BENCHMARKING INTERORGANIZATIONAL TECHNOLOGY COOPERATION:

THE LINK BETWEEN INFRASTRUCTURE AND SUSTAINED PERFORMANCE

By

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ABSTRACT

Cooperative efforts among government, industry, and universities have gown in importance as strong contributors to the nation's technological and economic competitiveness in the global environment. Such efforts include cooperation among networks of government R&D/technology laboratories, industrial R&D laboratories, and universities. The resulting novel organizational formats created to accommodate these cooperative efforts influence the degree to which such multipartner cooperations perform in a sustained manner. A stellar example of the complex, multipartner cooperative programs is the network of 52 industry-university-cooperative research centers (IUCRCs) established in 1973 and supported by the National Science Foundation.

This paper examines the effects of dimensions of infrastructure of IUCRCs on their sustained performance. A study of 87 industrial companies and 12 additional companies who terminated their membership in a single center over a ten-year period has generated two main findings. First, the decisions by industrial companies to join, remain, or terminate membership in a multipartner cooperation with universities are three different phenomena, impacted by different combinations of infrastructure dimensions. Second, the effect of dimensions of the infrastructure on sustained performance varies according to the stage in the life cycle of the cooperation. These results suggest that complex multipartner cooperations, such as the IUCRCs, may be benchmarked by dimensions of the infrastructure. The contribution of this study is that managers and policy makers in the area of interorganizational technology cooperation now have powerful new analytical tools, in addition to

their knowledge about technology transfer. These tools allow for planned intervention that will impact membership decisions and improve sustained performance.

Key Words: Benchmarking; Interorganizational Cooperation; R&D; Technology; Infrastructure; Sustained Performance; Industry-University-Cooperative-Research Centers

1. INTRODUCTION

Cooperative efforts in R&D and technology among industry, government entities, and universities have grown in number and importance in recent years. The motivations for such cooperation vary, and include strategic as well as operational needs of participating organizations.[1] These cooperative efforts have also received attention from scholars who have suggested that they contribute to the strengthening of the technological base of the participants themselves and add to the nation's competitive position in world markets.[2]

Several authors have studied various aspects of cooperative programs[3] in an effort to better understand how these programs work and what makes them succeed or fail.

The purpose of this paper is twofold: First, to explore the fundamental structural and managerial dimensions that underlie cooperation in R&D/technology[4] and the emerging new forms of cooperative arrangements. This was accomplished by means of a study of cooperative centers and interviews with selected corporate R&D/technology mangers; and, Second, to analyze these organizational and managerial dimensions and their possible effect on the sustained performance and survival of the cooperative programs. Therefore, the study reported here had modest objectives: to identify key factors impinging on cooperative programs of IUCRCs and, by content analysis, to examine whether these factors affect performance and survival.

The contribution of this research is an effort to benchmark the more complex cooperative arrangements in technology among different types of organizations. The focus is on the roles played by the structure and architecture of the cooperation in the emerging new forms of organization that characterize such cooperative arrangements.

2. BACKGROUND AND CONCEPTUAL MODEL

2.1 Background and Review

For over two decades there have been studies of industry-university-government R&D/technology cooperation. Chakrabarti and Rubenstein[5] conducted an early study of adoption of NASA innovations. They found that for process cases successful adoption depended on connection with the firm's existing operations, whereas in product cases, top management support and organizational variables such as climate were crucial for success. Others include: Bloedon and Stokes,[6] Bozeman and Coker,[7] Ettlie,[8] and Geisler and Furino.[9]

The growth of R&D/technology cooperation has also generated several modes of cooperative programs. **Table 1** shows a classification scheme of cooperative programs by collaborating organization and type of cooperation.

TABLE 1 ABOUT HERE

As the table shows, cooperation in R&D/technology may assume many different types—from a simple transaction such as information transfer to a complex array of organizational arrangements. Broadly, cooperation in R&D/technology may be defined as any arrangement, formal or informal, among two or more parties in which resources are utilized by the parties for a scientific and/or technical activity shared by at least two of the parties. Hence we have cooperative arrangements between universities and industrial firms, universities and government laboratories, and industrial firms and government laboratories. Another and more complex cooperative arrangement includes all three: government, industry, and universities.

Cooperative activities in R&D/technology occur constantly among entities who produce or transform R&D and its outputs. These activities range from a short exchange between scientists from different organizations—to a licensing agreement or participation in a research center or research consortium. Included in this spectrum are cooperative activities across *different* types of organizations and, since this is the focus of the study, there is a need to exclude here *company to company* consortia, strategic alliances, and similar intercompany arrangements. Also excluded are cooperative activities among *universities* and among *government laboratories*. The choice of cross-sector cooperation as the focus of study allows for the exploration of a more interesting phenomenon of cooperation across *different* organizational settings.

The vast array of types of cooperation shown in **Table 1** may also be classified by level of organizational or institutional complexity. In this scheme a joint participation of scientists from a university and a company in a research symposium is clearly different and much less complex than, for example, a company's participation in a multi-year membership in a university-based engineering research center. **Figure 1** shows the relation between level of complexity and type of cooperation.

FIGURE 1 ABOUT HERE

The figure illustrates that as R&D/technology cooperation becomes more sustainable and longer term, it requires organizational and institutional arrangements of increased complexity.

In this paper the emphasis is on the cross-sector tripartite arrangements that include universities, government, *and* industry. These are of high institutional complexity and rely on long term arrangements with a sustainable structure. Furthermore, these arrangements generally foster the development of innovative forms of organization.[10] These cooperative arrangements are but a small segment of all possible types of cooperation listed in **Table 1**. They are university-industry cooperative programs in which government entities are actually involved by providing (in addition to funding) guidance, nonfinancial support, incentives, and other forms of assistance. These entities are the IUCRCs (Industry-University-Cooperative Research Centers); ERCs (Engineering Research Centers); and state-supported science and technology centers. In the past two decades there has evolved an emerging albeit limited body of published studies on their operation and performance.

These are two basic streams of research into cross-sector, complex, and sustainable cooperative arrangements: explorations into the processes by which such cooperations function, and studies of the outcomes and survival of these cooperations by means of technology transfer. Much of this research is anecdotal, and there is very little on the structure and architecture of these arrangements and how they affect the success and survival of the cooperation. In the first stream Gray,[11] Geisler,[12], and Geisler, Furino, and Kiresuk[13] explored processes and mechanisms by which industry-university-government cooperative programs are managed and what the factors are that affect their functioning. They assessed the roles of the industrial advisory board, program evaluators, and the degree of organizational responsibility of managers from the various participating entities. Chen *et al.*[14] studied the function of information exchange and management in the communication network among cooperating organizations. Gibson and Rogers[15] analyzed the processes by which MCC (Microelectronics and Computer Technology Corporation), the first major U.S. industrial R&D consortium, was managed.

The literature thus suggests that the key elements of processes in long term institutional cooperation seem to be: communications, interactions among partners, support from government, the level of active government participation, and support from top and middle management of the participating organizations.[16]

The second stream includes studies of the outcomes, the technology transfer activities, and the effect these have on the survival of cooperative efforts. Geisler, Furino, and Kiresuk[17] proposed a seven-stage model of the life cycle of cooperative research. In an earlier study[18] they have also identified factors in the success and failure of industry-university-cooperative research centers. These factors were grouped into five categories: (1) relations of company with the university; (2) relations of the university with the company; (3) internal management; (4) research and technology strategy; and (5) individual attributes of the founders and managers. Geisler[19] identified and discussed the various issues involved in such interorganizational cooperation. He added the following issues to the list of challenges to modern managers of innovation proposed by Drucker:[20] (1) intellectual property; (2) differences in cultures; (3) differences in basic organizational and managerial processes; and (4) differences in assessing success and performance. Marazitta[21] conducted a study of engineering research centers in the U.S. and the role that successful transfer of technology plays in their survival. Radosevich and Kassicieh[22] studied government-industry cooperation and also emphasized the crucial role that technology transfer plays in the performance and success of the cooperation

In summary, this stream of research suggested that the outcomes from the cooperative effort need to be transferred to and absorbed by participating institutions so that the proscribed benefits from the cooperation are realized to the satisfaction of all parties involved. Once this is achieved, the parties will continue the cooperation and will contribute to its sustained performance.

2.2 Motivation to Cooperate

The extant literature has also identified some motives for engaging in cooperative effort. Geisler and Rubenstein,[23] citing a study of 400 cases of university-industry relations, list 12 main motives, including access to students and professors, access to technology for problem solving, outsourcing R&D activities, prestige, and obtaining state of the art information. Universities are also motivated by opportunity to expose students to practical problems, potential employment for graduates, and access to technology areas where industry has special expertise.

Hagedoorn[24] listed 8 major motives for interfirm cooperation, grouped into 3 categories: (1) basic and applied research (increased complexity and intersectoral nature of new technologies, reduction and sharing of uncertainty, and reduction and sharing of costs); (2) concrete innovation processes (technology transfer and leapfrogging, and shortening product life cycle); and (3) market access (monitoring environmental opportunities, internationalization, and new products and market entry).

Geisler[25] identified several motives usually found in interindustry R&D cooperation that are also applicable in complex industry-university-government cooperative programs. Access, opportunities, outsourcing, and a more economic and productive use of technological resources were found to be key motivators in starting and maintaining sustained cross-sector R&D cooperation. These motivators are also linked to benefits that are accrued from the cooperation, since many benefits are viewed as the fulfillment of the original reasons or motives that have prompted the parties to cooperate.

2.3 Architecture and Infrastructure

If the above motives are the factors that trigger the cooperative efforts and are responsible for its organic viability and initiation, it is then the architecture and infrastructure of the cooperative effort that seem to determine its sustainability and resilience, and to contribute to its performance and survival.

In recent years some scholars have written about the infrastructure of cooperative efforts and the core dimensions of their structure. Hagedoorn and Schakenraad[26] considered company structure (particularly size) in their study of the effect of cross-firm technology cooperation on economic performance. Borys and Jemison[27] analyzed strategic alliances as hybrid forms of organizational arrangements. Gray, Gidley, and Koester,[28] Gray,[29] and Gray and Meyer[30] collected and analyzed structural information on the IUCRCs. Finally, Morris and Ferguson[31] related structure to technological performance in the company. The structure or infrastructure[32] of the cooperative effort has not been benchmarked in this literature. Rubenstein and Geisler[33] conducted an initial attempt at a comprehensive benchmarking of industry-university cooperative partnering. They identified such structural dimensions as size, mode of funding, and autonomy. Other dimensions mentioned in the literature, although not in the framework of a precise nor adequate classification, are formalization and reporting.[34]

In all, these studies represent a small, yet growing, body of knowledge on the role that architecture and infrastructure of the cooperative arrangements play in the performance and the sustainability of the cooperation.

2.4 Novel Organizational Forms

In this paper the emphasis is on those cooperative efforts in which the cooperating parties have established *separate* institutional entities (programs, centers, university-based centers, institutes) and in which industry, universities, *and* government are actively involved. Therefore the resulting arrangements tend to be a novel organizational form.

In a seminal editorial, Daft and Lewin[35] suggest that "the design of organizations that are flexible, that adapt and create change, that more fully use both human and technology resources, and that are global in scope, are perhaps the most significant variables of the new forms" (p. ii). They also cite interorganizational collaborations as one phenomenon in which organizations experiment with new forms.

R&D/technology partnering programs in which industry, universities, and government cooperate are excellent examples of novel organizational forms. Institutional arrangements such as IUCRCs and ERCs have the following attributes:

(1) They are created as a result of *joint* effort of two or more distinct partners.

(2) They operate within, yet alongside, traditional boundaries. For example, IUCRCs and ERCs operate within universities yet, unlike academic departments, have different criteria for performance evaluation and different structures.

(3) They have different rules and criteria than traditional academic departments for: (1) funding; (2) performance assessment; (3) personnel policies; (4) research portfolio; (5) intellectual property.

(4) They accept and implement changes in structure and processes via joint agreement of the partners.

(5) They are terminated by joint agreement of partners.

This new organizational form may be categorized as a *hybrid form*, since it incorporates features from traditional university structure, corporate organization, and government policies. The new form of cooperative R&D is an integration of the university, the corporate laboratory, and the public agency.

2.5 Nature of the Cooperative Arrangements

This research focuses on Industry-University-Cooperative Research Centers (IUCRCs). IUCRCs are university based R&D/technology tripartite collaborative entities supported by the federal government with funding in an average of $60,000 per year for each center.[36] State government funding also participates in selected centers. For example, the state of New Jersey funded two IUCRCs with over $3 million per year.[37]

The main characteristic of these centers is that they have an industrial membership. Companies subscribe to these cooperative centers as members, with an annual fee averaging some $40 thousand. As members, companies enjoy a voice in setting the R&D portfolio of projects and in sharing the results. Companies may also elect (in addition to membership) to enter with the center into proprietary R&D agreements. The average number of industrial members for IUCRCs is 12 companies per center, with a wide range between 3 and 52 members. In 1999 there were 52 centers, 29 of which were over 5 years old, with a total of over 700 industrial members.[38]

Largely because of requirements established by the National Science Foundation (the federal agency supporting these centers since 1973), there is a "model" for setting-up a center, obtaining federal support, and maintaining such support. The model includes:

(1) benchmarks on minimum number of members for support and qualification;

(2) procedures and standards for the organization chart, including the structure and role of the Industrial Advisory Board;

(3) procedures and standards for relations with the focal university, including such issues as payment of overhead; and

(4) procedures regarding the conduct of activities in the center, periodic meetings with the funding agency and industrial members, intellectual property issues, and membership of foreign companies.

Overall, these centers have evolved in the past 27 years to a point where there is a formal structure and workable procedures for many processes. In this way, many issues that normally act as barriers to such technology collaboration have been worked out, negotiated, and resolved. Chief among these are: (1) intellectual property rights; (2) conflicts in structure and culture among partners; and (3) support from management.

3. STUDY DEIGN AND METHOD

A model is proposed by which the success of complex institutional R&D/technology cooperative efforts and their sustainability over longer periods of time depend, to a large extent, on their infrastructure. A schematic view of the model is given in **Figure 2**.

FIGURE 2 ABOUT HERE

The dimensions of the infrastructure and the variable of sustained performance are further operationally defined in **Table 2**.

TABLE 2 ABOUT HERE

These dimensions were extracted from an extensive review of the R&D management, technology transfer, and organization theory literatures.[39]

3.1 The Conceptual Model

This conceptual model (the effect of the infrastructure on success and sustainability) is similar to the resource-based approach to strategic management which suggests that organizations achieve competitive advantage by the use of similar internal capabilities.[40] Although the resource-based approach refers to advantages *vis-á-vis* competitors, cooperative efforts gain advantage by using their infrastructure *vis-á-vis* barriers in their environment and those inherent in their own organizational arrangement.

The conceptual model in **Figure 2** hypothesizes that the effects of the dimensions of infrastructure on the sustained performance of IUCRCs is moderated by the stages in the life of the cooperation. Geisler[41] suggested that the cooperation will be more likely to survive over time the more the relationship is institutionalized up to a range of optimality, beyond which the relationship is reversed. His arguments were grounded in theories of interorganizational relations. Hagerdoorn[42] also found a relation between different modes of structure and success of strategic technology partnering.

The effect of the infrastructure on sustained performance of the cooperation seems to occur by means of impact on barriers to the cooperation. The dimensions of the infrastructure tend to reduce the effect of negative factors, or to enhance the effect of positive factors in the cooperation. Since IUCRCs are complex and novel forms of organization, the effects of these dimensions need to be explored individually and in relation to the organization's life cycle.

To clarify this, **Table 3** shows the hypothesized relation between selected elements of the infrastructure and stages in the life of the cooperation.

TABLE 3 ABOUT HERE

In this table, there are three main stages in the life of the cooperation. These stages are a composite of the seven stages in the life of an IUCRC, identified by Geisler, Furino, and Kiresuk (1991).

3.2 Research Questions

The conceptual model and the earlier discussion have generated three main research questions. First, how does the infrastructure, as operationalized in **Table 2**, impact the sustained performance of the IUCRCs? More specifically, how does each of the dimensions of infrastructure affect sustained performance? Second, how does the infrastructure affect the sustained performance of the IUCRCs at different stages of the life of these centers? That is, are there significant differences in the elements of the infrastructure at the different stages of the life of a center, and are there different combinations of these dimensions that are more conducive to sustained performance at each stage of the life of the center? Finally, on operationalizing the effects of the dimensions on sustained performance, the question that emerges is: what are the factors (barriers and facilitators) that are impacted by the dimensions so that their effect is modified, thus influencing sustained performance?

Insights into these questions would certainly enrich our understanding of the IUCRC phenomenon and allow for far-reaching implications for policy matters. If we understand how infrastructure affects performance (in addition to the well-studied effects of successful technology transfer), we can then introduce and better manage novel organizational forms for increased performance of such complex cooperative arrangements.[43]

3.3 Method

In order to study the phenomenon of complex interorganizational and multimember R&D/Technology cooperation, the institutional configuration of the IUCRCs was selected. The reasons for this selection were: (1) IUCRCs are the oldest and most successful experiment of agreement sponsored industry-university cooperation; (2) IUCRCs have been in existence for 27 years and, as stated in section 2.5, there are currently 52 operating centers, 29 of which are self-sufficient (over 5 years old). This number provides a research population of centers of various types and different experiences; (3) IUCRCs were established according to a predetermined pattern ("model") whose characteristics are described in section 2.5. This model allows for relative ease in inter-center comparisons; and (4) the author has served as evaluator of a center for almost a decade, is thus familiar with the network, and has had relative ease in accessing the centers and their member companies.

The study design was based on two sources of data. The first was responses obtained from a survey of corporate managers on their relations with, and membership in, IUCRCs. The second source was exit interviews conducted with technical managers of companies who terminated their membership in an IUCRC.[44]

3.4 The Survey

The survey targeted a stratified sample of 316 manufacturing companies who engage in R&D and are members of the Industrial Research Institute. The sample was stratified by the unit in which R&D was located: division or corporate central lab. A survey questionnaire was developed and tested with four companies who are all members of one center. The revised survey was mailed to the 316 companies. The target respondent in each company was the Vice President for R&D, or similar position. In all, 87 completed questionnaires were returned, a response rate of 27%. **Table 4** shows the distribution of the respondents classified by their relations with an IUCRC.

TABLE 4 ABOUT HERE

In the sample of respondents who completed and returned the research instrument, the vast majority (92%) were in a division of the company with only 8% in a central laboratory. Also, about half the responding companies (47%) have joined a center and 75% of these are currently members in an IUCRC. An analysis of the nonresponses showed no consistent patterns.

Respondents were asked to provide four categories of data. First, they were asked to rank by order of importance to their company those factors that impacted their decision to join or not to join an IUCRC. Second, they were asked to rank order those factors that impacted their decision to remain or not remain members of a center (for those companies who had jointed a center). These responses were tailored to the three stages in the life of a center, as shown in **Figure 2**. Third, they were asked to rank order the problems they have encountered with their membership in the center. Finally, respondents who have never joined a center were asked to list, in order of their potential impacts, those factors which would have made them join a center (assuming that funds were available for such a venture). The four lists of factors that impact membership were developed by the researcher from the literature, and additional factors were then added by respondents who completed the survey instrument in the four test companies and by respondents to the exit questionnaires.

The second source of data were exit interviews over a period of ten years with technical managers of 12 companies who terminated their membership in one IUCRC. These interviews were used to substantiate the survey results on factors that impacted the companies' decision to remain or not remain members of the center. The choice of all the companies from a single center reduces the intervening effects of control variables.

It should be noted that some companies are members in several centers. Respondents were thus asked to reply in connection with only one of these centers, and to list the name of this center. This data item was later used in relating their responses to sustainability of the centers.

4. FINDINGS

The findings from this study are presented below in the order in which the data categories were obtained in the survey of respondents and from the exit interviews.

4.1 Why Companies Join an IUCRC

From a list of 20 potential factors, respondents in this study have identified and ranked 14 factors that impact a company's decision to join a cooperative research center. The factors in the generic list were grouped into four categories: economic, structural, scientific/technical, and managerial/experiential. **Table 5** shows the ranking of the top 14 factors within the original list and the percent of respondents who ranked each factor. No significant differences were found between division and central laboratory respondents.

TABLE 5 ABOUT HERE

Among the top ten factors that impact the company's decision to join a center we find five factors that refer to or describe some attribute of the center that are *structural* in nature. Among the top five factors, three are structural. Companies seem to join a center to obtain exposure to state of the art, and because of the unique expertise of the center. However, the role that NSF plays in the center and its unique structural characteristics seem to tilt the decision toward joining *this specific* center.

4.2 Why Companies Don't Join an IUCRC

The factors that have impacted the decision of companies not to join a center are shown in **Table 6**.

TABLE 6 ABOUT HERE

The factors impacting the decision not to join are different from those that impact the decision to join. Companies seem to join an IUCRC because of what they perceive would potentially benefit them *and* because of unique attributes of this particular mode of institutional cooperation. However, companies decide not to join because they lack information and/or resources, or foresee little or no benefits arising from the cooperation. No significant differences were found between division and central laboratory respondents.

4.3 Why Companies Remain as Members in an IUCRC

Respondents were asked to list those factors that impacted their company's decision to remain members of an IUCRC. These factors were allocated to one or more of the three main phases in the center's life. Companies who have been members for a short time period assigned factors to only the early phase. Since the decision to remain is made annually (after an initial three-year commitment), some companies who have been members in a center for several years have had to contend with this decision many times. Again, no significant differences were found between respondents from divisions and from central laboratories.

Table 7 shows those 15 factors that respondents identified as impacting the decision to remain members of an IUCRC.

TABLE 7 ABOUT HERE

Companies that tend to remain members in the *early* stages do so because of structural factors, such as NSF's role, the IAB (Industrial Advisory Board), and their access to the university's facilities and resources. In the midlife of a center, structural factors are complemented with factors that assess benefits gained by the company, such as cost effectiveness and research quality considerations. Management support becomes a crucial factor throughout the viability stage. In this last stage, structural factors are joined by factors describing benefits attained by the company, such as gaining unique experience and having a window to current technology.

4.4 Why Companies Terminate Their Membership in an IUCRC

The findings for this question come from two sources. The first source is the survey of companies. As shown in **Table 4**, 8 companies in the sample have terminated their membership in an IUCRC and are not currently members of such a cooperation. These 8 companies represent about 20% of the sample companies who have joined an IUCRC at any given time. This ratio is similar to the actual average yearly center turnover of about 15% for the period 1985-1999. In the period 1973-1994, 405 companies terminated their membership, from a total of 1049 companies who had joined—a 38% turnover ratio.[45]

The second source are 12 companies in which "exit interviews" were conducted shortly after their departure from the center. The results from the two sources were lumped together. **Table 8** shows the factors identified by the 20 companies as impacting the decision to terminate membership in an IUCRC.

TABLE 8 ABOUT HERE

Further analysis of the two data sources has shown no significant differences between the companies in the survey sample and those who terminated membership in a single center over the past decade. As **Table 8** shows, there are two main groups of factors that impact the decision to terminate membership: paucity of measurable results/benefits, and economic pressures within the company where competition for R&D dollars tends to intensify the scrutiny with which cooperative programs are examined.

4.5 What Would Make a Company Join an IUCRC

The 46 companies in the sample of respondents who have never joined an IUCRC were asked what would have probably made them join a center, assuming that funds were available. **Table 9** shows the top 5 factors that these respondents ranked, classified by whether the respondent worked for a divisional or corporate research laboratory or unit.

TABLE 9 ABOUT HERE

Data from this table show that there are marked differences between the two types of respondents. As would be expected, divisional R&D managers are more concerned with tangible and demonstrable potential benefits, and with the support of their management. Although both types of respondents overwhelmingly need more information, corporate lab managers are more concerned with exposure to current technology, and much less interested in benefits and their management's support and policies. This is perhaps due to the relatively higher level of flexibility that corporate labs enjoy in their research agenda and outsourcing practices, and the longer term approach they undertake in their research portfolio.[46]

5. DISCUSSION

The findings suggest that structural factors play a significant role in the decision of companies to join an IUCRC and to remain members in a center.[47] The findings also show that different sets of factors impact the decisions to join a center, to remain as members, and to terminate membership. With some exceptions, each set of factors is not the “flip-side” of the other set. That is, the decision to terminate membership is not necessarily impacted by factors that are mirror-images of the factors impacting the decision to remain in the center. Rather, the different sets of factors suggest that the decisions to join, remain, and terminate membership in an IUCRC are *three distinct phenomena*.

IUCRCs are a novel organizational form in which a complex array of three types of organizations are intertwined in a relatively predetermined structural arrangement. All three participants cooperate with the aim of producing high quality research that is also relevant to industrial members, and within guidelines established by the federal agency that supports the collaboration.[48]

The criteria for sustained performance are shown in **Table 2**, and include structural as well as technology transfer factors. Although the findings in this study show no direct statistical evidence linking infrastructure to sustained performance of the centers, it is possible to qualitatively arrive at such a relationship.

In the period 1973-1994, about 15% of the centers initiated have failed, and 38% of the industrial members had terminated their participation. However, the IUCRC network in 1999 had 52 centers, 23 of which had fewer than 5 years. Sustained performance of the centers *depends on industrial membership* and, as the survey and exit interviews show, companies credit to a large extent their decision to join and remain members on structural factors. When moderated by size or geography, the centers listed by survey respondents do not show any clustering or bias.[49] The findings that structural factors affect membership decisions seem to hold for all types of centers.

5.1 Infrastructure and Sustained Performance

The success and sustained performance of the network of IUCRCs is measured by the continued support from its industrial members. The findings of this study show that in the three decision phenomena about membership (join, remain, and terminate), structural and process factors have a predominant role. Furthermore, the success of the IUCRC network over the past 27 years cannot be solely credited to successful transfer of technology, nor to financial and economic reasons. The history of the IUCRC network shows that in the “lean” years of the early 1980s, there was hardly an exodus of companies. On the contrary, 15 current centers were established in 1980-1984. There are corporate members who are unhappy with the relevancy of the research agenda or with technology actually transferred to them—yet they remain active members of their center. Similar findings were also identified in the study of SEMATECH.[50]

As different phenomena, the decisions to join a center, remain in it, and terminate membership are all driven by the unique structural characteristics of the IUCRCs. This may explain the resiliency of this network, and *why companies prefer to join and to remain members in these, rather than other cooperative arrangements*. About half the companies sampled in this study are members in at least one center.

Another important finding shows that companies decide to join and to remain members primarily because of factors associated with the center’s infrastructure (**Tables 6** and **7**). Yet they decide to terminate membership primarily because of economics and poor outcomes from the center. In the early stages of the center’s life, structural factors are the key to the company’s decision to remain in the center. In latter stages, research outputs, their quality, relevancy, and actual transfer to the company gain increased importance in impacting the decision to remain in the center.

5.2 How Infrastructure Affects Sustained Performance

In **Table 2** there are seven dimensions of structure and five dimensions of processes that compose the infrastructure of the IUCRC. The findings of this study show that in complex R&D/technology multisector cooperation, the infrastructure plays a significant role in the sustained performance through the membership of corporate sponsors. This study investigated only the degree to which infrastructure factors affect decisions to join, remain, and terminate membership in a center. The study did not specifically explore the effects of the individual dimensions. Nevertheless, **Table 3** lists the hypothesized relations between the dimensions and stages in the life of a center. Further content analysis of this table would suggest the following:

1. *Formalization*: should be high in the early stages, low in the middle, and high in later stages. This u-shaped relationship should reduce (1) the negative influence of inherent differences in mission and objectives; (2) issues of intellectual property; and (3) conflicting structures among partners. In the early stages, high formalization helps to establish the structural boundaries of the cooperation. In the middle stages there is a need for some leeway in attending to special needs of the partners. Yet, in advanced stages, there is again a need for high formalization to reestablish structural boundaries.
2. *Autonomy*: should be high in the initial stages, low in the middle, and high again in later stages. This u-shaped relationship should have an effect on: (1) reducing the negative impacts of differences in organization, structure, and culture among the parties by allowing the new form of organization the freedom to enter in contracts and agreements with different parties; (2) reducing the negative effects of conflicts of different commitments and interests

among the partners—by having the leeway to establish unique and separate modes of operation.

In the middle stages, as the cooperation progresses, autonomy is not so crucial as patterns have already been established. However, as the cooperation matures, some of the above differences and conflicts among partners seem to resurface, hence the need for added autonomy.

3. *Complexity*: This dimensions starts low and develops into a high complexity as the cooperation matures.

4. *Control*: As with formalization and autonomy, the proposed relationship is a u-shaped curve. This will induce the following impacts: (1) in the early stages, high control allows the management of the cooperation the tools to minimize the negative effects of differences in orientation, philosophy, culture, and interests of managers and researchers from the different partners; (2) as the cooperation matures again, high control allows management to deal with conflicts that tend to reemerge.

5. *Communication and Networking*: This first of the dimensions of processes also has a u-shaped relationship. High communications and establishment of networks are essential in the early stages to create acquaintances and improve relations. This dimension may not be as essential in the middle stages, but becomes critical again in latter stages when the cooperation tends to weaken with the passage of time.

6. *Interaction Among Partners*: This dimension is hypothesized as also having a u-shaped relationship. In the early stages, high interaction helps to establish patterns of structure. This is less crucial in middle stages, but becomes critical again as the cooperation matures.

7. *Support from Government*: It is hypothesized that support from government should be high throughout the life of the cooperation. High support contributes to the prestige of the cooperation and, in many instances, serves as the glue that holds the parties together.

8. *Active Participation of Government*: Needed in the early stages to solidify the cooperation.

9. *Support from Management*: Needed throughout the life of the center.

The proscribed structure and procedures for activities and other routine processes have generated a substantial knowledge/experience base shared by established as well as new centers. This "blueprint" for starting a center and managing it allowed centers to overcome routine problems and foresee major problems before they erupted. Consequently, the centers are relatively free of major uncertainties, imbalances, and of having to "reinvent the wheel" for handling each incident that arises in the collaboration.

Although there is agreement among scholars in R&D/technology management that academic research needs relative freedom from constraints of bureaucracy and regulations,[57] in the case of multipartner cooperative R&D, it seems that the *more structured* the cooperation, the *more it will succeed*. The reason for this seems to be that many of the critical barriers to cooperative R&D are structural and others are inherent in different outlooks, perspectives, and attitudes of those involved in the cooperation.

A strict and acceptable structure and benchmarked selected processes seem to greatly contribute to the minimization of the effects of these barriers, thus allowing the center's personnel to concentrate their effort on conducting research, rather than on solving organizational problems or managing conflicts of the collaboration itself.

The National Science Foundation has defined some criteria for success of the centers.[52] They are considered "minimally effective" if 80% achieve at least one goal, and 50% meet two or more.

The goals are: (1) to conduct interdisciplinary research; (2) to transfer knowledge; and (3) to graduate students with unique skills. These criteria are *in addition* to the minimum criteria listed in **Table 2**. A center would cease to exist as an NSF-sponsored center without continuing corporate membership.

This study of the IUCRCs has therefore suggested that the hypothesized effects of formalization, autonomy, and control have contributed to a more uniform and stable flow of activities in the generation and development of the centers. These dimensions helped the center director and the industrial members to construct a collaborative arrangement with little friction, low uncertainty, and fewer conflicts. The strict center model forced the partners to collaborate along structural lines that have already incorporated (and to some degree also resolved) many of the thorny issues that might generate dispute, such as intellectual property. The center model contains procedures for sharing, distribution, and publication of research results. It recognizes the need of academics to publish in the open literature while allowing member companies 90-120 days to review the material being published and to offer inputs. Another example is the planning of the research portfolio. Industrial members have an opportunity to provide inputs through the structured body of the industrial advisory board and its formal semi-annual meetings.

Autonomy of a center provides it with maneuvering space within the university, thus reducing potential conflicts with other academic departments. This also allows the center added flexibility in its interaction with industrial members.

Active participation and support from government are also crucial dimensions. In addition to the element of prestige, the study of the centers show that government support acts as a magnet to attract industrial partners by virtue of: (1) effect of the multiplier, in which companies see their fee multiplied by government funding and other partners' contributions. That is, in a ten member center, for a fee of $30 thousand per year, a company benefits from a research program of $300 thousand. 2) The symbolics of the highest stamp of scientific quality provided by the rigorous selection and assessment criteria of the National Science Foundation.

5.3 Limitations of the Study

The study has three major limitations. First, it focuses on the IUCRC programs, hence difficulties in generalizing the findings to other types of cooperative technology programs. Second, the study's methodology was confined to content analysis of the outcomes. Statistical tests were not performed on data that link infrastructure to performance.[53]

Third, the study was confined—by design—to the sample of industrial companies and their relation to the IUCRCs. Since the phenomena of joining, remaining, and terminating membership are decided by the member companies, their decision criteria were the sole target of the study. However, other factors in determining performance of the cooperation, such as technology transfer, were not included in the study design. The rationale was that the success or failure of technology transfer should have played a role in the company's decision to remain or terminate its membership.

6. CONCLUSIONS

R&D/technology cooperative organizations with a multipartner collaboration is an important mode in furthering the national economy's innovation base. These are also novel forms of organizations which have primarily been studied as mechanisms for technology transfer.

This study, which focused on the IUCRC network, suggests that there is value in shifting such research from the role of technology transfer toward the effects of the infrastructure as determinants of sustained performance. Focusing on infrastructure is a way to benchmark the cooperation. Focusing on infrastructure is a way to benchmark the cooperation, whereas emphasis on technology transfer limits the assessment of these novel organizations to its outputs. Benchmarking the infrastructure opens new directions for policy makers and scholars.

This study suggests that the infrastructure of cooperative organizations affects their sustained performance in that the dimensions of infrastructure impact decisions to join, remain, or terminate membership. These effects vary by the stage in the life cycle of the cooperative organization, and by the nature of the decision. For R&D/technology policy makers the implications are: (1) an improved understanding of how infrastructure affects the partners' decisions and (2) how to influence the dimensions of the organization's infrastructure for an improved chance of survival and sustained performance.

Because each decision (to join, remain or terminate) related to membership is essentially a different phenomenon, participants in the cooperation, when armed with this knowledge, may be able to modify their behavior and introduce changes in the infrastructure that would enhance incentives for members to join and remain in the cooperation. With the current state of knowledge, participants are called upon to merely improve the transfer of relevant technology from the cooperation to corporate members. This is a limited approach that creates tension and, because it is also difficult to measure, relies on the level of satisfaction of members— therefore suffering from biases in method and perceptions. Focus on infrastructure, getting down to the level of detail as the effects of specific dimensions at a given stage of the life cycle and for a specific type of decision allows for a much greater flexibility for interventions by participants who are vying for improved chances of success and survival.

Although this research is grounded in a study of a distinct group of R&D/technology collaborative organizations, it seems plausible to assert that the structure and established processes contribute to the resiliency and success of similar organizations. As Gibson and Rogers[54] have shown in their study of the Microelectronics and Computer Technology Corporation (MCC), this corporate consortium was “. . . constrained by political, social, economic, and legal conditions” (p.

545). They continue: “These constraints caused MCC's management to . . . support the concept of a standard package to facilitate technology transfer . . . and rely on formal structure . . .” (p. 545). The resiliency of MCC may be attributed, in part, to the structural model of standardization and formalization.

The contributions of the study reported in this paper are primarily in presenting a framework for analysis and benchmarking R&D/technology collaboration—in a scheme that differs from the traditional output-oriented approach which is based on technology transfer and commercialization criteria. This paper calls attention to the infrastructure of the cooperative arrangement as a major determinant of the collaboration's success and survival. Collaborative organizations that are novel and largely untried, if they are to succeed and survive, require an established, acceptable, formal, and standardized architecture of structure and processes. “Trial-and-error” approaches and uncertainty are detrimental to these organizations. Adaptation to external conditions seems to come from internal strength of a stable infrastructure.

For the organization scholar this study offers research possibilities in extending the line of investigation to different types of cooperative systems, and in learning about the behavior of structure and process dimensions in a multipartner collaborative arrangement.

7. FUTURE RESEARCH

This study focused on the complex organizational arrangements of multipartner R&D/technology cooperation, and its objective was to explore the role that infrastructure plays in the sustained performance of such cooperation.

Further research should focus on the specific effects of individual dimensions of infrastructure on sustained performance of IUCRCs as well as other types of complex R&D/technology cooperation. In **Table 2**, and in the discussion section, the dimensions of structure are listed and their hypothesized effects are outlined. These hypothetical effects roughly correspond to the research questions in section 3.2. The present study was the first attempt at finding out how infrastructure affects performance. Future research will therefore identify the factors (barriers and facilitators) impacted by the dimensions of infrastructure, thus influencing sustained performance.

Finally, future research should extend this line of investigation to other R&D/technology cooperations, such as engineering research centers, industry-government consortia, industrial R&D consortia, and strategic technology alliances.

NOTES AND REFERENCES

1. Geisler, E. (1995), "Industry University Technology Cooperation: A Theory of Interorganizational Relations," *Technology Analysis & Strategic Management*, 7(2), 217-229; Geisler, E. (2001), "Explaining the Generation and Performance of Intersector Technology Cooperation: A Survey of the Literature," *Technology Analysis & Strategic Management*, 13(2), 195-206.

2. Crow, M., and B. Bozeman (1987), "R&D Laboratories' Environmental Contexts: Are the Government Lab-Industrial Lab Stereotypes Still Valid?" *Research Policy*, 16(5), 229-258, and Bozeman, B., and M. Crow (1991), "Technology Transfer from U.S. Government and University R&D Laboratories," *Technovation*, 22(4), 231-246. Also see Geisler, E. (1994), "Commercializing Technology from Federal Laboratories: A Model and a Study of Mechanisms and Outputs," *Proceedings of the Conference of Technology Transfer Society*, Huntsville, Alabama, June, 61-68.

3. The terms cooperative "effort," "program," and "arrangement" are used interchangeably in the early sections of this paper. A more detailed description of the various modes of cooperation and their boundaries is offered later in the paper.

4. This paper explores cooperation in both R&D and technology. Although there are conceptual as well as operational distinctions in the definitions of research, development, and technology, they are lumped together because of two reasons. First, organizations cooperate across the entire innovation continuum from basic research to transfer of product and process technology. The transfer process allows very little flexibility (if any) to differentiate and isolate the precise portion or segment of the continuum being exchanged or in which cooperation is conducted. Second, the legal, organizational, and financial instruments used

by cooperating entities in describing, evaluating, and managing the cooperation do not make such distinctions.

5. Chakrabarti, A., and A. H. Rubenstein (1975), "Interorganizational Transfer of Technology: A Study of Adoption of NASA Innovations," *IEEE Transactions on Engineering Management*, 23(1), 20-34.

6. Bloedon, R., and D. Stokes (1994), "Making University/Industry Collaborative Research Succeed," *Research Technology Management*, March-April, 44-48.

7. Bozeman, B., and K. Coker (1992), "Assessing the Effectiveness of Technology Transform from U.S. Government R&D Laboratories: The Impact of Market Orientation," *Technovation*, 12(4), 239-255.

8. Ettlie, J. (1982), "The Commercialization of Federally Sponsored Technological Innovation," *Research Policy*, 11(1), 173-191.

9. Geisler, E., and A. Furino (1993), "University-Industry-Government Cooperation: Research Horizons," *International Journal of Technology Management*, 8(6/7/8), 802-811.

10. Geisler, E. and A. Rubenstein (1989), "University-Industry Relations: A Review of Major Issues," in A. Link and E. Tassey (Editors), *Cooperative Research: New Strategies for Competitiveness*, St. Martin's Press, 43-62; Borys, B., and D. Jemison (1989), "Hybrid Arrangements as Strategic Alliances: Theoretical Issues and Organizational Combinations," *Academy of Management Review*, 14(3), 234-249; Scott, S. G., and R. Bruce (1994), "Determinants of Innovative Behavior: A Path Model of Individual Innovation in the Work Place," *Academy of Management Journal*, 37(3), 580-607; Tornatzky, L., L. Casson, P. Waugaman, and A. Furino (1994), "Defining the Center Analyst Function in State/Industry

University Cooperative Research Centers: Summary Report," The Southern Technology Council, December 27, NSF Grant 9422603.

11. Gray, B. (1985), "Conditions Facilitating Interorganizational Collaboration," *Human Relations*, 38, 911-936.

12. Geisler, E. (1986), "The Role of Industrial Advisory Boards in Technology Transfer Between Universities and Industry," *Journal of Technology Transfer*, 10(2), 33-42.

13. Geisler, E., A. Furino, and T. Kiresuk (1990), "Factors in the Success or Failure of Industry-University Cooperative Research Centers," *Interfaces*, 20(6), 99-109.

14. Chen, H., K. Lynch, A. Himler, and S. Goodman (1992), "Information Management in Research Collaboration," *International Journal of Man-Machine Studies*, 36(1), 419-445.

15. Gibson, D., and E. Rogers (1994), *R&D Collaboration on Trial*, Harvard Business School Press, Boston, MA.

16. Hagerdoorn, J. (1993), "Understanding the Rationale of Strategic Technology Partnering: Interorganizational Modes of Cooperation and Sectoral Differences," *Strategic Management Journal*, 14(5), 371-386, and Rubenstein, A. H. and E. Geisler (1994), "Relations Between University-Industry Interaction and Industrial Innovation," *CITT*, Final Report to National Science Foundation, Northwestern University, Evanston, IL.

17. Geisler, E., A. Furino, and T. Kiresuk (1991), "Towards a Conceptual Model of Cooperative Research: Patterns of Development and Success in University-Industry Alliances," *IEEE Transactions on Engineering Management*, 38(2), 136-145.

18. Geisler, Furino, and Kiresuk (1999), *op. cit.*

19. Geisler, E. (1993), "On the Importance of University-Industry-Government Cooperation: A Global Perspective," *International Journal of Technology Management*, 8(6/7/8), 435-439.

20. Drucker, P. (1979), "Science and Industry: Challenges of Antagonistic Interdependence," *Science*, May 25, pp. 1110-1116.

21. Marazitta, C. (1991), "Technology Transfer in the United States: Industrial Research at Engineering Research Centers Versus the Technological Needs of U.S. Industry," *Technological Forecasting and Social Change*, 39(4), 397-410.

22. Radosevich, R., and S. Kassicieh (1993), "Strategic Challenges and Proposed Responses to Competitiveness through Public-Sector Technology," *California Management Review*, Summer, 35(1), 33-50.

23. Geisler and Rubenstein (1989), *op. cit.*

24. Hagedoorn (1993), *op. cit.*

25. Geisler (2001), *op. cit.*

26. Hagerdoorn, J., and J. Schakenraad (1994), "The Effect of Strategic Technology Alliances on Company Performance," *Strategic Management Journal*, 15(4), 291-310.

27. Borys and Jemison (1989), *op. cit.*

28. Gray, D., T. Gidley, and N. Koester (1988), *Evaluation of the NSF Industry/University Cooperative Research Centers: Longitudinal Analyses of Outcomes and Processes*, North Carolina State University, December, Raleigh, N.C.

29. Gray, D. (1994), "The 1980-1992 Structural Information on the Industry-University-Cooperative Research Centers," North Carolina State University, IUCRC Program Database.

30. Gray, D., and D. Meyer (1995), "1993-1994 Structural Information of the Industry-University Cooperative Research Centers," North Carolina State University, IUCRC Program Database.

31. Morris, C. R., and C. Ferguson (1993), "How Architecture Wins Technology Wars," *Harvard Business Review*, March-April, 86-96.

32. The terms "structure" and "infrastucture" are used interchangeably. They refer to the basic dimensions that describe the organizational building blocks of cooperative arrangement, such as the traditional dimensions of formalization complexity and control. The term "architecture" refers to the combination or mode of arrangement of these dimensions so that different forms of organization emerge from different combinations.

33. Rubenstein and Geisler (1994), *op. cit.*

34. Walters, G., and D. Gray (Eds.) (1998), *Managing the Industry/University Cooperative Research Center*, Columbus, OH, Battelle Press.

35. Daft, R., and A. Lewin (1993), "Where are the Theories for the 'New' Organizational Forms?" *Organization Science*, 4(4), i-vi.

36. In the case of the IUCRCs, the financial support of government is designed to be drastically reduced after 5 years. Yet, where government maintained *some* financial support, the cooperative program seemed to have a better chance to remain a viable entity. (Industry participation accounted for about 38% of total center funding (2000 figure).)

37. Gray (1994), *op. cit.*

38. Gray, D. (2000), *Trends From Center Structure Database*, Report to the National Science Foundation, North Carolina State University.

39. See Borys and Jemison (1985), *op. cit.*; Geisler and Furino (1993), *op. cit.*; and Rubenstein and Geisler (1994), *op. cit.* These are illustrative sources of an extensive literature.

40. Grant, R. M. (1991), "The Resource-Based Theory of Competitive Advantage," *California Management Review*, 33(3), 114-135 and Wennerfeldt, B. (1984), "A Resource-based View of the Firm," *Strategic Management Journal*, 5(2), 171-181.

41. Geisler (1995), *op. cit.*

42. Hagedoorn (1993), *op. cit.*

43. Mervis, J. (1995), "Asking Science to Measure Up," *Science*, 267(6), January 20-22.

44. "Exit interviews" are part of the evaluation package that center evaluators administer in their evaluation effort, as mandated by NSF. The author administered these interviews to 12 companies who terminated their membership in the center that the author was evaluating.

45. Gray and Meyer (1995), *op. cit.*

46. Zenger, T. (1994), "Explaining Organizational Diseconomies of Scale in R&D: Agency Problems and the Allocation of Engineering Talent, Ideas, and Effort by Firm Size," *Management Science*, 40(6), 708-729.

47. Although this paper emphasized the effect of structure and processes on success and sustainability, there is also the effect of technology transfer and the degree to which centers satisfy their constituencies that may impact success (Geisler, Furino, and Kiresuk, 1990). The purpose of this paper's emphasis on structure and processes was not intended to diminish the relative contribution of technology transfer (i.e., outputs from the cooperation), rather to highlight the role that structure and processes play. This role has received little attention in the literature and this paper is therefore an attempt to offer a contribution in this area.

48. Faulkner, W., and J. Senker (1994), "Making Sense of Diversity: Public-Private Sector Research Linkage in Three Technologies," *Research Policy*, 23(6), 673-696.

49. Another moderating variable may be the type of technology or main discipline in the center's research agenda. However, the findings do not show any clustering of data by the type of technology.

50. Browning, L., J. Beyer, and J. Shetler (1995), "Building Cooperation in a Competitive Industry: SEMATECH and the Semiconductor Industry," *Academy of Management Journal* 38(1), 113-151.

51. See, for example, Scott and Bruce (1994), *op. cit.*, and Chakrabarti and Rubenstein (1975), *op. cit.*

52. See Mervis (1995), *op. cit.*

53. Except to verify the differences in the attributes of respondents.

54. Gibson and Rogers (1994), *op. cit.*

FIGURE 1. RELATION BETWEEN TYPE OF COOPERATION[(1)] AND LEVEL OF ORGANIZATIONAL COMPLEXITY[(2)]

LEVEL OF ORGANIZATION OR INSTITUTIONAL COMPLEXITY			
High		•joint research •joint ventures •advisory review boards •start-up support	•consortia •research centers •research parks •extension services
Medium		•research sponsoring •licensing agreements •staff exchanges •subcontracting •joint publications •training & advancement •joint writing of proposals	
Low	•information transfer •informal contacts		
	Short term contact or activity	Longer term activities with agreements	Sustainable organizations with institutional arrangements

TYPE OF COOPERATION

(1) The entries in the cells do not constitute a complete nor an exhaustive list. They are only illustrations.

(2) Assignment of entries to cells is arbitrary and based on the relevant literature and interviews with managers of cooperative R&D.

FIGURE 2: THE CONCEPTUAL MODEL

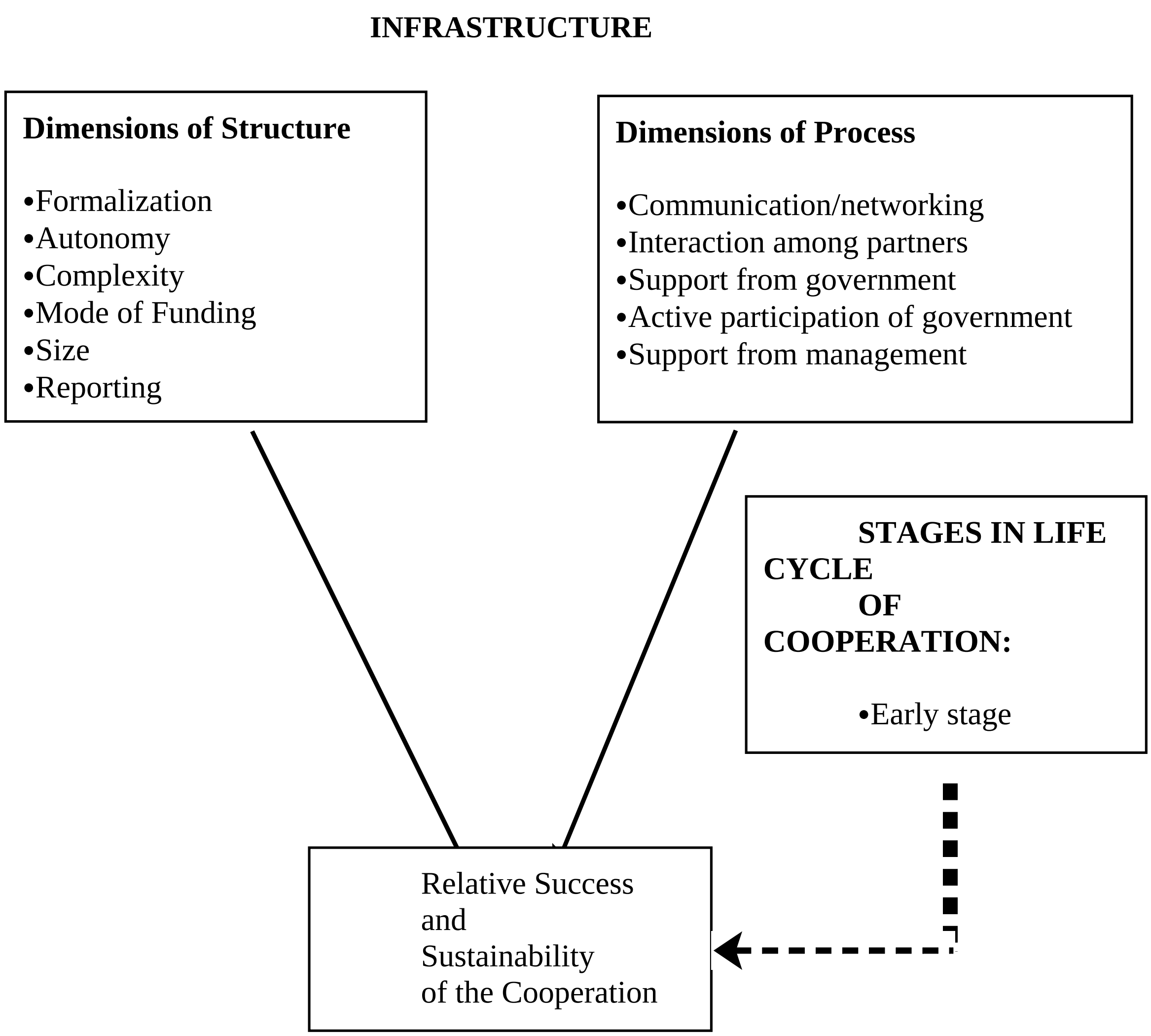

TABLE 1: INDUSTRY-UNIVERSITY-GOVERNMENT R&D/TECHNOLOGY COOPERATION: CLASSIFICATION BY ORGANIZATION AND TYPE OF COOPERATION

Major Types of Cooperation[1]	University-Industry	Government-Industry[2]	Government-University	University-Industry-Government
•Research sponsoring	x	x	x	x
•Joint research	x	x	x	x
•Licensing agreements	x	x	x	x
•R&D limited partnerships	x			x
•Staff exchanges	x	x	x	x
•Procurement of services	x	x	x	x
•Extension services		x	x	x
•Subcontracting	x	x	x	x
•Joint publications	x	x	x	x
•Joint writing of proposals	x	x	x	x
•Joint ventures	x	x	x	x
•Information transfer	x	x	x	x
•Advisory review boards	x	x	x	x
•Start-up support	x	x	x	x
•Training & advancement (seminars, symposia, meetings)	x	x	x	x
•Consortia	x	x	x	x
•Research centers/institutes	x	x	x	x
•Research parks				x

(1) Not in order of complexity nor sustainability of the cooperation. Type may also be defined in some cases as a *mode* of cooperation rather than an organizational construct. This list is not exhaustive.

(2) Refers to government R&D performing laboratories and government agencies who fund and sponsor research. The latter do not participate in joint research or other such cooperative effort.

TABLE 2. OPERATIONAL DEFINITIONS OF THE DIMENSIONS OF THE INFRASTRUCTURE AND THE SUSTAINED PERFORMANCE OF COOPERATIVE R&D/TECHNOLOGY

A. DIMENSIONS OF STRUCTURE

1. Formalization

1.1 How formal is the cooperative association, measured by:

- It has a separate legal entity.
- It has its own basic constitution or set of principles at time of foundation.
- It has a separate set of rules, regulations, and work procedures.

2. Autonomy

2.1 How much leeway/autonomy does the cooperative organization have (leeway/ autonomy is defined as the ability to make decisions and carry out activities, without the prior consent and interference from others—in the following areas):

- In deciding and procuring resources (human, financial, facilities, equipment).
- In entering into agreements with other organizations.
- In having its own independent and unique set of work rules, structure, and procedures—regarding its relations with partners and with others extraneous to the cooperation.

3. Complexity

3.1 How complex is the structure of the cooperation in terms of:

- Number of entities who are partners to the cooperation:
  —Dyadic or triadic association
  —Multimember association
- Number (diversity) of types of entities who are partners (e.g., industrial members and government labs who are members in the cooperation comprise entities from various industries, product lines, sizes, disciplines, and mode of production) versus, for example, industrial members who are all from the same industry (e.g., computer makers).

4. Mode of Funding

4.1 How is the cooperative effort being funded:

- Government funds only (federal and/or state and/or county, municipality, etc.)
- Participants (partners) only
- Mix of government and participants (partners)

4.2 Level of Funding

- Sufficient for total operation of the cooperative entity
- Insufficient for total operation: cooperative entity needs to supplement the budget. For example, through selling of technical projects and consulting to individual partners and/or to entities extraneous to the cooperation.

5. Size

5.1 How large is the cooperative entity:

- Number of administrative staff
- Number of full time equivalent scientists and engineers
- Number of full time equivalent technicians
- Ratios of above
- Average size of a *project* in dollars and scientific personnel

6. Control

6.1 Lines of reporting

- Director/Head of cooperative entity reports to:
  —Board of directors representing the participating organizations (partners)
  —Government agency
  —Other

6.2 Existence of a dedicated monitoring/evaluation activity:

- Dedicated evaluator assigned by a participating organization/s
- Dedicated evaluator assigned by government agency
- One form of monitoring/evaluation

7. Reporting

- Modes of reporting
- Frequencies of reporting

B. DIMENSIONS OF PROCESSES

1. Communications/Networking
2. Interaction among partners
3. Support from government (nonmonetary, i.e., guidance, advice, administrative, assistance)
4. Active participation of government agencies in the cooperation
5. Support from management of participating entities (e.g., support from senior corporate management and/or from senior university administrators, and/or session government laboratory administrators)

C. SUSTAINED PERFORMANCE

1. Cooperation is still viable.
2. Cooperation has a core of at least five member companies who maintain membership for 5 years or longer.
3. Rate of membership terminations does not exceed 20% of membership per year.
4. Quality of outputs consistently to the satisfaction of partners.

TABLE 3: HYPOTHESIZED RELATION BETWEEN SELECTED ELEMENTS OF STRUCTURE AND PROCESSES AND STAGES IN LIFE CYCLE OF COOPERATION[(1)]

STAGE IN LIFE CYCLE[(2)]

Dimensions of Infrastructure	Early Stages[(3)]	Midlife Stages[(4)]	Viability[(5)]
A. Structure			
1. Formalization	High	Low	High
2. Autonomy	High	Low	High
3. Complexity	Low	Low	High
4. Control	High	Low	High
B. Processes			
5. Communication/Networking	High	Low	High
6. Interaction Among Partners	High	Low	High
7. Support from Government	High	High	High
8. Active Participation of Government	High	Low	Low
9. Support from Management	High	High	High

(1) Entries in the cells of the matrix are hypothesized levels of the selected element that would lead to success of the cooperation.
(2) Source: Geisler, Furino, and Kiresuk (1991).
(3) Comprises the following stages: Genesis, Planning, and Initial Operation.
(4) Comprises the following stages: Intermediate and Growth and Change.
(5) Comprises the following stages: Maturity and Viability (Self-Sustainability).

TABLE 4: DISTRIBUTION OF RESPONDING COMPANIES BY UNIT OF R&D AND PARTICIPATION IN IUCRCs (N = 87)

A. Joined Center (N = 41)

Current Status	Division	Central Laboratory
Current member[(1)]	31 (75%)	2 (5%)
Have terminated membership	7 (17%)	1 (2.5%)
Total	38 (92%)	3 (8%)[(2)]

(1) Average stay as member in a center was 3.5 years.
(2) Percentages are rounded upwards to nearest integer.

B. Never Jointed a Center (N = 46)

Division	Central Lab
31 (67%)	15 (33%)

TABLE 5: FACTORS IMPACTING A COMPANY'S DECISION TO JOIN AN INDUSTRY-UNIVERSITY-COOPERATIVE RESEARCH CENTER

Rank	Factor/Potential Benefit[1]	Category	% Respondents Ranking[2] (N=41)
1	Exposure to state of the art knowledge	S/T[3]	93%
2	Prestige of NSF	STR[4]	90
3	Unique expertise of the center	S/T	85
4	NSF's active involvement with center	STR	80
5	NSF's financial support	STR	73
6	Existence of a blueprint for center	STR	71
7	Interaction with other companies in the center	STR	68
8	Previous experience with university interaction	MAN/EXP[5]	61
9	Relative low cost of academic research (outsourcing)	ECON[6]	56
10	Previous personal contacts with professors	MAN/EXP	54
11	Center contacted company & marketed itself	STR	51
12	Relative autonomy of center within the university	STR	49
13	Improve scientific skills of company researchers	STR	44
14	Senior management's support of center membership	MAN/EXP	39

Other Factors in the Original List

- Enlarge pool of R&D dollars
- Reduce costs in manufacturing and other areas in company
- Help solve technical problems
- Experience of other companies with centers
- Potential receipt of technology
- Potential inputs into new product development

(1) Some factors are potential benefits that the company expects from its eventual participation in the center.
(2) This number is the rounded percent of respondents who ranked the factor by the degree to which it had impacted the company's decision to join a center.
(3) S/T is the scientific/technical category.
(4) STR is the structural category.
(5) MAN/EXP is the category combining experience with the managerial aspects of the factor.
(6) ECON is the economic and financial category.

TABLE 6: FACTORS IMPACTING THE DECISION NOT TO JOIN AN INDUSTRY-UNIVERSITY-COOPERATIVE RESEARCH CENTER

Rank	**Factor**	**% Respondents Ranking (N = 46)**
1	Don't know much about the center	91%[(1)]
2	Little trust in potential outputs/benefits	85
3	Lack of funds	70
4	No need for membership to obtain academic outcomes	65
5	Already involved with other types of cooperation with universities	63
6	Never contacted by a center	58
7	Poor experience of other divisions with university cooperation	54
8	Poor experience of our division with university cooperation	49
9	Lack of support from top management	44
10	There are no documented benefits	39

(1) This number is the rounded percent of respondents who ranked the factor by the degree to which it had impacted the company's decision not to join a center.

TABLE 7: FACTORS IMPACTING THE DECISION TO REMAIN MEMBER OF AN IUCRC BY STAGE IN THE CENTER'S LIFE CYCLE

	Stage of Life[2]		
Factor[1] (N = 31)	**Early**	**Midlife**	**Viability**
•Access to university facilities/resources	96%[3]		
•NSF's financial & administrative support	90		
•Existence of a structured interaction with faculty and other companies	64		
•NSF's role as quality control	61	80	71
•The Industrial Advisory Board	48	71	64
•Communication network with faculty and students		58	55
•High quality of research outputs		45	55
•Management supports membership		42	48
•Unique experience gained			42
•Window to state of the art technology		35	
•Existence of a structure for interaction and conflict resolution		39	32
•Technology actually transferred			32
•Technical problems solved			29
•Cost effectiveness of membership (payoff at least equal to membership fee)		29	26
•Relative autonomy of the center in the university setting			26

(1) Some factors are potential benefits to the company.
(2) See Table 3 for description of the stages in the life cycle of the center.
(3) This number is the rounded percent of respondents who ranked the factor by the degree to which it had impacted the decision to remain in a center.

TABLE 8: FACTORS IMPACTING THE DECISION TO TERMINATE MEMBERSHIP IN AN IUCRC BY STAGE IN THE CENTER'S LIFE CYCLE

	Stage of Life[2]		
Factor (N = 20)	**Early**	**Midlife**	**Viability**
• Competition for corporate R&D funds	95%[1]	95%	55%
• Inability to justify membership fee	90	90	
• Poor transfer of technology		85	80
• Cost effectiveness of membership		80	70
• Management lacks support for membership		65	60
• High expectation not fulfilled		50	45

(1) This number is the rounded percent of respondents who ranked the factor by the degree to which it had impacted the company's decision to terminate membership.
(2) See Geisler, Furino, and Kiresuk (1991) for composition of the stages.

TABLE 9: FACTORS ON BENEFITS THAT WOULD HAVE PROBABLY MADE A COMPANY JOIN AN IUCRC

Factor(1)	Respondent in Division(2) (N = 31)	Respondent in Corporate Lab(3) (N = 15)
• Additional relevant information	97%(4)	93%(4)
• Support & approval of the management	90	33
• Demonstrable potential benefits	81	53
• Exposure to current technology	45	87
• Corporate policy dictating such ventures (e.g., outsourcing)	55	27

(1) Factors include benefits to the organization or circumstances/situations that respondents have ranked in order of their contribution to the decision to join, if they had occurred, and if funds were available.
(2) Respondents who work for a company division, and who have never joined an IUCRC (although they may have cooperative programs with universities).
(3) Respondents in corporate research laboratories who have never joined an IUCRC (although they may have cooperative programs with universities).
(4) This number is the rounded percent of respondents who ranked the factor by the degree to which it would have contributed to their company's decision to join an IUCRC, assuming that funds were available for such a venture.