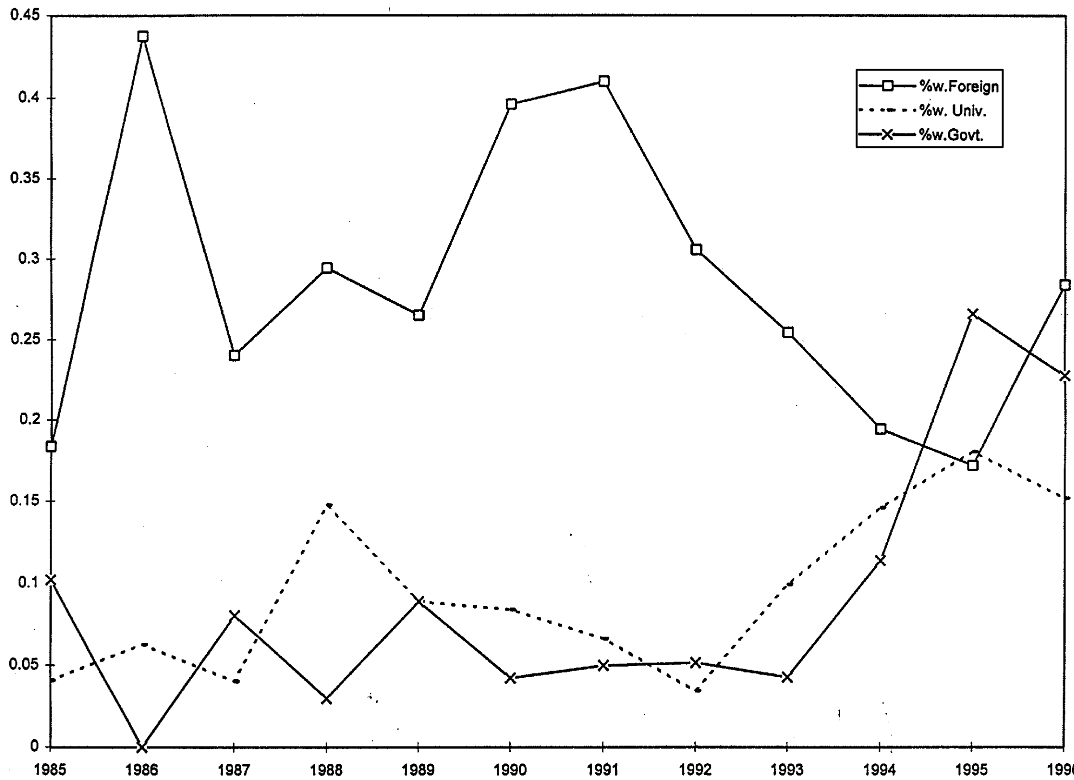

Figure 2. US consortia: proportions by membership composition 1985–96.

consortia registered under the NCRPA. Most of these include Bellcore itself and one other member. These ventures usually involve basic research and the integration of two or more technologies. The Petroleum Environmental Research Forum registered 59 consortia from 1985 to 1996. These were projects funded by a number of oil companies which sought to improve products or processes with respect to their environmental impacts. Many of these have a fixed duration. South West Research Institute registered 37 consortia during this time period. Many of these are automotive firm/fuel company ventures designed to improve technology wiith respect to the environment. Together, these three organizations accounted for 31% of all consortia formed.

Reasons for Joint Research[17] There has been some evolution in purposes of consortia within the three time periods we have studied (see Fig. 3). Specifically, later periods show a greater diversity of purposes than those initiated in the early years. The categories of 'safety/environmental improvement', 'comply with legislation', and 'cost reduction/scale benefits' have decreased in importance over time. These categories typically focus on research which is cost cutting but does not typically yield competitive advantages for individual firms. For example, the Petroleum Environmental Research Form Project 86-01, registered in 1987, was a consortium of nine oil companies focused on comparing and ranking existing technology for the microbiological degradation of petroleum oil sludges.[18] These types of projects can be governed by economic cooperation. The economic payoffs for the parties justify involvement, and trust of the other parties need not be strong since the effort is not concentrated on a key business area, thus the risk of leakage of proprietary information is low.

Later periods have featured more consortia formed in 'closer to the market' areas for the businesses involved, which requires more trust of the other parties. These include matching of complementary resources, standardization (which requires sharing of proprietary code and architecture, in the case of computer firms), and horizontal diversification.

US consortia often have multiple objectives,[19] and the dispersion of objectives has increased over time

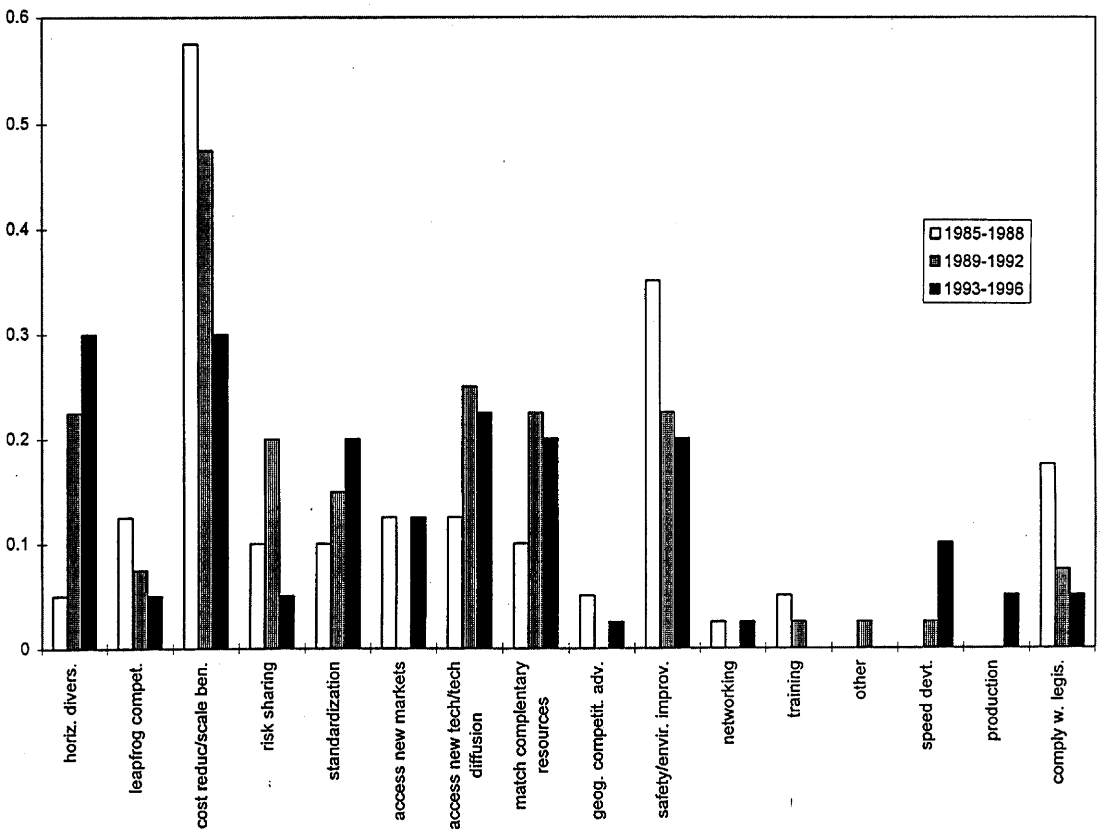

Figure 3. US consortia: proportions by purpose and period.

(see Fig. 4). US data were classified using the categories from the Japanese FTC survey, but these categories had to be expanded to account for the wider variety of activities undertaken by US consortia. The following categories were added: basic research, integration of technology, testing, prototype development, production, and marketing/licensing. Figure 5 shows the distribution of objectives of US consortia as compared to those listed by the Japanese consortia in the FTC sample. Since basic research and technology integration are only measured for US consortia, precise comparison is not possible. Nevertheless it appears that US consortia, which are mostly private- sector driven, undertake a larger variety of activities and concentrate more activities at earlier stages of the innovation cycle than both private-sector- and government-sector-initiated consortia in Japan, which tend to focus on the middle range of the innovation cycle. (This is consistent with Aldrich and Sasaki's, 1995, finding.) It is, however, apparent that Japanese government-initiated consortia more than their private-sector- initiated consortia emphasize material research (search for new material and new use of material) and development of production methods, and de-emphasize new product development and product improvement.

Distribution of Organizational Forms Organizational forms for both the US and Japanese R&D consortia are shown in Fig. 6. (Japanese figures are from Table 3). The much higher incidence of joint ventures in the USA than in Japan reflects the fact that most US consortia are ongoing versus Japanese research consortia which have specific termination dates. Only 2.9% of US consortia specify a duration; the mean specified is 17.9 months. The incidence of government involvement is higher for Japan than for the US. Nevertheless, the total number of cases involving government is quite small for both Japan and the US compared to the total number of all research consortia including those based in the private sector.

Other Differences between US and Japanese Consortia The communication between the consortia and the participating partner firms is much more intense and systemic for Japanese than for US

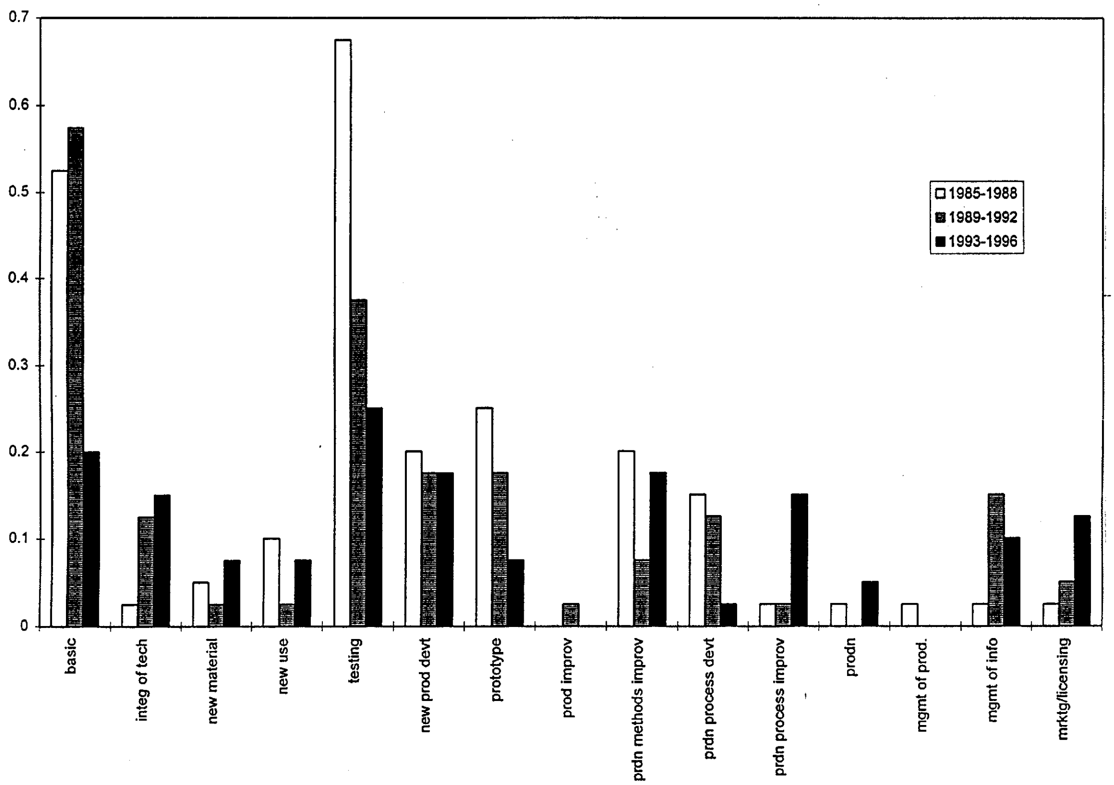

Figure 4. US consortia: proportions by objective and period.

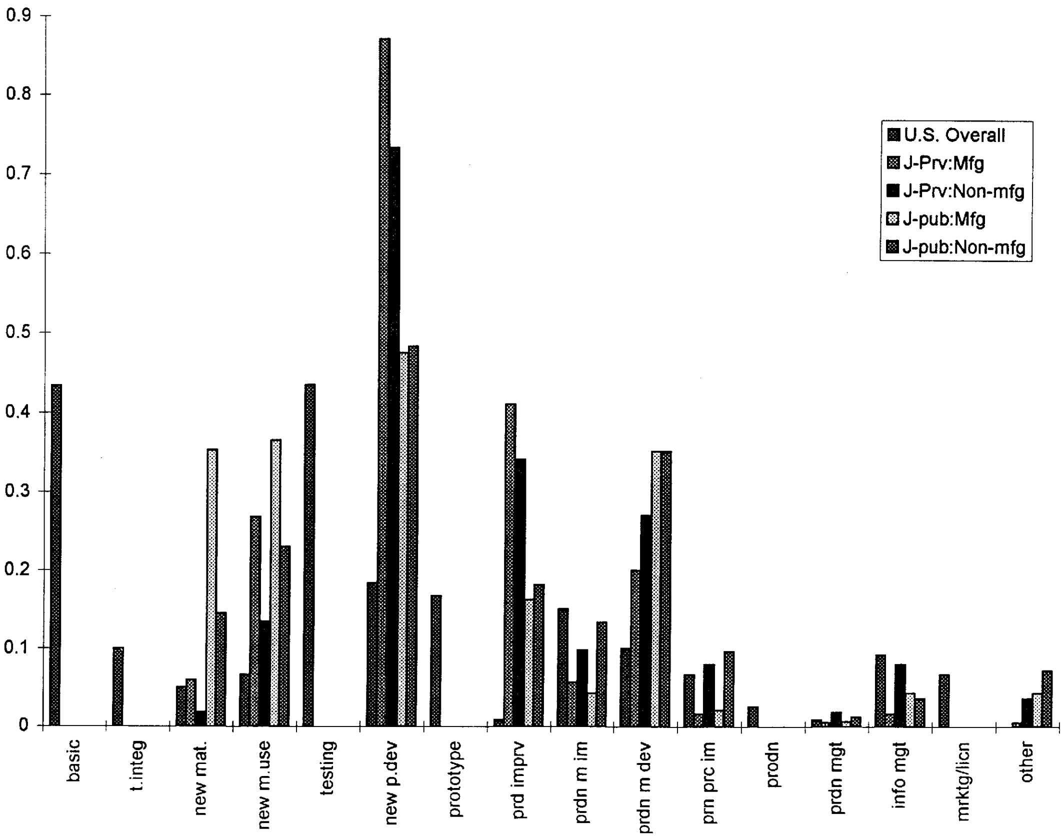

Figure 5. US and Japanese consortia: proportions by objective and type.

consortia. This may be in part because of the relative lack of career mobility for R&D personnel of Japanese firms. Such a lack of mobility implies that Japanese firms have few R&D personnel who are familiar with the research activities of competitors. Joint research projects with competitors and government agencies are likely to bring valuable information on other firms' R&D and management practices. It also means that firms could lose some information about their R&D practices to other competitors through joint projects. This is one reason why Japanese research associations have resisted creating joint facilities.

Researchers of Japanese consortia are typically on loan from their participating firms or government agencies, while in the US most are not. MCC, for example, has 400 researchers, only 36 of whom are on loan from participating firms. In Japan research is generally conducted at member firms (89%), while in the USA consortia are more likely to use multiple combinations of locations for research, and perform less at member firms (44%) and more at joint facilities (49%), universities (54%), and independent labs (33%) (Aldrich and Sasaki, 1995, p. 308).

It should also be noted that MCC, like most other US consortia, determines its own research and management strategies to a large extent and drops certain projects if they do not meet the MCC timetable requirements.[20] Another difference between US and Japanese consortia is that the US has more of both large and small consortia. US membership sizes are more heterogeneous.

Table 5 lists differences between Japanese and US consortia, compiled from Aldrich Sasaki's data, as well as the data developed in this study.

Interpreting the Differences in Inter-Firm Cooperation in R&D between Japan and the US

Differences in macro institutional arrangements and, in particular, the role of government affect the evolution of cooperative arrangements between firms.

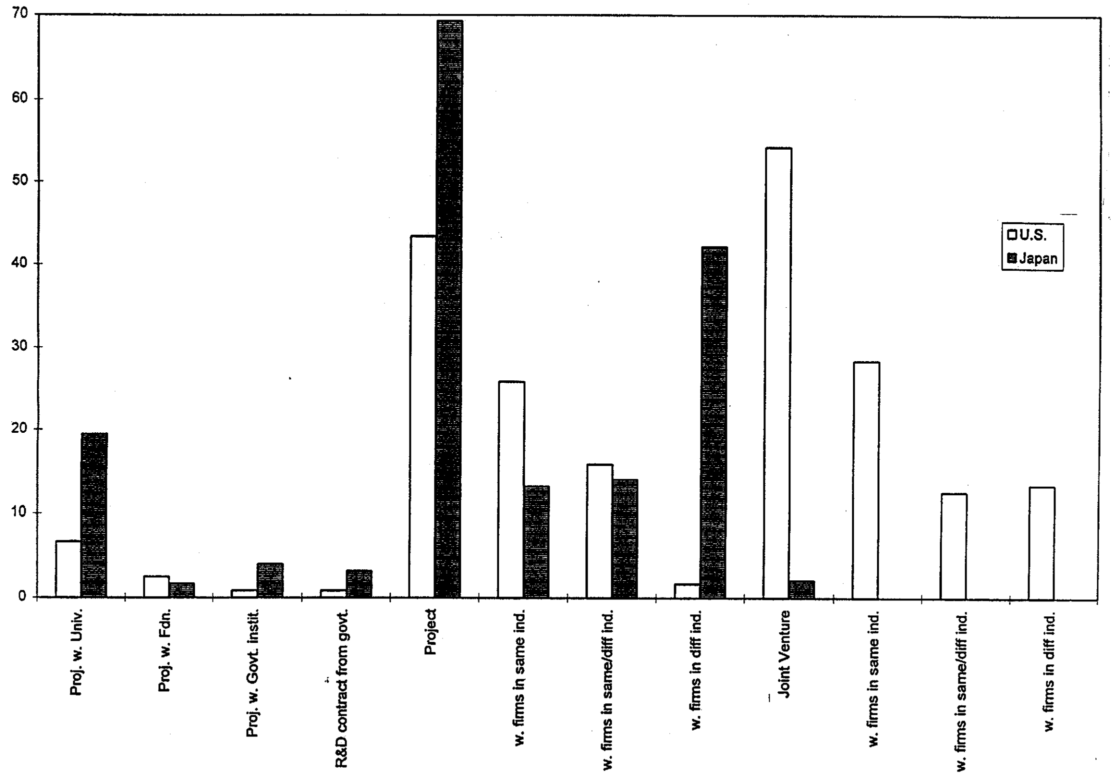

Figure 6. US and Japanese consortia: organizational forms (%).

When legal barriers to inter-firm cooperation in the US were removed or at least lowered, cooperative arrangements started to evolve. Globalization of markets and pressures to ensure level playing fields for domestic firms are leading to some degree of convergence in institutional environments.

For example, the Japanese government has expanded the range of activities which are subject to anticompetition regulations in recent years (see FTC, 1994), though no consortium has been prosecuted. The US government has increased its support for consortia formation in three ways: (1) by softening its antitrust stance through gradually allowing more consortia activity, first through the passage of the NCRA, then even more liberally through NCRPA, (2) by supporting it more through the increasing involvement of NIST/ATP, and (3) by centralizing/harmonizing government technological information and assistance at the National Technical Information Service, and through NIST. Though consortia in the US have not typically been subject to antitrust prosecution, the sole case of the Open Software Forum (see note 13) may have significant implications in the future if it is perceived by business as increasing the risk of cooperation in R&D.

Other evidence of convergence is found also with respect to foreign participation in consortia, and intellectual property rights arising from consortia; the US has changed its policies such that they are more in line with MITI's policies (American Technology Preeminence Act, 1992).[21] The expansion of ATP's funding role is more consistent with MITI, though in the USA, consortia initiation must still come from the private sector.

Governments can facilitate cooperative research by (1) limiting the risk of anti-competitive prosecution, (2) providing monetary incentives for consortia, and (3) reducing transactions costs by limiting the negotiation space of parties. A government can also act as a conduit of reputation information and promote learning about consortia formation and administration. (Tripsas, Schrader and Sobrero, 1995.)

Our analysis shows, however, significant differences in the role of governments in Japan and the US. In Japan the direct involvement of the government as a senior partner that exerts authority and invokes group identity is often necessary (except for cooperative ventures established within some business groups such as the vertical *keiretsu*). Involvement of foreign firms is therefore limited as

Table 5. R&D Consortia in Japan and the USA

Characteristic	Japan	USA
Government involvement	High: planner/initiator/ funder/participant	Low: regulator/non- intervenor Post-1993: moderate participant
Size of member firms	Large	Various
Number of members	Small, uniform	Moderate, diverse
Foreign participation	Low, restricted	Moderate, partially restricted
Stage of innovation cycle of majority of activities	Mid-stages: technical feasibility, applied product development, prototype/pilot plant	Early to mid-stage: high idea generation, technical feasibility, moderate product development, prototype/pilot plant
Purposes of involvement	Incremental innovation in new product line or non- core products	Broad range from cost cutting to breakthrough innovation
Funding	Public and private	Mainly private but increasing public share
Duration of consortia	Temporary organizations, 1–3 years	Most ongoing
Location of research activity	Most within member firms	Various: more within joint facility or university lab, some within member firms
Form	Primarily joint projects with other firms. Few joint ventures.	Split between joint projects and joint ventures.
Intellectual property rights	Determined by government policy/FTC guidelines	Specified by parties

it may threaten the legitimacy of the 'association' as a 'national group'.

In the USA with a national culture characterized by small power distance and weak uncertainty avoidance, market relationships rather than the guidance of an authoritarian government prevail. Governments' role in encouraging cooperation is largely limited, for example, to affecting prices through subsidies and reducing uncertainties by the provision of information or insurance mechanisms. The individualistic nature of national culture in the US resulted in a wider range of forms and a higher diversity of purposes for inter-firm cooperative organization in R&D. Reliance on market relations means also that cooperation can include foreign firms if economic reasons justify such involvement.

Strong 'uncertainty avoidance' means high risk premia and avoidance of ambiguities. As predicted, the Japanese showed preference for structural cooperation which allows containment of risks. In the USA initial cooperative ventures involved economic cooperation focusing mainly on cost cutting. Some of these after successful experience and learning have been transformed into organizations based on relational governance. In Japan, because of factionalism, cooperative relationships between competitors have continued to be based on structural cooperation, except for those cases where cooperation involved members of a vertical *keiretsu* where group identity was strong and hierarchy ensured discipline and coordination. In these cases the strong form of trust often became the basis of the cooperation.

In terms of outputs, as we have already noted, that structural cooperation tends to lead to a focus on incremental product and process improvements and thus a high chance of producing innovations which can be utilized immediately. This was the experience in Japan. In the US the economic model of cooperation provided opportunities for a diversity of relationships with differences in scope, scale and duration of the cooperation. On the one hand, cost-cutting projects associated with regulatory changes provided an immediate motive for inter-firm cooperation. Such cooperation was generally of short duration and limited scope. On the other hand, the existence of high-payoff, high-risk project opportunities involving complex innovation processes, where obtaining scale and scope economies and sharing risks were desirable, created the incentive for firms to develop more complex models of economic cooperation. Since such projects involve, however, high transaction and monitoring costs, a variety of mechanisms were developed by firms to reduce opportunistic behavior. For example, firms frequently established independent organizations to do the cooperative research, ensuring their stakes by joint equity holdings. Such organizational forms allowed engagement in innovative projects that defied contractual arrangements.

Research output differences may however be related to culture directly. Shane (1993) has found a relationship between breakthrough innovation and both individualism and low uncertainty avoidance, suggesting that innovation may be a skill in which Americans have cultural advantages relative to the collectivist Japanese. Institutional factors have probably also contributed to the differences in research outputs between the US and Japan. Yamamoto (1994) suggested that the Japanese university system is underfunded, therefore talented researchers go to companies where conformance to existing structures is necessary, curtailing their creativity. Nakamura and Vertinsky (1994, p. 66) pointed to the ratio of one scientist per seven engineers among new university graduates in Japan, saying 'Japan has an abundant supply of well-trained technical personnel but likely has a shortage of the scientists with graduate training and research leadership necessary for the original development of technically advanced products'. The USA university system is strong and is showing an increasing presence in consortia.

Despite these concerns, there is no denying the success that Japanese consortia have already achieved. Kotabe and Swan (1995, p. 632) raise a salient point: 'It is not clear . . . whether increased product innovativeness is necessarily the most productive route to enhanced performance in all situations. Rapid product and process incremental innovation geared toward satisfying customer needs is vastly easier to maintain and less risky then committing the firm to a strategy of discontinuous product development.' Gover and Gwyn (1994, p. 65) echo this point by stating that the Japanese 'develop (incremental innovations) soon enough for Japan to reap the economic rewards... The timeliness of incremental innovation can be as important as the original discovery that started the technology.'

CONCLUSIONS

We have argued in this paper that inter-firm cooperative research, if freed from institutional barriers, is likely to grow, due to the changing nature of the process of technological innovation. The advantages of cooperation are especially pronounced where (1) corporations tend to focus on core technological competencies, (2) technological development requires a measure of inter-firm coordination (for example, establishing industry standards), and (3) technological innovation involves high risks and large capital commitments.

Governments have a role to play in establishing R&D consortia, at least removing barriers and developing a legal framework which can discourage opportunism and reduce uncertainties and ambiguities resulting from cooperative relations. The scope and nature of the government role, however, is likely to vary significantly depending on the macro-institutional national environment and the national culture. The comparison of US and Japanese experiences with R&D cooperation shows clearly that national culture matters. The cooperative forms which evolved in each country are not converging even though successful forms provide models for social learning (and imitation). The forms which evolve reflect the specific values and behavioural patterns in each society. These are slow to change.

Mahoney, Huff and Huff (1994, p. 161) suggest that it is foolish to think that Western firms can directly adopt Asian alliance practices. 'Asian alliances have been in place over a much longer time frame than most Western companies contemplate. They encompass a multifaceted context that is more complex than considered by most Western firms. The result of this framework is that any given exchange is only a small part of the total relationship, and the social context places a constraint on short-term, self- interested behavior.' Our analysis shows, however, that economic forms of cooperation characterizing the US can be as or perhaps more versatile and effective. The economic solution to risk of opportunism in the West lies in careful design of incentives to discourage dysfunctional behaviours. A well-developed legal framework for cooperation may be an important step in reducing transaction and monitoring costs and may encourage cooperation. Furthermore, while in collective cultures opportunistic behaviour is minimized within a group, factionalism reduces the propensity for cooperation between groups.

APPENDIX: JOINT RESEARCH PROJECTS INVOLVING MITI NATIONAL RESEARCH LABORATORIES

Table A1. Joint Research Projects at MITI Laboratories, March 1994[a]

Laboratory	#Projects, their length[b] (months)	#Research associations involved[c]	#At least one other firm involved	#Universities involved	#Foundations involved	#Gov./public institutes involved
NI for Advanced Interd. Res.	1 (9, –)[b]	1	0	0	0	0
N. Res. Lab. of Metrology	44 (1.9, 3–69)	1	29	6	4	4
Mechanical Eng. Lab.	19 (12, 4–84)	1	16	1	6	0
NI of Materials & Chem. Res.	32 (21, 1–41)	3	18	5	7	2
Osaka N. Research Institute	25 (16, 2–52)	4	15	0	4	4
N. Ind. RI of Nagoya	28 (16, 6–7)	1	22	2	4	2
NI of Biosci. & Human Tech.	24 (8, 6- 47)	4	13	1	7	0
Geological Survey of Japan	4 (36, 19–36)	0	3	0	0	1
Electronics & Electrotech. Lab.	57 (16, 1- 91)	2	23	14	7	6
NI for Resources & Environ.	25 (19, 3- 58)	0	13	6	9	2
Hokkaido N. Industrial RI	19 (5, 6–12)	0	8	2	8	2
Kyushu N. Industrial RI	5 (6, 6–45)	0	4	0	0	4
Shikoku N. Industrial RI	12 (5, 5–57)	0	11	2	1	3
Tohoku N. Industrial RI	11 (12, 57–)	0	6	4	0	3
Chugoku N. Industrial RI	8 (8, 8–12)	0	4	5	0	3

Source: compiled from MITI (1994).
[a] No specific budget is assigned by MITI to the projects reported here.
[b] Median and range for the lengths of projects in months.
[c] A research association typically consists of some large firms and government research agencies and works on certain research topics selected by the government sector.

Table A2. Patents, MITI Labs and Some Government Research Projects

Laboratory	Overseas patent: owned	Overseas patent: applied	Japanese patent: owned	Japanese patent: applied	Budget (100 million yen)	#Full-time researchers
NI for Advanced Interd. Res.	0	0	0	0	12	49
N. Res. Lab. of Metrology	8	9	43	104	24.6	197
Mechanical Eng. Lab.	122	43	804	362	37	252
NI of Materials & Chem. Res.	343	182	1421	914	61.6	415
Osaka National RI	112	37	553	219	29.3	203
N. Ind. RI of Nagoya	87	43	383	312	28	225
NI of Biosci. & Human Tech.	129	88	638	282	38	220
Geological Survey of Japan	3	0	11	12	53	324
Electronics & Electrotech. Lab.	259	157	816	865	102	633
NI for Resources & Environ.	46	43	258	231	40	290
Hokkaido N. Industrial RI	31	4	121	83	14	97
Kyushu N. Industrial RI	112	39	266	119	11.5	90
Shikoku N. Industrial RI	24	23	118	118	7.8	47
Tohoku N. Industrial RI	5	3	109	75	7	51
Chugoku N. Industrial RI	5	0	56	26	8.1	51
Total	1286	671	5597	3722		
(former) Large project program	100	3	1689	562	—	—
(former) Sunshine program	25	2	539	24	—	—
(former) Moonlight program	0	2	62	36	—	—
(former) Next generation program	184	23	841	343	—	—
Medical/operating programs	47	14	548	389	—	—
Total	356	44	3679	1354	—	—
Grand total	1642	715	9276	5076	—	—

Source: compiled from MITI (1994).

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NOTES

1. We do not consider the fifth dimension (long-term orientation) introduced in Hofstede (1993).
2. The government remains an active participant in certain types of projects in Japan. Table A1 in the Appendix shows the breakdown of joint research projects between Ministry of International Trade and Industry Laboratories and their partners by the type of partner as of March 1994. The majority of their projects are seen to be with private-sector firms. Table A2 gives the numbers of patents owned and applied by these laboratories, their budgets and the number of researchers.
3. There is no restriction, however, for foreign firms to set up joint research programs with Japanese firms in Japan, assuming that such joint projects do not violate the Japanese anti-monopoly laws. There are many such cross-border private-sector alliances involving Japanese firms for research purposes.
4. See, for example, *Berkey Photo* v. *Eastman Kodak*; IBM; VCR-1977 EC case.
5. For example, if Toyota develops new products jointly with Supplier A, Toyota cannot prevent Supplier A from selling those products to Honda. However, Toyota can demand a licensing fee from Honda for their purchase.
6. Interestingly, similar concerns were voiced with respect to scientists sent from their home companies on two-year assignments with SEMATECH in the USA (Browning, Beyer and Shetler, 1995).
7. ATP is a significant funder of American research and development.
8. Department of Commerce Technology Administration, National Institute of Standards and Technology (NIST), *Federal Register*, **59:4**, 15 CFR Part 295, 59 FR 663.
9. In constrast, Aldrich and Sasaki (1995) found that two-thirds of Japanese research associations received more than half of their revenues from government, while 18% of US consortia surveyed (pre-1993) received a similar proportion. These figures may differ from ours because (1) they include funding for research contracts as well as direct subsidies, (2) they reflect the financing arrangements of consortia which have been in operation for some time, whereas our figures reflect financing at the time of formation, (3) some consortia may not report their funding in Federal Register filings, and (4) Aldrich and Sasaki explicitly excluded some consortia from their sample, which were included in ours.
10. DARPA focuses on defense technology and potential commercial uses of defense technology.
11. ATP focuses on high-risk technology with substantial expected long-term economic impact.
12. Another example of restrictive foreign participation is the European Union's European Strategic program for Research and Development in Information Technology (ESPRIT) launched in 1984. It is estimated that more than $4 billion have been spent for supporting ESPRIT-related research projects between 1984 and 1992. IBM as a US firm had considerable difficulty before it could get involved in the ESPRIT program despite the fact that IBM does a significant amount of R&D in Europe (Dodgson, 1993).
13. In *Addamax Corp*. (plaintiff) v. *The Open Systems Forum Inc., Digital Equipment Corp., and Hewlett-Packard* (defendants) following a request by the defendants for summary judgment, the court found that OSF was by its nature anticompetitive, since (1) it was formed expressly for the purpose of combatting Sun Microsystems and AT technology, and (2) no research of the type indicated in OSF's initial federal register filing under NCRPA had been conducted up to the time of the trial. This case may have significant implications for other research consortia whose objective is similarly stated as standardization within the industry. Firms which get together to develop compatible systems naturally exclude some competitors. To the extent that these firms are large and can be considered to be splitting up markets, the consortia may be found to be in violation of antitrust legislation. The judge in this case allowed the defendants' request for summary judgment on some issues, and denied it on others. The judgment may be appealed.
14. United States Code Services 15:4301, p. 342.
15. According to the US Justice Department in June 1996.
16. Excluding one outlier of 389 members. Including the outlier, standard deviation is 20. The median number of members is 5.3.
17. The firm-level data which is presented for Japanese consortia in Fig. 3 is unavailable for the USA. The purposes identified in Fig. 6 are those listed by consortia in Federal Register filings, as classified by the researchers.
18. As detailed in a Federal Register amendment, #53 FR 4233, 12 February 1988.
19. As many consortia listed more than one objective, the numbers do not sum to 100%.
20. Certain characteristics of successful consortia in the USA are discussed in Lee and Lee (1992), Werner and Bremer (1991), Smilor and Gibson (1991), Link (1990) and Evan and Olk (1990).
21. At least one writer suggests these changes could go further: Nelson (1995) points out that the compulsory licencing of technology which is needed to enable a company to exploit its own invention could eliminate serious issues with systems technologies, where putting together a state-of-the-art system may require significant, difficult-to- obtain licensing.

REFERENCES

Addamax Corp. (plaintiff) v. *The Open Systems Forum Inc., Digital Equipment Corp., and Hewlett-Packard* (defendants). CA. No. 91-11152-JLT, US District Court foor the District of Massachusetts, decided 19 May 1995.

H. E. Aldrich and T. Sasaki (1995). R&D consortia in the United States and Japan. *Research Policy*, **24**, 301–16.

G. T. Allison (1971). *Essence of Decision: Explaining the Cuban Missile Crisis*, Boston, MA: Little, Brown.

Anonymous (1995). $90 Million? No thanks. *Quality Progress*, **28:5**, 27.

J. B. Barney and M. H. Hansen (1994). Trustworthiness as a source of competitive advantage. *Strategic Management Journal*, **15**, 175–90.

L.D. Browning, J. M. Beyer and J. C. Shetler (1995). Building cooperation in a competitive industry: Sematech and the semiconductor industry. *Academy of Management Journal*, **38:1**, 113–51.

M. Dodgson (1993). *Technological Collaboration in Industry*, London: Routledge.

W. M. Evan and P. Olk (1990). R&D consortia: a new US organizational form. *Sloan Management Review*, Spring, 37–46.

Fair Trade Commission—Japan (1990). *Joint Research and Development and Competition Policy* (*Kyodo Kenkyu Kaihatsu to Kyouso Seisaku*), Tokyo: Kosei Torihiki Kyokai.

Fair Trade Commission—Japan (1993). *Joint Research and Development and Anti-Monopoly Law* (*Kyodo Kenkyu Kaihatsu to Dokusenkinshiho*), Tokyo: Kosei Torihiki Kyokai.

L. Felker (1984). Cooperative industrial R&D: funding the innovation gap. *Bell Atlantic Quarterly*, **1:2**, Winter, 26–34.

J. E. Gover and C. W. Gwyn (1994). *Using Federal Technology Policy to Strengthen the US Microelectronics Industry*, Alberquerque, NM: Sandia Report SAND94-168.

I. Hayashi, M. Hirano and Y. Katayama (1989). Collaborative semiconductor research in Japan. *Proceedings of the IEEE 77*, 1430–41.

L. Hoecklin (1995). *Managing Cultural Differences*, Reading, MA: EIU-Addison Wesley.

G. H. Hofstede (1980). *Culture's Consequences: International Differences in Work Related Values*, Beverly Hills, CA: Sage Publications.

G. H. Hofstede (1993). Culture constraints in management theories. *Academy of Management Executive*, **9**.

M. Kotabe and K. S. Swan (1995). The role of strategic alliances in high- technology new product development. *Strategic Management Journal*, **16**, 621–36.

M. K. Lee and M. K. Lee (1992). High technology consortia: a panacea for America's technological competitiveness problems? *High Technology Law Journal*, **6**, 335–62.

A. N. Link (1990). Strategies for cooperation in R&D;. In *Management of Technology II: The Key to Global Competitiveness* (edited by T. Khalil and B. Bayraktar), Norcross, GA: Institute of Industrial Engineers and Management Press.

A. Madhok (1995). Revisiting multinational firms' tolerance for joint ventures: a trust-based approach. *Journal of International Business Studies*, **26:1**, 117–37.

J. T. Mahoney, A. S. Huff and J. O. Huff (1994). Toward a new social contract theory in organization science. *Journal of Management Inquiry*, **3**, 153–68.

Ministry of International Trade and Industry (MITI) Industrial Research Institute (1994). *Research Plans* (*Kenkyu Keikaku*), Tokyo: Nihon Sangyo Gijutsu Shinko Kyokai.

M. Nakamura and I. Vertinsky (1994). *Japanese Economic Policies and Growth: Implications for Businesses in Canada and North America*, Edmonton, AB: The University of Alberta Press.

National Cooperative Research and Production Act (NCRPA) of 1993, *United States Code Service*, **15**, 4301, 339–48.

R. R. Nelson (1995). Why should managers be thinking about technology policy? *Strategic Management Journal*, **16**, 581–88.

D. I. Okimoto, T. Sugano and F. B. Weinstein (1994). *Competitive Edge—The Semiconductor Industry in the US and Japan*, Stanford, CA: Stanford University Press.

M. Porter (1990). The competitive advantage of nations. *Harvard Business Review*, **68:2**, 73–93.

G. R. Saxonhouse (1983). The micro- and macroeconomics of foreign sales to Japan. In *Trade Policy in the 1980s* (edited by W. R. Cline), Cambridge, MA: MIT Press.

S. Shane (1993). National rates of innovation. *Journal of Business Venturing*, **8**, 59–73.

R. W. Smilor and D. V. Gibson (1991). Technology transfer in multi- organizational environments: the case of R&D consortia. *IEEE Transactions on Engineering Management*, **38:1**, February.

K. G. Smith, S. J. Carol and S. J. Ashford (1995). Intra- and interorganizational cooperation: toward a research agenda. *Academy of Management Journal*, **38:1**, 7–23.

M. Tripsas, S. Schrader and M. Sobrero (1995). Discouraging opportunistic behavior in collaborative R&D;: A new role for government. *Research Policy*, **24**, 367–89.

G. Werner and J. Bremer (1991). Hard lessons in cooperative research. *Issues in Science and Technology*, Spring, 11–14.

O. E. Williamson (1993). Calculativeness, trust and economic organization. *Journal of Law*, **36**, 453–86.

Hisatoshi Yamamoto (1994). Complementary competition in Japan. *Research-Technology Management*, **37:2**, 49–54.

A. Zaheer and N. Venkatraman (1995). Relational governance as an interorganizational strategy: An empirical test of the role of trust in economic exchange. *Strategic Management Journal*, **16**, 373–92.

L. G. Zucker (1986). Production of trust: institutional sources of economic structure 1840–1920. In *Research in Organizational Behavior* (edited by B. M. Staw and L. L. Cummings), Greenwich, CT: JAI Press, **8**, 53–111.

