EVALUATING THE EFFECTIVENESS OF STATE-BASED R&D CENTERS: A
STUDY OF THE OHIO EDISON TECHNOLOGY PROGRAM

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy
in the Graduate School of The Ohio State University

By

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****

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1998

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Graduate Program
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Chapter Four will elaborate on the methodology of the dissertation. Chapter Five will highlight the data collected from the surveys which will then be analyzed to identify critical factors and processes that help determine the effectiveness of the consortia.

The sixth chapter will contain discussion of the findings and conclusions. A discussion of the generalizability of these findings as well as suggestions for further studies in this area will follow. A copy of the survey instruments is attached in a separate appendix.
This project is dedicated to four generations.

My grandparents for my heritage,
My parents for their love,
My sister and brother-in-law for their steadfast faith,
My niece and nephew who give me hope for the future.
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# TABLE OF CONTENTS

Abstract ......................................................................................................................... ii

Dedication ..................................................................................................................... iv

Acknowledgments ........................................................................................................... v

Vita ................................................................................................................................. viii

List of Tables .................................................................................................................. x

List of Figures ................................................................................................................ xii

Chapters:

1. Introduction .............................................................................................................. 1

2. The Edison Program ................................................................................................. 13
   2.1 Edison Program Evaluation ............................................................................... 20
   2.1.1 Summary of NRC Survey (1990) ................................................................. 20
   2.1.2 Summary of Mt. Auburn Survey (1992) .................................................... 22
   2.1.3 Summary of Battelle Study (1996) ............................................................ 26
   2.2 Evaluation Efforts to Date .................................................................................. 27
   2.3 Future Assessment Needs ................................................................................... 28

3. Literature review ....................................................................................................... 34
   3.1 Background ........................................................................................................ 34
   3.2 Strategic Alliances ............................................................................................. 35
   3.3 Research on Alliance Member Characteristics .............................................. 43
   3.4 Consortial Functions and Objectives ............................................................... 46
   3.5 The Problems with Cooperative R&D ............................................................. 47
   3.6 Research Questions ........................................................................................... 49

4. Methodology ............................................................................................................. 52
   4.1 The Survey Decision ......................................................................................... 52
   4.2 General Survey Design ..................................................................................... 53
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.3</td>
<td>The Survey Packet</td>
<td>54</td>
</tr>
<tr>
<td>4.4</td>
<td>Design of the Questionnaire</td>
<td>54</td>
</tr>
<tr>
<td>4.5</td>
<td>Data Collection</td>
<td>59</td>
</tr>
<tr>
<td>4.6</td>
<td>Non-response Bias</td>
<td>62</td>
</tr>
<tr>
<td>4.7</td>
<td>Validity and Reliability Issues</td>
<td>63</td>
</tr>
<tr>
<td>4.8</td>
<td>Data Analysis</td>
<td>66</td>
</tr>
<tr>
<td>5</td>
<td>Results</td>
<td>68</td>
</tr>
<tr>
<td>5.1</td>
<td>Question 1</td>
<td>68</td>
</tr>
<tr>
<td>5.2</td>
<td>Question 2</td>
<td>70</td>
</tr>
<tr>
<td>5.3</td>
<td>Question 3</td>
<td>73</td>
</tr>
<tr>
<td>5.4</td>
<td>Question 4</td>
<td>74</td>
</tr>
<tr>
<td>5.5</td>
<td>Question 5</td>
<td>80</td>
</tr>
<tr>
<td>5.6</td>
<td>Question 6</td>
<td>81</td>
</tr>
<tr>
<td>5.7</td>
<td>Question 7</td>
<td>85</td>
</tr>
<tr>
<td>5.8</td>
<td>Question 8</td>
<td>93</td>
</tr>
<tr>
<td>6</td>
<td>Discussion and Conclusions</td>
<td>94</td>
</tr>
<tr>
<td>6.1</td>
<td>Summary of Findings</td>
<td>94</td>
</tr>
<tr>
<td>6.2</td>
<td>Mapping the Research Process</td>
<td>98</td>
</tr>
<tr>
<td>6.3</td>
<td>Contributions</td>
<td>103</td>
</tr>
<tr>
<td>6.4</td>
<td>Limitations of the Study</td>
<td>104</td>
</tr>
<tr>
<td>6.5</td>
<td>Future Research</td>
<td>106</td>
</tr>
</tbody>
</table>

Appendices

- A. The Ohio Edison Technology Program Survey | 109
- B. Logit Regression | 112

Bibliography | 113


<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1</td>
<td>Distribution of firms based on years with an Edison Center</td>
<td>68</td>
</tr>
<tr>
<td>5.2</td>
<td>Distribution of firms based on size</td>
<td>69</td>
</tr>
<tr>
<td>5.3</td>
<td>Distribution of firms based on R&amp;D/sales</td>
<td>70</td>
</tr>
<tr>
<td>5.4</td>
<td>Cross-tabulation for satisfaction and demographic variables</td>
<td>73</td>
</tr>
<tr>
<td>5.5</td>
<td>Reasons for dissatisfaction with the Edison Program</td>
<td>73</td>
</tr>
<tr>
<td>5.6</td>
<td>Frequencies and availability for Program offerings</td>
<td>74</td>
</tr>
<tr>
<td>5.7</td>
<td>Cross-tabulation of length of tenure and importance of Program offerings</td>
<td>77</td>
</tr>
<tr>
<td>5.8</td>
<td>Cross-tabulation of member firm size and importance of Program offerings</td>
<td>78</td>
</tr>
<tr>
<td>5.9</td>
<td>Cross-tabulation of R&amp;D intensity and importance of Program offerings</td>
<td>80</td>
</tr>
<tr>
<td>5.10</td>
<td>Availability of benefits within an Edison Center</td>
<td>81</td>
</tr>
<tr>
<td>5.11</td>
<td>Cross-tabulation of consortia-type &amp; ranked importance of Program offerings</td>
<td>82</td>
</tr>
<tr>
<td>5.12</td>
<td>Cross-tabulation of consortia-type &amp; ranked importance of Program benefits</td>
<td>83</td>
</tr>
<tr>
<td>5.13</td>
<td>Cross-tabulation of previous experience with an Edison Center and ranked importance of Program offerings</td>
<td>86</td>
</tr>
</tbody>
</table>
5.14 Cross-tabulation of previous experience with other R&D centers and ranked importance of Program offerings ...........................................87

5.15 Cross-tabulation of previous experience with other forms of R&D alliance and ranked importance of Program offerings ...........................................93
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Trends in U.S. R&amp;D spending (1953-1993)</td>
<td>5</td>
</tr>
<tr>
<td>5.1</td>
<td>Satisfaction and length of tenure</td>
<td>71</td>
</tr>
<tr>
<td>5.2</td>
<td>Satisfaction and firm size</td>
<td>72</td>
</tr>
<tr>
<td>5.3</td>
<td>Satisfaction and R&amp;D intensity</td>
<td>72</td>
</tr>
<tr>
<td>5.4</td>
<td>Ranked importance of state-of-the-art facilities</td>
<td>78</td>
</tr>
<tr>
<td>5.5</td>
<td>Ranked importance of customer/supplier networking opportunities by firm size</td>
<td>79</td>
</tr>
<tr>
<td>5.6</td>
<td>Ranked importance of meeting other firms with similar research interests by consortia-type</td>
<td>83</td>
</tr>
<tr>
<td>5.7</td>
<td>Received new sales contract based on consortia-type</td>
<td>84</td>
</tr>
<tr>
<td>5.8</td>
<td>Received new research agreement based on consortia-type</td>
<td>85</td>
</tr>
<tr>
<td>5.9</td>
<td>Ranked importance of meeting firms with similar research interests and previous Edison Center experience</td>
<td>86</td>
</tr>
<tr>
<td>5.10</td>
<td>Ranked importance of state-of-the-art facility and experience with other R&amp;D centers</td>
<td>88</td>
</tr>
<tr>
<td>5.11</td>
<td>Ranked importance of the latest development and previous experience with an R&amp;D center</td>
<td>89</td>
</tr>
<tr>
<td>5.12</td>
<td>Previous experience with R&amp;D centers and ranked the importance of training and education</td>
<td>90</td>
</tr>
</tbody>
</table>
CHAPTER 1

INTRODUCTION

An Ohio Edison R&D center manager made the following observation during an introductory interview for a market research study (Camp and Ward, 1990) that laid the premise for this dissertation on state-based R&D programs. “As an engineer for McDonnell-Douglas during the ‘60s and ‘70s, I was constantly running into problems in developing materials to build better aircraft. Often the solution for a problem lay outside my staff’s expertise. The funny thing is that I knew a person who had the solution to my problem. Unfortunately, he worked at Lockheed and I was not allowed to contact him. That is why this country needs a best-team’s approach.”

A best-team’s approach is an industrial system where companies would share intellectual assets – technology, employees, and intellectual property – in order to create better goods at lower costs. This approach would be especially useful to firms in industries that require large amounts of research and development expenditures in order to stay competitive. But utilizing a best-team’s approach runs contrary to American public policy.

Until the passage of the National Cooperative Research Act in 1984, the U.S. government had shown a reluctance to pursue any policy that would allow this type of collaboration. The reason for the change in this attitude can be explained by examining
historical events (and consequent R&D funding) at three levels – national government, state government, and the individual firm – in the past three decades.

**History**

**National**

For over two centuries American industry has been founded on the idea of free enterprise, open competition (where each competitor independently develops its own innovative product to satisfy a consumer need), and individual initiative. The U.S. government worked hard to maintain that ideal by passing antitrust legislation in the first half of the century to prevent ‘unfair’ collaborations. In the second half, the Justice Department has abrogated any proposed merger or joint venture that might be deemed anti-competitive.

Believing that an open system was the best way to secure continued market growth and a diverse economy, the U.S. government has resisted creating any form of cohesive industrial policy that would favor one industry (or company) over another. Although this open system may lead to additional product innovation and more choices in the marketplace, it also means that firms might spend millions of dollars for technology and products that will flop in the market (e.g. the choice of VHS over Beta as the industry standard for videocassette recorders).

This does not mean that the government has abstained from influencing U.S. industry. The pursuit of various national and geopolitical objectives over the years has created a de facto or latent industrial policy that funneled billions of dollars into various industries. The first national programs benefited a wide range of industries. These programs included the drive to create transportation infrastructure through the building of
railroads and canals in the 1800s and the growth of hydroelectric projects in the years leading up to the second world war. However, believing that science and technology were major factors in a winning war effort (e.g. the Manhattan Project), the U.S. government began committing more dollars to basic research (Quinn, Baruch, Zien, 1997).

This renewed emphasis on basic research led to the creation of bureaucratic structures (e.g. National Science Foundation (NSF)) to help channel government spending. In addition, the onset of the Cold War ensured that the Department of Defense would continue to receive massive infusions of government research funding. The focus on matching the Soviet development of arms led directly to a similar race in space exploration and the resultant funding of the National Aeronautics and Space Agency (NASA). As new interests and crises arose the government developed new bureaucratic systems to deal with these areas (e.g. the 1970s oil embargo and government programs to develop alternative energy sources).

Although total federal funding for R&D has grown in the past thirty years, the allocation process has been somewhat unsteady. Depending on the geopolitical situation and the current party in office, defense R&D might fall as it did from 1968 to 1975 or rise dramatically as it did during the Reagan administration’s arms race with the Soviet Union in the 1980s (Payson and Jankowski, 1996). In addition to changing national objectives influencing federal R&D spending, the federal R&D allocation process is also influenced by the political pork system. Legislators often see the R&D funding process as a way to gain political favor with their constituents by garnering research contracts for organizations within their districts. These two factors – in combination with the
preference for an open, competitive marketplace – virtually guarantee that an industrial policy with specific R&D objectives is an unlikely prospect in the foreseeable future.

State

In the 1960s, one-third of Ohio’s workers were employed in manufacturing. Although manufacturing employment in Ohio reached its zenith in 1973, six years later the state still had one of the highest levels of manufacturing employment of any state. However, the years 1980-1983 saw Ohio lose nearly one-fourth of its manufacturing jobs as many large firms began closing plants and laying off workers due to economic problems and the realities of global competition. Since many other jobs dependent on manufacturing were also lost, Ohio became a part of the so-called Rust Belt. (Mount Auburn Associates, 1992)

The economic realities of the Rust Belt forced state legislatures (and municipal governments) to begin looking for ways to improve their downtrodden manufacturing sectors. Their eventual responses to encourage economic development were varied. Bartik (1991) divides economic development programs into two categories – traditional and ‘new wave’. Traditional programs – tax abatements, customized employee training, and potential site development – are designed to encourage business growth through plant and business relocation from outside the state. New wave programs – small business assistance plans, industrial research parks, technology transfer activities (including R&D consortia), and export assistance – are designed to stimulate business growth from the inside. Ohio adopted both traditional and new wave approaches.
Firm

The market forces that left the Rust Belt states scrambling to shore up their crumbling manufacturing sectors were obviously felt at the individual firm level. Businesses that had long thrived through all the cycles of the American economy were suddenly faced with the twin specters of increased international competition and massive industrial upheaval through restructuring. Firms were forced to cut back on many expenses that were deemed less essential to the health of the organization. These cutbacks often included a large portion of the allocations for research and development.

The Current U.S. Situation

In 1992, a report by the National Science Board Committee on Industrial Support for R&D revealed several startling facts:

1) The U.S. has experienced a decrease in the real growth rate of spending on R&D since the early 1980s,

2) This decrease has occurred at both the federal and the industry level

3) In non-defense R&D expenditures, the U.S. spent 25% less than most of its national competitors in the G-7,

4) U.S. firms that do invest in R&D weight their spending toward product-oriented R&D at the expense of process R&D,

5) An unwillingness to invest in pre-competitive or ‘basic’ research was cited as the primary factor impacting the U.S. industry’s capacity to compete in international technology markets.

This situation is unlikely to improve in the near future. In examining the semiconductor industry, Rea, Brooks, Burger and LaScala (1997) suggest that
these numbers will continue to drop as the U.S. government continues to move toward a balanced budget. More government programs will find their budgets severely reduced – leaving less money available to invest in R&D. This reduction will accentuate a long-term trend of less reliance on federal support for research and development (see Figure 1.1).

![U.S. Trends in R&D Spending](image)

Figure 1.1 – Trends in U.S. R&D spending (1953-1983)
(Source: National Patterns of R&D Resources – 1996)

**An International Comparison**

While American firms are experiencing a shortfall in R&D funding, many of their international counterparts are able to invest heavily in R&D. For
example, Japanese companies have had several factors working in their favor. The first is that Japan does have an industrial policy as set forth by the Ministry of International Trade and Industry. This allows the government to prioritize its spending on R&D. Secondly, unlike American firms, Japanese managers are not pressured to create high profit margins or make short-term investments. This allows them to reinvest their profits rather than pay out dividends. Thirdly, the Japanese have been willing to participate in collaborative arrangements and large-scale projects for the industry’s good (e.g. the Very Large Scale Integration – VLSI – project in semiconductors which yielded almost 1000 patents in just four years) (Link and Tassey, 1987).

**Consortia**

**The Passing of the NCRA**

Despite lapses in other areas, the Reagan Administration did recognize that American businesses competing internationally were up against firms with an unfair advantage. To assist U.S. firms in highly competitive industries with higher R&D costs, the National Cooperative Research Act was passed in 1984. The NCRA relaxed antitrust regulations and paved the way for businesses to enter into multi-firm collaborative arrangements for conducting research and development. One of the most common forms of this type of collaboration is the R&D consortium.

Consortia involve the pooling of resources between organizations to reduce the risks and costs of particular activities (Evan and Olk, 1990). In the United States and
Europe this often involves direct competitors – companies at the same horizontal level in a single industry – as well as other firms in the supply chain coming together for research and development purposes. In the Pacific Rim countries, the Japanese keiretsu and the Korean chaebol are often formed across more vertical levels -- supplier and buyer (Lei and Slocum, 1991), although horizontal relationships, such as Japan's VLSI chip program, are not totally unknown (Leibowitz, 1990).

The use of consortia in the U.S. business sector dates back to the founding of the Electric Power Research Institute (EPRI) in 1973 (Corey, 1997). However, its usage in the business community was limited due to the fear of the triple damages that can be awarded for violating the antitrust laws. While the NCRA was not the genesis for the utilization of consortia in the U.S., its existence helped legitimize the form as a tool for conducting joint research and development. Over 140 firms were registered under the NCRA in the year following its passage into law.

**State-based Consortia**

In the early 1980s, several states began planning to create R&D centers to encourage economic development. The state of Ohio founded one of the first state-based R&D centers – the Thomas Edison Program – in 1983. Scattered throughout the state, these R&D centers were designed to create a three-way partnership between the government, academic institutions, and private industry. It was hoped that these centers would facilitate technology transfer from research programs in academe to private industry. In turn this would improve the competitiveness of existing firms as well as create an environment for the creation
of new firms. The state encouraged business participation by offering to leverage private industry research dollars with matching state funds.

**Differences between Industry and State-based Consortia**

The fact that these centers were established and partially funded by the state makes them somewhat unique in comparison to consortia formed by solely by industry. Two of the differences include accountability and membership

*Accountability:* The directors of industry-based consortia answer only to their members while the directors of state-based consortia must answer to the state. This extra layer of accountability creates a three-tiered pyramid in terms of organizational interests – the states’, the consortia directors’, and the participating organizations’.

*Membership:* Since an industry-based consortium is formed for the express benefit of its members, its membership may be closed – meaning that membership can be restricted by the consortium itself. However, a state-based consortium – a public organization sanctioned by the state – must be open to all business organizations that are interested in joining the consortium. Therefore, the membership in a state-based consortium may be larger and more diverse than a strictly industry-based consortium.

**Stakeholder Interests**

As stated previously, a state-based consortium has three major stakeholders. The legislature represents the interests of its citizens. Since state-based consortia are seen as an economic development tool, the state expects to see increased technological capability – which will lead to more jobs, more sales
revenue, and an increased taxbase. The directors of the consortium are concerned with the continued operation of the consortium – which includes recruiting new members as needed, coordinating or executing research projects, and handling members’ requests that fall within the relative domain of the consortium. The individual firms are concerned with developing new technology, learning new skills, and acquiring member benefits.

While the stakeholders’ interests are not mutually exclusive, each group of stakeholders has areas of interest that are relevant only to them. The state is not interested in the success or failure of a single project, but whether the overall program is successful and contributes to the economy. The firms are not concerned with developing new jobs except as that development leads to increased benefits for the firm. Therefore, multiple assessments are often needed to understand how well a state-based consortium is performing.

**Assessing the Edison Program**

The Technology Division of the Ohio Department of Development is charged with assessing the effectiveness of the Edison Technology Center Program. To accurately measure effectiveness of this program requires a twofold assessment. The first assessment – an economic assessment of the centers’ impact on the state – was conducted by the Battelle Memorial Institute. Concluded in December of 1996, the Battelle report measured new job creation and assessed the program’s net contributions to state revenues. This report helped the state to determine if it is receiving a good return on its investment. The second assessment – one of the reasons for this study – will examine how well the
program meets the needs of its members (i.e. are member firms receiving a good
return on their investment).

This second assessment is vital to maintaining the Edison Program. An
industry-based consortium, which primarily serves the interests of its members,
can discontinue operations if its members believe that it is no longer needed.
However, a state-based consortium’s greater purpose of stimulating economic
development does not allow it the same level of freedom regarding cessation of
operations. The economic development assessment examines multiplier effects of
jobs and revenues that are secondary effects to member firm activities (e.g. the
service jobs that are created to support the new manufacturing jobs and the
additional manufacturing jobs created up and down the supply chain). The
second assessment is directly tied to member satisfaction and, therefore,
dissatisfaction with the program will leads to firms withdrawing their
memberships.

The Study

This dissertation study was developed with objectives of examining the
following questions:

1) *Examining whether the Edison Technology Center Program is successful in
   the eyes of its participants (i.e. are member firms satisfied with the Edison
   Program).* (While the Technology Division of the Ohio Department of
Development did not commission this study, it was agreed that the results of
the dissertation study would be shared with the Division in exchange for its
assistance).
2) Are there differing opinions regarding whether the program is successful (i.e. do reports of firm satisfaction with the Program vary based on their demographic characteristics)?

3) If firms are dissatisfied, why are they dissatisfied? Does this dissatisfaction vary based on the demographic characteristics of the member firms?

4) Which center’s offerings/opportunities are most important to the participants? Are there offerings/opportunities not provided by the Program?

5) Examining whether member firm’s perceptions of the Program vary by consortia type.

6) Examining whether the variables identified within the dissertation study are useful in predicting firm satisfaction.

7) Can the research project process be mapped in order to improve Program efficiency.

Scope of the Dissertation

Membership in the Edison Program is quite varied. In addition to the primary constituents -- for-profit businesses and academic institutions -- membership includes municipal and regional economic development councils, industry trade organizations, and federal research institutions as well as banks and accounting firms. However, this study will primarily examine the interaction between private industry and the Edison Program. While other members are useful partners in the Edison Program, the program exists to benefit private industry. Recommendations for future studies at the conclusion of this paper will provide suggestions on how to evaluate other member contributions and participation.
Each Center with in the Edison Program varies in its depth of program offerings. In turn, these offerings vary in complexity from simple library searches to complex consortial research. This study will evaluate the more complex research activities (contractual R&D and consortial R&D) in an effort to improve this process. Therefore the scope of this paper is limited primarily to examining private industry participation in contractual and consortial R&D activities within the Edison Program.

**Outcome Measures**

As noted in the National Research Council and Mount Auburn Associates studies, developing a universal outcome measure for the Edison Program is difficult. This difficulty is due to the wide variation in center programs and the diversity of program constituents. Therefore, at this time, the best outcome measure may be the simplest – a survey that includes some question regarding industry members' general satisfaction or dissatisfaction with the program. While this measure does address the Ohio Department of Development's need to assess how the centers are performing, it does not provide any information on how to improve a center's performance. Exploring the reasons for member satisfaction/dissatisfaction through additional surveys might provide insight into center needs, but it is doubtful that this method would be a very precise tool for adjusting a center's programs. An evaluative component that can be universally applied to all centers is needed. This justifies trying to map the research processes found in the Edison Centers.

**Chapter Summaries**

Chapter One contains an introduction of the study. Chapter Two will describe the Edison Program in greater detail and summarize two previous assessment reports as well
as the Battelle Memorial Institute report. Chapter Three will contain a survey of the relevant literature in the areas of R&D centers, strategic alliances, and R&D consortia. Chapter Four will explain the methodology used in collecting the data and the tools for analysis. Chapter Five will contain the results. Finally, Chapter Six will offer conclusions and recommendations for the program as well as discuss limitations of the study and possible future studies. Included at the back of the report will be a bibliography as well as appendices containing a copy of the survey forms and additional data.
CHAPTER 2

THE EDISON PROGRAM

Ohio's Edison Center Program today has seven centers representing such diverse areas as biotechnology, polymers, and welding and joining technology. Despite the state's supervision, the Edison centers maintain relative autonomy. This is perhaps due to their formation process. When the state introduced this program in 1983, they encouraged interested individuals and groups to develop and submit proposals for establishing centers supported with state funds. In some cases, the new center was a crystallization of groups already available within the industry (EWI - Edison Welding Institute - has many members that are part of the Welding Institute in Europe). In other cases the center was founded through a development council or a city's industrial leaders (CAMP - the Cleveland Advanced Manufacturing Program - can trace its roots to efforts begun before the establishment of the Edison Program). Still others were established to support the research efforts of ongoing university programs (e.g. EPIC - the Edison Polymer Innovation Corporation - was developed to help commercialize the world-class polymer research being conducted at University of Akron and Case Western Reserve University). This research center formation process of 'from-the-grass-roots up' - as opposed to a 'top-down' mandate - has created statewide programs that vary somewhat in terms of organization and delivery systems.
Centers

According to the staff at the Ohio Department of Development’s (DoD) Technology Division, total organizational membership of the seven Edison centers is now well over 1000 companies and perhaps double that number of similar organizations have received assistance without becoming formal members. As could be expected in a process that was conceived by a legislative body representing differing constituents spread throughout the state, an Edison Center can be found in the six of the largest metropolitan areas of Ohio – Columbus, Cincinnati, Cleveland, Dayton, Toledo, and Akron.

The Edison Welding Institute (EWI) was founded in Columbus where it now shares a building with The Ohio State University welding program. EWI has some of the most sophisticated equipment available in the area of joining technology and serves as the home for the Naval Joining Center. With over 400 members, EWI offers a wide range of services and programs.

Cleveland is the home for two of the Edison Centers. The Cleveland Advanced Manufacturing Program (CAMP) is comprised of over 200 members who utilize one of five CAMP centers in the Cleveland area. The Advanced Manufacturing Center (AMC) at Cleveland State University (CSU) assists firms through engineering assessment. The Center for Automation and Intelligent Systems Research (CAISR) at Case Western Reserve University (CWRU) specializes in robotics and machine process controls. Another center, The Edison Sensor Technology Center (ESTC) is also located at CWRU and develops generic sensor systems for a wide variety of environments. The Unified Technologies Center (UTC) at Cuyahoga Community College (CCC) offers training in
such diverse areas as computer-aided drawing / computer-aided manufacturing (CAD/CAM), total quality management (TQM), and automated office systems. The Great Lakes Manufacturing Technology Center (GLMTC) is also found at the Cuyahoga Community College. Federally-supported by the National Institute of Science and Technology (NIST) as part of its national manufacturing technology center program, GLMTC assesses the manufacturing capabilities of smaller-sized companies.

The Edison Biotechnology Center (EBTC) is the other major Edison center in Cleveland. Many of its 30-plus members are small start-up firms that need a wide variety of assistance – from managerial problems to regulatory paperwork to finding venture capital. Although originally affiliated with CWRU and area hospitals and research firms, EBTC has expanded its reach across the state and is establishing support centers in Cincinnati and Columbus.

South of Cleveland is Akron, the home of the Edison Polymer Innovation Corporation (EPIC). EPIC is closely aligned with two internationally-known polymer research programs at CWRU and the University of Akron. These programs are aided by the participation of several multinational rubber and plastics companies. While its research-investing membership is quite small (16 organizations), overall EPIC has 50-plus members.

The Institute of Advanced Manufacturing Sciences (IAMS) in Cincinnati has undergone several changes in its brief history. Although IAMS has close ties to the University of Cincinnati, it has separate laboratory facilities at its headquarters. Historically, IAMS has offered assistance to its 200-plus members in the areas of computerized manufacturing processes and waste reduction management.
In the southwest portion of the state, the Edison Materials Technology Center (EMTEC) at Dayton serves as research coordinator for projects involving its 100-plus members. Although it has strong ties with several universities in the region, EMTEC’s biggest strategic ally is at the federal level – the Air Force Materials Lab at Wright Patterson Air Force Base. As is to be expected by its name, EMTEC focuses upon a wide variety of materials (metals, ceramics, alloys, etc.) and the processes (casting, forging, machining, coating, etc.) used to turn these materials into useable products.

The final Edison Center – the Edison Industrial Systems Center (EISC) – is located in Toledo. The center covers a wide range of research from machine vision and industrial computed topography to food manufacturing technology. While some of the research for its 50-plus members is conducted at EISC’s facility in Toledo, other work is carried out at academic institutions such as University of Toledo, Bowling Green State University, and Owens Technical College.

**Program Offerings**

Although each center offers some form of education or training assistance, program offerings vary greatly in breadth and depth in each center. For example, EMTEC coordinates multiple consortial research programs that are administered by the staff, but the actual research is conducted at member organization sites. This is the primary thrust of their program. On the other hand, EWI offers a great variety of services. Members can request assistance in establishing technical standards for equipment or materials (benchmarking) from the EWI testing labs, pursue individualized contracts for proprietary research on new types of joining technology, or participate in
consortial research conducted on site. In addition, EWI might serve as a participating member of a much larger national consortium.

This variance in program offerings is explained through four separate factors. The first factor is a center’s degree of control over its relevant research facilities. The centers range from the totally decentralized EMTEC – which serves as an administrative clearinghouse for research conducted at member sites – to the highly centralized EWI – which has very sophisticated facilities and conducts most research on-site. CAMP is an example of a middle ground in center research facilities where the staff is basically administrative, but the center controls programs at nearby universities.

A second factor that affects center offerings is funding. Each center receives funding from the Ohio Department of Development through a biennial funding process. The amount varies by center and the importance of this source of funds to a center is dependent on the center’s access to other financial resources. Firms also receive money through member organizations’ participation fees. Each center has a sliding scale of membership dues based on the size of the organization and, in some instances, desired level of membership. Therefore, the number of members, the organizational size of the members, and their desired level of participation can impact the amount of funds available for various activities.

Another source of funding is the offering of specialized services for a fee. These services can range from database searches for information to educational programs to contractual R&D. A final source of money is available from the U.S. government. Two of the centers have been designated as national centers/administrative arms of federal programs (the Naval Joining Center at EWI and GLMTC at CAMP). Therefore both
programs receive a portion of the annual budget for their related federal programs. In addition, each center may request federal grants for a particular research program if it meets the federal program's guidelines.

The third factor impacting center offerings is the Ohio Department of Development. By controlling a portion of each center's funding, the state – through the DoD – can request that the research centers offer certain programs. From the beginning, the DoD has mandated that each center will offer technical education. Therefore, each center has training programs covering a wide range of topics. For example, IAMS might offer a training program for plant managers on the latest automated manufacturing system while EBTC might offer a seminar to executives on how to secure bridge financing for their firms.

The final factor affecting programming is the interests of the participating organizations. The state expects each center to maintain industry participation in order to receive state funding. If firms refuse to participate, then the center may lose its charter. An example of this occurred at IAMS during its reorganization in the late 1980s. The director of the center (a university faculty member) insisted on a strictly consortial format. As a result, membership dropped from 40-plus members to three. This lack of support forced IAMS to reorganize once again – only this time the center based its approach on information provided by a regional survey of industry.

Control

The State of Ohio – through the Technology Division of the Department of Development – does not try to exert control over the centers to any great degree. The biennial budgetary process whereby the centers must submit their expected usage of
funds provide the greatest leverage. The state maintains a set of funding guidelines that each center must meet in order to receive continued funding. These guidelines include a certain level of participation by state firms and a focus on research. In addition, the centers must submit – on a quarterly basis – a narrative report detailing programs, finances, and key performance measures. These measures include 1) number of services initiated, 2) number of establishments assisted, 3) number of return/repeat customers, 4) number of businesses created, 5) number of people trained, and 6) total value of awards given to the center. Perhaps equally important, members of the technology division often serve on advisory boards for the centers as well.

These advisory boards exert a strong influence on the activities and direction of each center. Board composition as well as its influence varies with each center. For example, CAMP’s board of directors contains members from various organizations in the Cleveland area as well as members from participating organizations. However, the board has a modest impact on the research programs or the daily operations of CAMP. In contrast, the board at EMTEC is comprised almost solely of representatives from participating organizations and is in charge of approving research projects.

The degree of dependency on state funding may also impact how each center responds to requests by the DoD. Centers that have some control over facilities have greater capacity to raise additional outside funding through testing, benchmarking, and providing contractual R&D for fees. The center with the most sophisticated facilities – EWI – has the ability to operate an independent research program for its own purposes.
EDISON PROGRAM EVALUATION

To gain a better understanding of the Edison program’s impact upon industry and the state economy, the DoD has supported independent evaluation by outside organizations. In the past eight years, three such studies have taken place – the 1990 National Research Council study, the 1992 Mt. Auburn Associates study, and the 1996 Battelle Memorial Institute study. The first two studies assessed the overall program, analyzed its effectiveness, and made recommendations for improving the centers. The Battelle study utilized an econometric model to evaluate the impact of the program on Ohio’s economy.

National Research Council

At the time of the National Research Council (NRC) study in 1990, the Edison Program was undergoing changes. The Institute of Applied Manufacturing Systems in Cincinnati was reorganizing and the board of the Applied Information Technology Research Center in Columbus had voted to dissolve the center. The Edison program also had an additional center – the Edison Animal Biotechnology Center (EABC) – which was located in Athens, Ohio.

In order to evaluate the Edison Program, the NRC set up on-site interviews with each center’s staff as well as members from various participating organizations. The NRC research committee grouped the centers’ activities into three broad categories: 1) Problem-solving – which included improving the existing technological capabilities of firms, 2) Developing technology – with a focus upon university-to-industry technology transfer, and 3) Commercialization – which would include moving research results from the lab to the market.
Upon concluding its evaluation, the NRC committee noted that each center performed well in Category 1 activities (with the exception of the Edison Animal Biotechnology Center – which had only one client). Although noting the efforts of several of the centers in the other two categories, the committee concluded that quantitatively evaluating these categories would be difficult due to the variety of programs offered by the centers and the longer time frames needed to achieve results. Instead, the committee members pooled their reports to identify key factors that seemed to contribute to the more successful centers and then gave a broad overview of how the centers were performing on these factors.

The key factors identified by the NRC committee included:

1) an enthusiastic leader/director who encourages organizational participation and seeks out new members,

2) a realistic mission statement which matches local realities,

3) a program built on the skills and strengths available within the local community,

4) an approval of the research agenda by the local academic institutions,

5) a strong evaluative component through an industrial advisory board and detailed research project review,

6) a strong financial commitment from long-term industrial members, and

7) an effective networking system for exchange of ideas.

In addition to the factors above, the committee recommended that the centers focus upon training with an emphasis on small firms and to allow industry, rather than academic
institutions, design the research projects. The committee then evaluated each center categorically as very good, moderately good, or in need of improvement for each area. (National Research Council, 1990).

This NRC study illustrates the difficulties of performing an evaluation of what at times seems to be a multi-headed Hydra (the mythological beast that grew new heads as each head was cut-off). It is important to realize the evaluation committee was working under two handicaps. First of all, the Edison Program was relatively new. Even though six of the center charters dated back to 1984, the programs were still in their infancy. Some of the centers were experiencing severe growing pains in terms of reorganization. Secondly, since there have been few (published) attempts of trying to evaluate this type of program, the committee had no comparative norm or standard to serve as a baseline. Instead, the committee determined which centers appeared to perform well and then examined each of these centers for common factors. While this did allow the poorer performing centers to get a glimpse of what might help them achieve the stature of the other Edison programs, it provided little or no guidance for those centers that were considered ‘very good’ – CAMP, EPIC, EISC, and EWI. It is also important to note that the NRC committee entered into the evaluation process with the hopes of identifying common factors that might be transferred to other R&D centers across the country that were undergoing the formation process. In the end, the NRC study might be critiqued as being somewhat general in its evaluation with little guidance for future improvement.

Mt. Auburn Associates

Two years later, a consulting firm in Massachusetts – Mt. Auburn Associates (MAA) – was invited by the Ohio Department of Development to evaluate the
performance of each Edison center. As noted in the firm’s report, the DoD’s guidelines for the centers had changed in the eight years since the program was founded. The guidelines now emphasized improving productivity over job creation, industry needs over academic institutional needs, and the need to assist Ohio industry over the need to become world-class research centers of the type found in the Silicon Valley.

Citing the difficulty of developing quantitative measures to evaluate the Edison Centers, MAA focused on three basic elements:

1) Appropriateness of Effort – does the center have a suitable mission and set of programs for the industry it serves,

2) Effectiveness of Effort – how well is the center performing in terms of its mission and how useful are the center’s programs to its constituents, and

3) Organization and Management – does the center have a good management team and how well does it perform basic functions such as financial evaluation of programs and marketing of services.

MAA’s methodology consisted of on-site visits with center staff and a phone survey of organizational participants. Utilizing effectiveness as the most important measure for evaluating the centers, Mt. Auburn Associates rated CAMP and EBTC as the two centers that most effectively served their industries’ needs. Rated just below them were four centers – EWI, EPIC, EISC and EMTEC – which had received good marks by the firms they serviced, but had failed to reach the smaller firms within their respective industries. EABC and IAMS were faulted for not having a clear mission. The researchers suggest that the centers were insufficiently independent of the research agendas of their primary
academic institutions. This problem foreshadowed the movement of the centers toward
industry-driven research over university-driven research.

Mt. Auburn Associates had a wide range of recommendations on how to improve
the overall performance of the Edison Technology Center Program:

1) In the area of governance, MAA suggested that the DoD should become a
more active participant in directing the efforts of the individual centers. This
would be accomplished by making the budgeting mechanism more contractual
in nature – each center should negotiate a set of goals with specific methods
for measurement in order to receive funding.

2) In the area of center cooperation, MAA proposed that the centers collaborate
in their marketing efforts as well as how they develop revenue.

3) Concerning the centers with in-house research facilities, MAA suggested that
these laboratories be spun-off as separate entities and allow the centers to
promote more collaborative/consortial research. The reason for the spin-off is
to prevent a mentality of creating research to justify the laboratories. Instead,
the centers should focus on industry needs.

In addition to the general recommendations, MAA provided an even greater
number of recommendations to each individual center. Although some are extremely
specific, others tended to be repeated for several of the centers. The more common
suggestions included:

1) Expand the program or reduce barriers so as to include smaller firms --
   CAMP, EISC, IAMS, EISC, EPIC, EWI, EMTEC.

2) Review/retool/revitalize mission statement -- IAMS, EISC, EWI
3) Improve financial controls/access to cost-benefit info -- EPIC, EISC, CAMP, IAMS

4) Improve marketing of services -- EWI, IAMS, EISC

5) Conduct needs assessment/planning for assessment -- EMTEC, EPIC, IAMS, EISC, EWI

While the National Research Council study developed its recommendations by comparing the Edison centers to each other and then identifying best practice/key characteristics of the successful programs, the Mt. Auburn Associates study evaluated each center separately. In addition, the MAA study utilized a survey form that provided measurable results on several key issues. These results were included at the end of the report in the form of tables with distribution frequencies for the responses. Most were general descriptive statistics regarding participant characteristics such as number of employees, years in operation, and the type of interaction with the relevant center. However, one table did examine the impact the program has had on the following member operations – product development, manufacturing process improvements, employee skills, customer linkages, cooperative relationships with other firms, and improvements in business practices. Based on responses from 160 firms, the centers scored a low of 69% (IAMS) to a high of 100% (EABC, CAMP, EISC) on the percentage of firms reporting any impact on at least one of the categories listed previously. This information was discussed briefly at the conclusion of the paper, but no recommendations were made based on its analysis.
Battelle Memorial Institute

In 1996, the Battelle Memorial Institute (BMI) conducted a study of the Edison Program utilizing an econometric model designed to analyze the program's impact on the state of Ohio's economy. Developed specifically by BMI for the purpose of evaluating the impact of various government programs upon the general population or industrial groupings, the methodology of the model itself was not discussed due to its proprietary nature.

BMI utilized a fairly conservative collection process for gathering data for its model. The BMI assessment team first met with staff members of each of the Edison centers in order to review how each center operated and to determine the availability of quantitative data for the assessment. Then the assessment team developed a standardized data protocol for the centers in order to ensure comparable data was collected by each Edison center. Based on the eventual findings, the data collected was primarily information regarding job creation and retention, costs savings, and plant expansion. This data was entered into the econometric model and the results were analyzed by BMI staff members to develop the report. The report contained the following statements regarding the Edison Program for the years 1992-1995:

1) The direct impact of the centers upon Ohio's economy is estimated to be greater than $700 million and the total impact is estimated to be $1.2 billion.

2) Firms that have participated in the Edison program have saved an estimated $168 million.

3) Over 2500 jobs have been created or retained at the firms which participated in the Edison Program.
4) Firms participating in the centers have increased their sales by $110 million.

5) The centers have brought in an additional $150 million in research funds into the state.

As noted in the statements above, the BMI report is strictly an economic estimation of how investments by both the government and private industry help to create a direct benefit to Ohio through additional jobs (or retained jobs), increase wages, and increased sales. In turn, these factors are used to estimate the additional jobs and investments created to support the industry jobs to derive the total impact of the Edison Program on Ohio's economy. Although this report is useful in justifying the tax dollars spent on the Edison Centers, it offers little utility in prescriptive recommendations for improving the Edison Program.

**Evaluation Efforts to Date**

The State of Ohio's Department of Development has attempted over the years to create some evaluative measure of the effectiveness of the Ohio Edison Program. Ostensibly the purpose of this assessment is threefold: 1) to justify requests for continued funding for the program by the state legislature, 2) to evaluate the utility of the program's offerings at increasing the competitiveness of Ohio's manufacturing sector, and 3) to ensure that the centers strive toward established goals.

The people of Ohio through the state legislature have a vested interest in the welfare of the Edison Centers. As a state-funded program, the Edison Technology Program must achieve some measure of demonstrable success in order to maintain that funding. Ohio's citizenry holds the government more or less accountable for spending the taxpayers' money wisely. The Battelle Memorial Institute report is highly suitable for
providing the justification for continued funding of the program. Since a contradictory
data source does not exist and anecdotal evidence is sketchy at best, studies such as the
BMI report tend to be accepted at face value by the general public. Critiques of the
report must center on the appropriateness of the data collection methodology and the
scientific validity of the formulas used to derive the economic multiplier effects. These
critiques are best left to practitioners in the field of economic science.

The National Research Council study and the Mt. Auburn Associates study
illustrate two different attempts to evaluate the management of the Edison Centers. The
NRC study established what could be considered a bench-marking process by identifying
the ‘best managerial practice’ within the Centers of the Edison Program and then
comparing each center to the benchmark. Its recommendations were designed to
encourage all centers to reach the achievement level of the ‘best performing’ members. In
contrast, the MAA study was concerned with the general effectiveness of each center in
regards to fulfillment of the center’s mission and the overall utility of the center’s
offerings to its membership. Therefore each center was critiqued by its own yardstick.
The recommendations section of the study encouraged the centers to market to a wider
range of constituents, to improve the management of the centers in regards to planning,
networking and fiscal accountability, and to improve the content delivery systems (with
little specificity however).
Future Assessment Needs

Observations

While the state must keep its constituents (taxpayers) satisfied by offering cost-effective programs that improve the quality of life within the state, the Edison Program must strive to keep its constituents (member organizations) satisfied by offering effective programs that improve the constituents' ability to compete.

Several observations within the body of the first two reports have some bearing upon future attempts to evaluate the centers. The first is the difficulty in developing useful measures of program effectiveness. Some measures are relatively easy to collect – total number of firms served, total number of participants in education/training programs, general effectiveness of the education/training programs (measured through surveys) – and require low levels of effort by center staff and/or member participants. Other measures (e.g. cost savings due to knowledge/technical expertise gained through research activities) are more difficult to establish and require greater effort on the part of member firms for assessment. Some measures are extremely difficult to establish (e.g. the contribution of center research to a firm’s competitiveness). This difficulty is due to an imprecise understanding of how knowledge gained from research and development impacts a firm’s competitive capabilities.

A second observation within the reports notes the need to encourage participation by smaller firms. This need is based on the fact that much of Ohio’s manufacturing base exists within these smaller firms and that many of Ohio’s larger firms are dependent on these smaller firms to offer component parts that reflect state of the art technology and highest structural quality. Any attempt at program assessment should reflect the entire
range of firms within the Edison Program and the resulting variance in needs. Areas of variance between firms could include size of the firm, importance of research to competitive aims (R&D intensity), and research focus. An assessment should also acknowledge that firms could have other reasons for joining an R&D center – such as keeping track of industry trends or observing competitors’ actions.

A third observation is made regarding the move toward an industry-driven research agenda for all centers. At the inception of the Edison Program, research proposals were developed with an emphasis on technology transfer – predominantly from the state’s academic institutions to its business organizations. This created a number of centers focused heavily upon a university-based research agenda. Not surprisingly, many of the university members desired basic ‘exploratory/experimental’ research so that their participating faculty members could more easily publish their results. These university researchers were motivated to publish in order to receive career advancement as well as recognition among their peers. This motivation contrasted directly with a firm’s need for applied research and the need to keep its proprietary competitive actions hidden from view.

Despite the influence of university researchers, over time the centers have moved toward an industry-based agenda. Due to an increasing need to improve competitiveness in a global marketplace and a decrease in the availability of funds slotted for research, member firms preferred less basic research and more emphasis on applied research. Within the reports, there is anecdotal evidence that firms are responding positively to this change in emphasis. Therefore, any attempt at measuring center effectiveness should
emphasize industrial membership interests over academic institutions and other support organizations.

A Proposal

Managers of any organization must focus on two measures in order to have a successful organization – effectiveness and efficiency. Effectiveness involves accomplishing whatever the organization sets as its goal. Efficiency is concerned with accomplishing the goal with a minimal cost of resources. Therefore, evaluations of the Edison Program should examine these two factors with respect to the triple-tiered nature of stakeholder interests.

An evaluation system similar to the Battelle Memorial Institute report is useful to examine whether the legislature’s goal of fostering economic development in the state of Ohio is being met. Since the funding of the Edison Program is allocated on a biennial basis, this evaluation should probably be undertaken at least once every four years and therefore be available for examination at every other funding decision. Measuring the efficiency of this process may be difficult, however the Ohio Department of Development can monitor other economic development programs around the country to determine if the Edison Program provides comparable worth for the dollars spent on the program.

A second level of evaluation would combine the best characteristics of the National Research Council report and the Mount Auburn Associates report to examine Center management practice. This would assist the managers in benchmarking their programs as well as assist in examining goal completion. As the research on state-based
consortia continues to grow, it may be possible to benchmark against programs in other states as well as the national industry consortia.

A third level of evaluation (to be conducted jointly with the management assessment) is a survey of member organization’ satisfaction and an evaluation of needs. This gives participants a voice in determining which programs will be offered and will increase the utility/efficiency of the Edison Program. The data should be collected and analyzed following proper statistical procedures and the results should be analyzed to determine areas for improvement.

To be fair, directors of each Edison Center currently conduct some form of evaluation of their program as well as sporadic needs assessments, but it is questionable whether these separate efforts are producing a true picture of the program. Since many of the Center officials are concerned about antagonizing their membership with too many surveys, it makes sense that a unified survey from the Technology Division of the Ohio Department would reduce the antagonism towards the individual Centers as well as create a more unified picture of the program. This could be conducted on a biennial basis in non-funding years.

**Research Program Assessment**

A separate assessment activity should be developed to examine the actual research processes. This would include the research proposal process, the actual experimentation/research process, and the results dissemination process. By mapping these activities as an input-output model, critical events can be identified that tend to create inefficiencies in the system. The Centers, in conjunction with participating organizations, can then work to eliminate these efficiencies. This allows the system to
become more efficient without the need to identify a universal measure to be used for all research activities at each Center.
CHAPTER 3

LITERATURE REVIEW

Background

Although the concept of consortia has been utilized in other fields (most notably education), consortia in the U.S. business sector date back to the founding of the Electric Power Research Institute (EPRI) in 1973 (Corey, 1997). However, the formation of consortia in the U.S. did not blossom until after the passing of the National Cooperative Research Act (NCRA) in 1984. This is a partial explanation for the relative paucity of literature specifically on consortia. Vonortas (1994) suggested four other factors as possible reasons for the lack of research on collaboration:

1) Traditional economics assumed firms act as independent agents in producing non-public goods and services and therefore collaborative efforts reflect a breakdown in the marketplace,

2) Collaborative activities of any sort suggests the formation of a trust and therefore should be deemed as anti-competitive,

3) Researchers believed that collaboration was found primarily in industries that had matured and were technologically lacking, and

4) Researchers general disregard for collaboration in the development of the theory of the firm.
The lack of research on R&D consortia impacts this dissertation in two ways. First, due to the absence of a generally accepted theory of consortia, much of this study is exploratory in nature. Second, the low levels of research on R&D consortia will lead to a review of relevant literature that will be rich in some areas and rather desolate in others.

**Strategic Alliances**

The Edison Centers may be broadly classified as a strategic alliance established between government, academia and private industry to facilitate research and development. A strategic alliance is defined as a multilateral relationship "characterized by the commitment of two or more partner firms to reach a common goal, and which entails the pooling of specialized assets and capabilities" (Jorde and Teece, 1989, p.29). Research in the area of strategic alliances is much more developed than R&D consortia and therefore the strategic alliance literature is useful in examining consortia. In the sections that follow, research on consortia will be combined with the more generic literature on strategic alliances as well as a specific type of strategic alliance – the joint venture.

The increasing popularity of strategic alliances is due to the heightened level of competition between organizations in global markets (Jorde and Teece, 1989) and the increased need for organizations to respond to changes within those markets (Modic, 1988). Exacerbating the problem is the high rate of change in technology coupled with rising costs in basic R&D (Devlin and Bleackley, 1988). Since alliances are adaptive or creative responses to a changing world environment, researchers concerned with the
competitive ability of a business, geographic region, or a country should focus on these phenomena.

The reasons for participating in strategic alliances are varied. Lorange and Roos (1991) suggest that the reason for alliances is the need for timely implementation of critical decisions. Devlin and Bleackley (1988) believe alliances are created for "securing, maintaining, or enhancing a company's competitive advantage" (p. 18). Whatever the reason for forming an alliance, Webster's dictionary (1974) defines it as "a union to promote common interests" and therefore the term implies a level of commitment over a period of time.

**Strategic Alliance Categories**

Lei and Slocum (1991) classify alliances into three broad categories:

1) *Licensing Agreements.* These agreements are the least complex form of alliance since a license does not allow one firm to have a direct impact on the other firm's day-to-day operations. The licensor realizes the advantages of a licensing agreement through the expansion of their product or technology into new markets, but must accept the risk that they may create a new competitor in the long run by giving technology to the licensee. The licensee gains access to a new technology or product, but may become dependent upon the licensor. Although the licensor may grant access to some of its technology, it is unlikely that a licensor would give away strategic or 'core' technology to a major competitor. Therefore, licensing agreements are usually granted to organizations that are not a direct threat to the licensor's operations and involve technology that will not devalue the licensor's 'core' competency.
2) Joint Ventures. The term 'joint venture' signifies the creation of a new organizational entity that is supervised by the originating companies through the development of the venture's operating strategy. Typically, these ventures are used to share costs of high-risk projects that (in theory) are mutually beneficial to all parties. Other potential reasons for forming a joint venture might include economies of scale for production or the need to offer a more complete line of products. Specialization ventures occur when the partners have complementary skills such as production processes for one company mated with the marketing skills of another. Shared value-added ventures exist when the companies have similar strengths and want to focus on a common problem. Advantages of joint ventures accrue through the sharing of risks, costs, and knowledge, while disadvantages can occur through problems due to a mismatch of corporate cultures or through one member taking advantage of another.

3) Consortia. These entities are created to share the costs and risks of a particular activity such as R&D among several firms. The particulars of this type of strategic alliance will be discussed in the following section.

Classifying R&D Consortia

R&D consortia can be divided into two broad classes according to structure: 1) in-house – where research is conducted in a separate entity from the sponsoring organizations and, 2) administrative – where an entity exists to coordinate activities at various locations within the consortium's sponsoring organizations (Evan and Olk, 1990). R&D consortia may also be grouped by time-frame. Temporary R&D consortia (labeled
consortial projects in this paper) are founded with very specific objectives. Once the objective is achieved, these consortia are disbanded. Permanent R&D consortia have an indefinite time-frame. While membership may change as organizations enter or leave the consortium, the consortium renews itself as members continually approve new research projects in the form of temporary consortia.

In addition to classification by structure, R&D consortia can be divided into specific categories using types of research, types of participating organizations, or types of financing as demarcation points (Souder and Nassar, 1990b):

1) **R&D Sponsor Pool** – companies combine their financial resources to conduct research at universities and other sites. Example: the Semiconductor Research Corporation.

2) **Basic Research Cooperative** – direct competitors working together on basic, high-risk research in order to reduce or prevent duplication of research. Since this type of consortium involves a high concentration of competitors in the same industry, any research beyond the most basic type would be considered grounds for an antitrust suit. Example: Microelectronics & Computer Technology Corporation (MCC)

3) **Equity Joint Venture** – two or more companies create a separate entity with each company having an equity position in the new entity. The joint venture can be extended indefinitely or dissolved after a period of time.
4) Non-Equity Joint Venture – the most common of this type is the cross-licensing or cross-marketing agreement. (Note: Evan and Olk (1990) would place joint ventures and licensing agreements in separate categories from consortia.)

5) University Research Center – a center established at an educational institution through federal grants or funds from individuals or corporations. IBM (among others) has established several of these across the country.

6) R&D Limited Partnership – an organization where one firm serves as a general partner to other firms wishing to conduct research in a similar vein. The U.S. government allows special tax breaks to these types of partnerships to encourage industrial R&D spending. Shares in the RDLP can be sold to the public to provide the partnership with equity capital.


8) Trade/Industry Association – a non-profit organization of competitors or non-competitors designed to increase an industry’s trade.

9) Industrial Development Cooperative – organizations created by state governments for research where companies, universities, and government agencies come together to assist local industry. Example: the Ben Franklin Partnership Program in Pennsylvania.

10) Government Agency-Industry Program – companies working with a local government institution in an ad-hoc fashion for a specific, limited purpose.
Although R&D consortia can appear in any number of possible combinations, Souder and Nassar (1990b) found these ten categories to be the most prevalent.

**Classifying the Edison Technology Centers**

When considering the Edison Program in its entirety, the Program should be classified as an industrial development cooperative, but the individual centers vary considerably in their make-up and how they perform their research. The Edison Materials Technology Center (EMTEC) can be generically classified as a consortium, however it spawns research programs that function specifically as R&D sponsor pools. The Edison Polymer Innovation Corporation (EPIC) has assisted in establishing a polymer research center at the University of Akron. Clearly this activity would match Souder & Nassar's definition of a university research center. These two Edison centers stand in stark contrast to the Edison Biotechnology Center (EBTC) which spends much of its budget in helping firms with non-research activities and little – if any – on collaborative research.

**National vs. State-based Consortia**

To avoid confusion, this dissertation will classify each of the seven Edison centers as an R&D center. The term 'R&D center' reflects several unique properties of the Ohio Edison Technology Center Program that may assist in distinguishing these centers from the more famous national consortia such as Bellcore, MCC, and Sematech. In the case of a national consortium, the primary reporting relationship is to the industry membership. While these consortia may receive funding from U.S. governmental institutions (e.g. Department of Defense), the reporting relationship to these governmental institutions is a secondary relationship with fiduciary (i.e. describing how the money is used) and/or
utilitarian (e.g. transferring a technological discovery that may have military applications) purposes. However, the Edison Centers receive funding directly from the Ohio legislature and are expected to provide certain benefits (e.g. employment and industrial development) specifically to the state of Ohio. This relationship also means that the state of Ohio (through the Technology Division of the Ohio Department of Development) holds the charter for these organizations and could decertify a center (e.g. the now-defunct AITREC center) for lack of industrial support.

A second distinguishing factor is the state's insistence that the Edison centers offer problem-solving assistance on demand and educational/training programs within the Edison Program. This emphasis does not exist for most of the national consortia. A third distinguishing factor is the criteria for center membership. The national consortia are often more exclusive in their membership – many are by invitation only or have extremely high membership fees that preclude membership for certain organizations. In contrast, the Edison Centers are open to all applicants that fall within the relevant industry's boundaries. Each center offers varying levels of membership (primarily based on organizational size). In some cases (e.g. the Cleveland Advanced Manufacturing Program – CAMP), an Edison Center does allow interested parties from outside the industry (e.g. banks, accounting firms, law firms, consulting firms) to receive a specialized membership in order to offer services to member companies.

A wide variance in size among organizational participants is the fourth distinguishing characteristic. The national R&D consortia and others formed under the NCRA tend to be populated by organizations that are roughly similar in size and which participate in the same industry. If a smaller firm does participate in these consortia it is
usually due to a relationship with a larger member. In contrast, the Edison Centers have a wide disparity of firms. While many of these firms are direct competitors in a single industry, others are related only through their research interest in a single material or manufacturing process. This disparity in research interests can lead to debates over the research agenda of the consortium. If too few of the members are interested in a specific material or application, a firm may find itself ‘ orphaned’ through a research agenda shift and therefore lose its primary reason for joining the consortium.

The fifth distinguishing factor is the nature of the research itself. Any consortium that is registered under the NCRA must restrict its activities to basic or pre-competitive research in order to receive the anti-trust protection provided under the act. While it has been suggested that all research (R&D Magazine, 1998) has become more ‘applied’ in nature, those consortia not registered under the NCRA (including the Edison Centers) are free to explore whatever research the membership desires. The caveat of not registering under the NCRA is that unregistered consortia may be subject to private antitrust suits or investigation by the Justice Department.

The five factors listed above along with the discussion in Chapter 2 suggest there are sufficient differences between the national industry-based consortia and state-based consortia to support the study of the latter as a related but distinct entity. Therefore, in studying state-based consortia, it may be useful to repeat some of the basic questions that have been already answered in regards to national industry-based consortia.
Research on Firm Characteristics

The following sections will examine research on various firm characteristics as it relates to collaborative R&D. Each section will conclude with a short discussion of the utility of the characteristic as a variable to be included in the proposed study.

Size

The results of studies on the impact of organizational size on collaborative research have generally shown that larger firms are more likely to participate in this type of research than smaller firms. Harrigan (1985) suggested that joint ventures have a greater success rate if the firms have similar characteristics (symmetry). Her paper in 1987 concluded that joint ventures last longer when the partners are similar in size. Hladik (1985) found that larger firms are more likely to establish international joint ventures. Firms with large market share (Berg, Duncan, and Friedman (1982) also displayed a greater proclivity for forming joint ventures. However, in a national survey of collaborative R&D in the Netherlands, Kleinknecht and Reijnen (1992) found that organizational size was not a significant factor for firms participating in cooperative R&D despite the fact that the raw data suggested that R&D cooperation increased with organizational size.

Utility of Size: Although the evidence above is conflicting, variance in firm size is a salient characteristic of state-based consortia. The 1992 Edison Program evaluation report from the Mount Auburn Associates recommended that the Centers should consider the interests of smaller firms. More than five years have passed since that report was conducted. Therefore, an assessment of firm satisfaction with the Edison Program should include size as a variable. In addition, larger organizations are more likely to have

43
broader interests, therefore organizational size might influence the types of benefits firms derive from the program.

**R&D Intensity**

Industries that foster above average R&D investment may be considered valuable to a nation’s economy since the increased R&D can lead to higher-paying jobs and the creation of new technologies (which in turn lead to new industries and further job creation). If the industry is relatively new and does possess a higher investment in R&D and a higher sophistication of plant and equipment, the industry may be classified as being ‘high-tech’ and thus receive additional government investment. One of the factors for determining whether an industry is high-tech is the R&D intensity of the industry.

Research and development intensity is a measure of the importance of R&D to the organization (or industry) – usually measured in ratios of R&D personnel hours to total hours or percentage of spending on R&D to overall sales. Fusfeld and Haklisch (1985) state that firms with higher R&D intensity are more likely to collaborate. Pakes and Griliches (1984) found a direct relationship between R&D intensity and innovation. In comparison, Kleinknecht and Reinjen’s (1992) research suggested that R&D intensity had no impact on cooperative research rates.

*Utility of R&D Intensity:* Since membership in the Edison Program is open to all firms that have relevant interests, varying levels of R&D intensity are expected to be found. This classification may be useful when examining firm expectations and satisfaction. Firms with higher levels of R&D intensity might be expected to concerned with research related activities, thus using the Edison Program to leverage their research dollars. Firms
with lower levels of R&D intensity may also be seeking leverage or may be simply taking advantage of the centers’ expertise for training or problem solving.

**Collaborative Research Experience**

Organizations often use alliances to manage risk and share costs (Barney, 1997). However, participation in an alliance offers a great deal of uncertainty for the first time participant. Assuming a successful outcome, it would be reasonable for a firm to repeat its collaborative behavior rather than try a new method with higher levels of uncertainty. Therefore, it could be expected that firms with prior collaborative experience would be more likely to participate in other similar-type efforts.

Harrigan (1988) found that previous joint venture experience was statistically significant in predicting venture duration and venture survival. Sakakibara’s (1997) study of Japanese consortia showed that the same set of firms steadily reinvest in succeeding consortial projects. Spender, et al. (1996) found that both large and small firms’ previous alliance experiences were positively correlated with perceptions of partnership effectiveness. Together these three studies suggest that previous venture experience will have a positive impact on organizational attempts at future collaborative endeavors.

**Utility of Prior Experience:** Experience with collaborative processes can be examined at two levels. The first is length of tenure with a single program. The second is experience with different programs. Both levels may influence firms’ perceptions of the Edison Program. All other factors being equal, firms with longer tenure should have higher levels of satisfaction with the Edison Program – otherwise, the firms would have opted to leave the Program. But experience with other programs might increase or decrease a
firm's satisfaction with the Edison Program depending on the success of their previous collaborative experiences.

**Consortial Functions and Organizational Objectives**

Corey (1997) states that consortia can cater to a wide range of organizations due to the many functions a consortium may serve. These functions include: 1) development of new products, 2) development and transfer of new manufacturing processes, 3) technical education and training, 4) research to create a safer working environment, 5) infrastructure development of the industry's suppliers, 6) research opportunities and support for academic institutions, 7) assistance in developing industry standards, and 8) organizational problem solving.

Sakakibara (1997) would add the following consortium participant objectives: 1) access to complementary information or knowledge provided by other participants, 2) opportunities to enter a new business area or technology, 3) prevention of duplication of effort, 4) sharing of R&D costs, and 5) maintaining pace with the latest developments in the industry both at home and abroad. Organizations then participate in R&D consortia to access the functions provided or to realize their own objectives.

**Utility of Consortial Functions and Participant Objectives:** These objectives and functions will be included in the study to examine whether firms in the Edison Program would rank these factors as important and to determine which are perceived as available.
**The Problems with Cooperative R&D**

When cooperating on research and development, organizations often find that collaboration is not without its problems. Since many R&D consortia have multiple members, a single firm's decision on whether to continue to participate is unlikely to jeopardize the consortium. Therefore researchers have conducted studies on 'participation' in consortia and firm 'satisfaction' with a consortium rather than consortium failure. Olk and Young (1997) studied the factors leading to an organization's decision on whether to continue participating in a consortium. They found that performance was not the sole determinant in continued participation. Firms may continue their participation in a consortium if they have additional relationships with other consortium members or if they have contributed personnel or technical knowledge to the consortium.

Corey (1997) suggests that over time, the research agenda of a consortium will change due to changes in technology as well as the interests of the participants. If the consortium shifts away from the one area in which a firm has interest, then the firm will most likely withdraw from the consortium. Camp and Ward (1990) found that firms may refuse to join a consortium because they believe the benefits will not outweigh the costs.

**Utility of Cooperative R&D Problems:** Obviously the Edison Program is concerned with maintaining its constituency. Therefore analyzing the reasons for dissatisfaction with the program should be a component of this study.

**Competitiveness**

The term research and development contains two concepts. 'Research' is the process of discovering new knowledge while 'development' is the process of converting...
that knowledge into innovative processes or products. Research and development activities can be divided into two basic categories. Product R&D provides new products or new product features that are perceived as desirable by current or potential customers of the organization. Process R&D contributes new or improved methods for manufacturing an organization’s product which may lead to cost efficiencies. Therefore R&D is often seen by organizations as a tool for gaining competitive advantage within an industry.

Michael Porter (1985) states that a firm may utilize two generic business strategies -- differentiation and low cost leadership -- to gain a competitive advantage over its competitors. (Note: Porter does describe a third generic business strategy -- focus -- in his earlier works. However, focus involves applying differentiation or low cost leadership to a specific market segment.) These competitive advantages enable a firm to earn above normal economic returns within an industry and thus, possibly ensure the organization’s long-term survival.

The first strategy -- differentiation -- is a set of actions taken by the firm in order to provide a product or service that is perceived as unique by customers. If the customer perceives that a firm’s product offers desirable qualities that cannot be found in other organization’s products, then the customer should be willing to pay a higher price or a premium to acquire that product. This provides an above average return given that the premium paid by the customer is greater than the firm’s cost to provide the product’s unique features. Product R&D can lead to the creation of a differentiated product or service.
The second strategy – low cost leadership – is a set of actions taken by a firm in order to reduce the costs associated with providing a particular product or service. Assuming the firm offers the product/service at a price that is comparable to the price of other organization’s competing products/services, the firm will now earn an above average return due to its lower cost structure. Process R&D can lead to the development of a lower cost structure. In the case of either product or process R&D, the firm will possess a long-term competitive advantage over other organizations within the industry assuming that the results of the R&D activity cannot be easily replicated by competitors. 

*Utility of Competitiveness:* Does participation in the Edison Program lead to increased competitiveness for a firm? Since the Edison Program can be considered an economic development tool designed to improve the competitiveness of Ohio’s firms, this question shows if firms are able to utilize the information or capabilities developed by participating in the program.

**Research Questions**

Based on the objectives of the dissertation listed in the introductory chapter and the literature examined above, the following specific research questions were developed.

1) *What types of firms participate in the Edison Program?*

This question examines the mix of firms found within the program in regards to size of the firm, length of tenure with the organization, research and development intensity, and collaborative R&D alliance experience. The Centers are charged with providing assistance to all of Ohio’s firms that fit within their areas of expertise and
this question determines the breadth of the program as well as describes the
categorical variables utilized in answering other research questions.

2) *Are firms satisfied with the Edison Program and do reports of satisfaction vary based
on the type of firm?*

Reports of firm satisfaction provide the Edison Program with an overall performance
measure for the Centers based on the participants' point of view. Pairing the
demographic variables with satisfaction allows the Program directors to determine if
they are serving all of their constituents equally well.

3) *What reasons do firms give for being dissatisfied and does this dissatisfaction vary by
type?*

This is the flip side of the second question. Understanding why firms might be
dissatisfied can direct the Edison Centers to ways of improving their operations.

4) *What types of services and opportunities are important to firms and are these
available through the Edison Program?*

R&D consortia are capable of offering a wide variety of services and opportunities to
their members. This question looks at the types of services and opportunities that
firms are most interested in receiving and whether they perceive that these offerings
are available through their Center.

5) *What benefits do firms perceive they have derived from participating in this program
and do these perceptions vary by type of firm?*

This question goes to the heart of the Program – do firms benefit from participating in
an Edison Center.
6) *Do firms’ perceptions of satisfaction vary based on the type of consortium?*

The Edison Program contains two types of consortia – in-house and administrative. By manipulating the data, firm responses can be classified consortia-type to determine if there is a difference in satisfaction.

7) *Do firm perceptions vary based on previous R&D alliance experience?*

This question examines whether previous experience in collaborative R&D arrangements has an impact on firm perceptions of the program.

8) *Can firm satisfaction be predicted?*

Understanding the variables that lead to firm satisfaction would be useful to the Edison Program both in recruiting and in developing ways to improve the Program.
CHAPTER 4

METHODOLOGY

The following chapter examines issues related to data collection. This includes the decision to utilize a survey, development of the questionnaire, examination of validity and reliability issues, sample selection, and survey distribution.

The Survey Decision

Fowler (1988) states four reasons for utilizing a survey in data collection: 1) Avoiding bias – by developing a new questionnaire and using proper sample selection, a researcher may avoid the bias which may be inherent in using ‘canned’ data from another source, 2) Consistency – a survey (when administered properly) can provide standardized information regarding the issue to be studied which prevents having to sort and reclassify data from disjoint sources, 3) Specific data requirements – can dictate the use of a survey in order to examine a phenomenon from a different point of view than previous researchers, and 4) Lack of other sources – may convince a researcher that collecting data is the best way to understand the phenomenon in question.

Although the Edison Technology Center Program had been surveyed in previous years, gaining access to the raw data from the Battelle study would be difficult due to the proprietary nature of the Battelle assessment process. The data from the two surveys
prior to the Battelle study were relatively old and lacking in depth of information.

Therefore, this dissertation relies on a new survey developed specifically to explore
issues within the Edison Program.

**General Survey Design**

Two factors led to the choice of utilizing a mail survey – time frame and scope. Due to the time constraints of good data collection (i.e. the need to avoid the effects of external events impacting responses) and the sheer size of the Edison Program, a mail survey was determined to be the best method for rapid data collection from this wide ranging population. This approach was modified to include transmission of the survey by fax due to requests from many of the respondents.

In a meeting with two of the coordinators of the Edison Technology Program, the Director of the Technology Division of the Ohio Department of Development and the program’s chief data analyst expressed concerns that as a whole, the general population of the Edison Program was probably ‘over-surveyed’. Participants in the program receive general surveys from their respective centers in order to evaluate program success (and justify continued Center funding) as well as surveys from Federal programs – which often serve as cosponsors or catalysts for Edison Program research.

This information led to three decisions: 1) the survey should be kept as brief as possible – two pages or less, 2) phone calls should be placed to member organizations to determine the proper recipient for the survey and to urge the recipient to complete and return the survey, and 3) the survey should be accompanied by a letter of support from the Ohio Department of Development. To secure the letter of support (and gain access to program mail and phone lists), an agreement was made to provide a copy of the findings
to the Department's Technology Division. In addition, the director and chief analyst were encouraged to make comments on the design of the questionnaire. These comments were useful in shaping the questions and in choosing terminology familiar to the survey recipients.

**The Survey Packet**

The survey packet was mailed in standard manila 9” by 12” envelopes. Each packet contained a two-page survey, the author’s cover letter, the letter of support from the Ohio Department of Development, and a stamped return envelope. The author's cover letter was printed on stationery with The Ohio State University’s Department of Management and Human Resources’ letterhead. The letters of support from the Ohio Department of Development were photocopies of the letter printed on Ohio Department of Development stationery. The survey was printed on canary yellow paper with the belief that the color would be easy to find in a stack of papers. Brightly colored stamps featuring famous American airplane designs were placed on both envelopes with hopes of attracting the notice of the survey recipients – a group that was predominantly male in composition. The faxed version of the survey featured a cover letter that included the name of the recipient, the return fax number, and a short message thanking the participant for completing the survey.

**Design of the Questionnaire**

The questionnaire was designed with three goals in mind – 1) to cover issues discussed in the previous chapters, 2) to emphasize closed-ended questions (and therefore limit the amount of writing for the respondent) and 3) to limit the actual survey to two
pages. The short survey length and ease of completion were prominently featured in the solicitation phone calls that preceded the mailing of the questionnaires.

Below the title of the questionnaire was a short statement to thank the survey participants for completing the survey and to assure them that their answers were completely confidential. The survey directions requested that the participants mark one response per question unless directed to do otherwise. The complete survey is found in Appendix A and is discussed in detail below.

Question One

The first question deals with the length of membership within an Edison Center. The first response choice was listed as less than one year. This was done to isolate the responses of new members for later analysis. It is expected that these new members will be somewhat limited in their ability to discuss benefits from the program and this fact might impact the analysis. The next five responses were grouped in increments of three years each. The final category is ‘greater than twelve years’ but is a de facto grouping of two since the Edison Program was founded fourteen years prior to the survey. It is expected that the number of firms falling in this category will be relatively low due to turnover through the years and the fact that several of the centers were not established until the second half of the 1980s.

Question Two

Question two examines the size of the organization based on number of employees. The response categories were chosen to coincide with the categories used by the Edison Centers for classifying member firms. In general there is greater detail available for firms below five hundred employees for two reasons: 1) the U.S.
government (Small Business Administration) uses five hundred employees as the general boundary standard for determining whether a manufacturing firm will be classified as a small or large business and 2) the manufacturing segment of the Ohio economy is comprised primarily of firms with less than five hundred employees as mentioned in the Mount Auburn Associates (1992) study.

Question Three

The third question deals with R&D intensity. Traditionally R&D intensity is measured as a percentage of R&D expense to total sales or as the percentage of people classified as conducting R&D to the total number of employees. For smaller firms the second categorization can be problematic – even skilled laborers may be able to contribute to the design of a product and therefore could be classified as ‘R&D’ people. Since many firms prefer to break out their R&D expenses from general manufacturing costs, the percentage of R&D to sales was thought to be a more consistent measure and possibly a more conservative measure. R&D intensity is divided into two-percent increments as most firms in the US would likely have less than ten-percent investment in R&D unless they are in a highly competitive industry that exclusively relies on R&D for product differentiation. The National Science Foundation’s Science Resource Studies report found the average R&D funds to net sales for most U.S. manufacturing firms was 2.8% for the years 1984 to 1994 (Payson and Jankowski, 1996). The lone exception was the group of firms with over 25,000 employees which had an average of 5.8%.

Question Four

The fourth question is divided into two parts. The first part asks the survey participant to rank ten items according to a four-point graduated scale where a score of 1
means the item is not important to the organization and a score of 4 means the item is highly important to the organization. The response items describe potential benefits that may be provided by the Edison Centers. These items are based on previous studies of the Edison Program, information provided by the Edison Center research directors and Center literature, and other studies of R&D consortia (e.g. Sakakibara, 1997).

The second part of the question asks the participant to check any item that they believe is available from their Edison Center. This part of the question examines whether the participant perceives that their Edison Center provides the benefits listed in the question response item.

*Question Five*

In the previous chapter it was suggested that research and development activities could be a useful tool for helping firms to compete. This question asks the survey respondent whether they perceive that their organization’s participation in the Edison Program has improved their organization's ability to compete.

*Question Six*

Azben and Fishbein (1972) suggest that attitudes have a cognitive component, an affective component, and an action tendency. This question examines the action tendency of a participating firm in regards to their satisfaction (attitude) with their Edison Center. If a firm is satisfied with the Edison Center (Question 10), it is expected that the organization would recommend that another firm of equal size and capability would benefit from joining their particular Edison Center.
Question Seven

This question asks the participant to examine a list of potential benefits that might be derived from participating with an Edison Center. The list of benefits is derived from discussions of benefits in other studies (e.g. Corey, 1997) and as suggested by the Center research directors. The final response option to this question is open-ended to allow the participant to note a benefit not found in the provided list.

Question Eight

Question eight asks the participant to note any increases in specific organizational measures that might be influenced by working with an Edison Center. This list was taken from the Mount Auburn Associates study. It is based on criteria – sales and employment – that the Ohio Department of Development deems important for continued funding of the Edison Program as well as criteria – profits, market share, and quality – which organizations may deem important in determining their continued participation in the Edison Program.

Question Nine

This question looks at a firm’s participation in other collaborative research activities. These experiences might influence the organization’s perception of the effectiveness of the Edison Program.

Question Ten

Question ten is the companion question to question number six in measuring the organization’s satisfaction with the Edison Program. This measure looks at cognition by asking the participant if the members of their organization would deem participation with the Edison Center a success. If the answer was no, the participant was then asked to
examine a list of items that might be associated with the failure to realize a benefit from participating with their Edison Center. This list of items was developed from several questionnaires used by the Edison Centers and from the literature. An open-ended response item was given to allow firms to list other reasons for why the program was not a success for their organization.

**Data Collection**

*Establishing Support*

Gaining access to the names, addresses, phone numbers and contact persons for each center was a process of consensus building. At the start of this project, the controlling body of the Edison Program – the Technology Division of the Ohio Department of Development -- was contacted. After listening to a presentation on the proposed study, the Director of the Technology Division and the chief program analyst agreed to assist the study by drafting a letter of support for the questionnaire. However, the desired contact information was not available through that office. It was recommended that meetings should be scheduled with the research coordinator for each Edison Center and that the proposed study be 'pitched' to each coordinator in order to gain support.

These meetings with the individual Center research coordinators were necessary for several reasons. First, although the Department of Development does supervise the Edison Program, the Centers are allowed a great deal of freedom to make their own decisions. Therefore the program supervisors suggested that voluntary cooperation from the centers be secured rather than having the Department of Development impose an unwelcome mandate to participate. Second, the contact information for participants is
considered proprietary by the Centers and therefore membership information is stored at each Center. Since the Centers have direct competitors working together, many of the organizational participants prefer to disclose as little information about their organizations as possible. This was especially true of the many defense contractors that work with the Edison Welding Institute.

The meetings provided a secondary benefit by giving insight into the operations of each center. This insight was utilized in developing the questionnaire as well as the research methodology. A final benefit was realized by asking the center directors to examine the questionnaire and provide comments regarding the suitability of each question.

Each center provided a typed list of organizational members. These lists included the name, address and (in most cases) the contact person for each Edison Center member. When multiple contacts were available, the Center was asked to provide the name of a contact that would have the most knowledge regarding the firm’s activities in conjunction with its Center. These lists were alphabetical and ranged in size from sixteen names (EPIC) to three hundred and ninety-five names (EWI). The contact individuals ranged from research coordinators to plant managers to company presidents.

*Sampling Procedure*

Several of the research coordinators for the Edison Centers were concerned about the reaction of organizations to being surveyed from an outside source. To alleviate complaints, it was agreed to select only half of the member organizations as potential survey recipients. Two of the smaller centers (EPIC and EISC) expressed no reservations
about surveying their membership and therefore their entire membership lists were included in the sampling pool.

One center was excluded from the study – the Edison Biotechnology Center. After a conversation with the research coordinator about the nature of the firms within the center, it was determined that a separate survey might be more appropriate for these firms. The participating industrial members of the EBTC are currently small start-up organizations (one or two employees) struggling with the attempt to find funding and to develop a professional business structure. Many of these firms have yet to sell a product. The employees of EBTC assist these firms in completing the necessary forms to receive research grants as well as helping the firms to write business plans or analyzing product feasibility. Therefore much of the assistance is relatively non-technical in nature. The survey designed for the other Edison Centers assumed that participants were established businesses.

For the remaining Centers, the lists of firms were examined for non-industrial members (e.g. banks, accounting firms, etc.). These organizations were eliminated from the survey. Firms with foreign addresses and phone numbers were also eliminated to ensure that national culture would not be an issue (this eliminated less than 20 firms). Finally, any firm on the list without a specific contact individual was eliminated. The remaining firms on each Center list were numbered in consecutive order. Firms were selected by using the last three digits of a random number as provided by a standard computerized random number generator. This process was continued until half of the total membership for each center was selected. This provided the pool of organizations to be contacted to participate in the survey.
**Initiating Contact**

From February 1, 1998 to April 30, 1998, firms from the selected group of potential survey participants were contacted by telephone. If the individual was available, they were told the purpose for the call and asked to participate. Emphasis was placed on the university name and the Ohio Department of Development's support. If the individual agreed to participate in the survey, they were given a choice of receiving the survey by fax or by mail.

If the contact individual was not available, a message requesting a return call was left with a personal assistant, a departmental secretary, or – in many cases – voice mail. If the individual did not return the call, then several follow-up calls were made. A firm was dropped from the list after four unsuccessful phone contact attempts over a period of three weeks.

In some cases an individual declined to participate in the survey. Typical reasons given were lack of time or a company policy that forbids disclosure of any information. Some of the firms declined due to the cancellation of their membership within the program. Still other individuals had left their organizations and the person replacing them was not familiar with the Edison Program.

**Non-response Bias**

Some firms agreed to participate in the study and then failed to return the surveys. A few of these firms were contacted by phone to determine why they declined to participate. In most cases the respondents stated they had been too busy or had reconsidered their decision to participate. Based on this additional information, there did not appear to be any pattern in the type of firm that failed to respond after agreeing to do
so previously. Coupled with a higher than average response rate, the probability that response bias exists in the sample is quite low.

**Validity and Reliability Issues**

Survey validity is the measure of how well an instrument measures what it is designed to measure. Litwin (1995) states there are four types of validity commonly used in assessing a survey’s ability to measure its relevant topic. Face validity is a general response by individuals with no specific knowledge on the topic regarding the general appearance of the survey. While face validity might help with simple matters such as proper spelling, simple logic errors, and general ‘readability’ of the survey, it carries little scientific weight.

Content validity measures the subjective response to the instrument by individuals with specific knowledge of the survey topic. Although it is not evaluated through statistical methods, content validity is the aggregate opinion of a panel of knowledgeable individuals regarding the appropriateness and suitability of the survey instrument. This opinion covers such things as correct usage of terminology, appropriateness of questions for the intended sample group, and – to a lesser extent – the comprehensiveness of the questions in assessing the topic area.

Criterion validity is a measure examining how well the survey instrument compares to other instruments accepted in the field. Typically it is measured through generating a correlation coefficient between the new instrument and the more accepted instrument. A high correlation between the two instruments offers some proof that the new instrument is valid.
The final type of validity is construct validity. Litwin (1995, p. 43) states this form of validity is the “most difficult to understand, to measure, and to report”.

Construct validity is based on the perceived utility of the instrument as demonstrated through its use in multiple studies spanning many years and many different populations.

The nature of this study did not lend itself to assessing all the various types of validity. Instead, careful attention was paid to examining the wording of the questions in an attempt to stress clarity and brevity. This was done to ensure the reader could easily understand and answer each question. The emphasis on creating a relatively short survey (less than two pages) was also expected to reduce confusion in the reader.

Once the survey was complete, members of the OSU faculty and staff were asked to examine the questionnaire to assess its ‘readability’ – thus contributing to the instrument’s face validity. Then, the director and the chief analyst of the Edison Program were asked to look at the questions and determine if the terminology matched that used by firms within the program. Finally, the research coordinators for each of the Edison Centers were asked to provide feedback on the questionnaire. Most of these individuals have held similar positions to the people actually participating in the survey. Questions were rephrased or amended based on this input deriving the content validity of the questionnaire.

It was impossible to establish construct and criterion validity for this study. Criterion validity requires a comparison to an instrument commonly accepted by researchers within the field. Such an instrument does not exist at this time. Construct validity is lacking because this is the first time this instrument was used in the field.
To improve the quality of the study, a small pilot test was run. Five firms were selected at random to complete the survey. (While this number is low, it was believed to be necessary in order to maintain the bulk of firms for the actual survey. At that time, the anticipated survey response rate was expected to be low -- based on the comments of the Edison Center research directors.) The respondents were then asked for their comments and adjustments were made to the survey as a result.

Reliability

Reliability examines the consistency of results from an instrument over time. Although several different methods can be used to assess reliability, the most commonly used method is test-retest reliability (Litwin, 1995). Under this format, the respondents to a survey are asked to complete the same survey again after a certain amount of time has elapsed. Correlation coefficients are then calculated to compare the scores from the two sets of tests. A correlation coefficient of greater than 0.70 is considered a benchmark for sufficient reliability (Litwin, 1995).

For this survey, a random sample of thirty-three firms were asked to complete the survey for a second time approximately four weeks after they had completed their first survey. The correlation coefficient was .72, suggesting that the survey instrument is indeed reliable.

Data Analysis

The Sample

From the lists provided by the research directors of the Edison Centers, four hundred seventy-five names were selected randomly for contact. This number is
approximately half of the names provided. After repeated attempts to contact all of these individuals, three hundred thirty-four surveys were sent either by mail or by fax. Two hundred one total surveys were returned – sixteen of which were rejected due to insufficient information. This left one hundred ninety-four usable surveys.

The response rate was 58% when comparing the number of usable surveys returned to the total number of firms contacted. The overall response rate for the sample was 40.8%. Bourque and Fielder (1995) state that a single survey mailing that does not include incentives and is made to a general population should not expect a response rate of over 20%. The higher response rate is likely due to the following factors: 1) use of recent membership rosters provided by the Centers, 2) the general education level of the individuals who received the questionnaire, 3) the pre-calling of the sample, 4) the design of the questionnaire, 5) the use of computerized faxing, and 6) the letter of support from the Ohio Department of Development.

Analytical Tools

The survey questionnaire was designed for ease of response for the participant. Many of the questions were simple checklists that were yes/no or present/not present responses. This provided data in mostly categorical form. The dependent variable, satisfaction, was also dichotomous.

The nature of the data led to the choice of using cross-tabulation as a method of analysis. Malhotra (1996) notes that cross-tabulation is ‘widely used in commercial marketing research because its results’ can be easily interpreted and understood by managers” (p. 516). This characteristic makes it very useful for breaking the data into reports for policy managers to utilize. The significance of association between the
crossed variables is measured by using a chi-square statistic. However, a normal chi-square should not be used if cell frequencies are extremely low. Therefore, the Yates corrected chi-square is used. It is designed for cross-tabulation and can be used in a 2X2 table where the degrees of freedom equal one.

To examine whether the variables chosen for the study can help in predicting firm satisfaction, logit regression was required. Logit allows the use of a dichotomous dependent variable, but allows for both categorical and non-categorical independent variables. The categorical variables were entered into the logit regression equation through the use of dummy variables. The proper statistic for examining goodness of fit for a logit model is $-2LL$ or $-2$ times the log likelihood.

The survey responses were encoded by the author and entered into a Microsoft Excel 97 spreadsheet. The data was analyzed using SYSTAT 7.0.1 for Windows on a P-233 computer.
CHAPTER 5

RESULTS

Research Questions

Question 1 – What types of firms participate in the Edison Program?

The firms in the survey provided the following demographic information – length of tenure with the Edison Program, size of the organization categorized by number of employees, and level of R&D intensity measured by the ratio of R&D to sales. This data is best examined by studying the number of firms for each category for each variable.

Tenure with an Edison Center

Membership in the Edison Program has varied over the years. Table 5.1 displays.

<table>
<thead>
<tr>
<th>Tenure</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1 yr</td>
<td>18</td>
</tr>
<tr>
<td>1-3 yrs</td>
<td>89</td>
</tr>
<tr>
<td>4-6 yrs</td>
<td>45</td>
</tr>
<tr>
<td>7-9 yrs</td>
<td>25</td>
</tr>
<tr>
<td>10-12 yrs</td>
<td>6</td>
</tr>
<tr>
<td>&gt;12 yrs</td>
<td>11</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>194</strong></td>
</tr>
</tbody>
</table>

Table 5.1 Distribution of firms based on years with an Edison Center
the distribution of firms in the sample based on length of tenure in the organization. It is worth noting that the majority (55%) of this sample is a set of firms with three years or less experience with the Edison Program. According to the chief program analyst at the Ohio Department of Development, this is due to the natural growth of the program rather than any overt push to add new members. This high number of relatively new firms may impact the firms’ reports of satisfaction with the program.

Size of the Organization

Size of the organization (as seen in Table 5.2) is measured in total number of employees. The distribution of firms is somewhat consistent with Ohio’s overall

<table>
<thead>
<tr>
<th>Size</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;20</td>
<td>20</td>
</tr>
<tr>
<td>20-99</td>
<td>59</td>
</tr>
<tr>
<td>100-249</td>
<td>43</td>
</tr>
<tr>
<td>250-500</td>
<td>24</td>
</tr>
<tr>
<td>500-999</td>
<td>13</td>
</tr>
<tr>
<td>&gt; 1000</td>
<td>35</td>
</tr>
<tr>
<td>Total</td>
<td>194</td>
</tr>
</tbody>
</table>

Table 5.2 Distribution of firms based on size (# of employees)

distribution of firms as described in the Mount Auburn Associates (1992) study. That is to say that the bulk of the firms in the sample (63%) have less than 250 employees.

R&D Intensity of the Organization

The Edison Program embraces a wide range of firms in regards to their expenditures on research and development. As seen in Table 5.3, a predominant number
of participating firms (73%) spend four percent or less on R&D when measured as a percentage of sales.

<table>
<thead>
<tr>
<th>R&amp;D</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 2%</td>
<td>99</td>
</tr>
<tr>
<td>2.1-4.0%</td>
<td>42</td>
</tr>
<tr>
<td>4.1-6.0%</td>
<td>23</td>
</tr>
<tr>
<td>6.1-8.0%</td>
<td>5</td>
</tr>
<tr>
<td>8.1-10.0%</td>
<td>9</td>
</tr>
<tr>
<td>&gt; 10%</td>
<td>16</td>
</tr>
<tr>
<td>Total</td>
<td>194</td>
</tr>
</tbody>
</table>

Table 5.3  Distribution of firms based on R&D/sales

While 4% is consistent with the national average, it suggests that high tech firms – those firms with high levels of R&D – are not primary users of the Edison Program as a source of research assistance.

**Question 2 – Are firms satisfied with the Edison Program and do reports of satisfaction vary based on type of firm?**

Question ten asked survey respondents if their organizational personnel would rate the organization’s involvement with an Edison Center as a success. In this case, seventy-six percent of the firms reported favorably on their interaction with an Edison Center. Twenty-four percent of the firms responded negatively. This would appear to be a strong affirmation of overall satisfaction for the Edison Program.

However, satisfaction might vary based on how a firm is classified on the demographic variables examined in question one. For example, are small firms less satisfied than large firms? To determine if this is true, the demographic variables were
collapsed into high and low categories and then were examined using a cross-tabular function. The results for each demographic variable were graphed into separate figures for physical examination and a Yates-corrected Chi-square was calculated for each cross-tabulation. Figures 5.1 – 5.3 help illustrate the relationships described in the cross-tabulation between satisfaction and these variables.

![Tenure Diagram]

Figure 5.1 Satisfaction and length of tenure
Figure 5.2  Satisfaction and firm size

Figure 5.3  Satisfaction and R&D intensity
The Yates-corrected Chi-square statistic value for the cross-tabulation of each demographic variable is found in Table 5.4. As the table indicates, there is not a strong association between satisfaction and tenure, size or R&D intensity.

<table>
<thead>
<tr>
<th>Cross-Table</th>
<th>Value</th>
<th>df</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satisfaction X Tenure</td>
<td>0.059</td>
<td>1</td>
<td>0.808</td>
</tr>
<tr>
<td>Satisfaction X Size</td>
<td>1.889</td>
<td>1</td>
<td>0.169</td>
</tr>
<tr>
<td>Satisfaction X R&amp;D Intensity</td>
<td>0.007</td>
<td>1</td>
<td>0.933</td>
</tr>
</tbody>
</table>

Table 5.4 Cross-tabulation for satisfaction and demographic variables

**Question 3 – What reasons do firms give for being dissatisfied and does this dissatisfaction vary by firm?**

As noted in the previous question, approximately twenty-four percent (n = 44) of the firms participating in the program stated they were dissatisfied. In the survey, firms claiming to be dissatisfied were asked to state the reason for their dissatisfaction. The frequencies for these reasons are displayed in Table 5.5. Given the small number of

<table>
<thead>
<tr>
<th>Reason</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Too costly for benefits received</td>
<td>15</td>
<td>34.1</td>
</tr>
<tr>
<td>Education programs did not match firm needs</td>
<td>3</td>
<td>6.8</td>
</tr>
<tr>
<td>Technical expertise did not match firm needs</td>
<td>15</td>
<td>34.1</td>
</tr>
<tr>
<td>Quality of research reports was insufficient</td>
<td>4</td>
<td>9.1</td>
</tr>
<tr>
<td>Research agenda did not match firm needs</td>
<td>16</td>
<td>36.4</td>
</tr>
<tr>
<td>Other</td>
<td>16</td>
<td>36.4</td>
</tr>
</tbody>
</table>

Table 5.5 Reasons for dissatisfaction with the Edison Program
dissatisfied firms, any analysis by demographic categories would be questionable due to
the small number of firms per category.

**Question 4** What types of Program offerings (e.g. services and opportunities) are
important to firms and are these available through the Edison Program? Does this
vary by type of firm?

The fourth question in the survey directed survey participants to examine a list of
ten Center characteristics and then rank the importance of each characteristic to their
organization. The list of factors was derived from the relevant literature as a set of items
that might be found within R&D consortia. The firm’s responses to these questions are
found in Table 5.6. In addition to ranking these factors, each participant was asked
whether they believed that this particular factor was available from their Edison Center.
The frequencies for these responses are found under the ‘Available?’ heading.

<table>
<thead>
<tr>
<th></th>
<th>Scale Responses</th>
<th>Available Thru Center?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Question 4A</td>
<td>36</td>
<td>42</td>
</tr>
<tr>
<td>Question 4B</td>
<td>24</td>
<td>56</td>
</tr>
<tr>
<td>Question 4C</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Question 4D</td>
<td>11</td>
<td>34</td>
</tr>
<tr>
<td>Question 4E</td>
<td>55</td>
<td>73</td>
</tr>
<tr>
<td>Question 4F</td>
<td>33</td>
<td>68</td>
</tr>
<tr>
<td>Question 4G</td>
<td>32</td>
<td>61</td>
</tr>
<tr>
<td>Question 4H</td>
<td>26</td>
<td>45</td>
</tr>
<tr>
<td>Question 4I</td>
<td>43</td>
<td>41</td>
</tr>
<tr>
<td>Question 4J</td>
<td>32</td>
<td>53</td>
</tr>
</tbody>
</table>

Scale: 1 = not important 2 = slightly important
       3 = moderately important 4 = highly important

Table 5.6 Frequencies and availability for Program offerings
A discussion of each program offering is provided below:

- Question 4A – *Assessment of a Firm’s Capabilities*. This question asked if the center’s ability to assess a firm’s product, process, or overall capabilities was a valuable factor to the organization. Thirty-five percent thought this ability was highly important. When adding the ‘three’ and ‘four’ responses together, almost 60% ranked this ability as at least moderately important. This almost matched the percentage of firms (55%) that perceived this ability as at least moderately important and was available through their Center.

- Question 4B – *Access to State of the Art Facilities*. Fifty-nine percent of the survey respondents perceived the factor to be at least moderately important. This percentage was exceeded by the percentage of firms (66%) that believed their Center did provide access to state-of-the-art facilities.

- Question 4C – *Knowledge of the Latest Technical Developments*. One hundred fifty-eight firms (81%) stated this characteristic was at least moderately important, but of that number, one hundred-seventeen claimed it was highly important (60%). These individuals were most likely disappointed when looking for the latest technical developments at their Edison Center as 57% said this characteristic was not available.

- Question 4D – *Assistance in Solving Technical Problems*. Again, a very high number of firms (76%) ranked this factor as moderately important to highly important to their firm. But, unlike the previous question, many firms (81%) did find the assistance they needed within their Edison Centers.

- Question 4E – *Assistance in Solving Non-Technical Problems*. This was the lowest rated item in terms of importance – 66% said it was slightly important at best. This
number was closely matched by the 64% of firms that recorded this form of assistance was not available.

- Question 4F – Opportunities for Employee or Management Training. While training was not a major item for most firms – only 13% said it was highly important – they did find it available (58%).

- Question 4G – Contacts with Other Firms with Similar Research Interests. Could an Edison Center serve as a place for firms to find research partners? Fifty-two percent of the firms found this item to have at least moderate importance. This was matched by the fifty-nine percent that believed such contacts were available.

- Question 4H – Contacts with Potential Customers or Suppliers. The opportunity to network with potential clients and suppliers was an understandably important factor for firms (63% found it at least moderately important). Fifty-three percent of the firms believed supplier or customer contacts were available through the Edison Program.

- Question 4I – Opportunities to Conduct Previously Unfeasible Research. Leveraging their research dollars was at least moderately important for fifty-seven percent of the firms and an equal percentage of firms stated these opportunities were available through their participation in an Edison Center.

- Question 4J – Insight into Other Firms’ Research Interests or Capabilities. This item was ranked at least moderately important by a majority of the firms (57%), but their desires were unfulfilled as 68% of the firms said that such insight opportunities were lacking.
Program Offerings and Type of Firm

The second portion of the research question asks if different types of firms vary in how they view the importance of these Program offerings. To make this assessment, the importance rankings were collapsed into two categories – low and high importance. These categories were then cross-tabulated with the demographic variables. Table 5.7 examines the cross-tabulation of length of tenure with the Program and the importance of Program offerings. As can be seen, the Yates corrected chi-square values indicate that there is not a strong association between how long a firm has been with the Edison Program and how firms rank the importance of various Program offerings.

<table>
<thead>
<tr>
<th>Tenure Crossed with</th>
<th>Value</th>
<th>df</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capability Assessment</td>
<td>0.533</td>
<td>1.000</td>
<td>0.465</td>
</tr>
<tr>
<td>State of the Art Facilities</td>
<td>0.033</td>
<td>1.000</td>
<td>0.855</td>
</tr>
<tr>
<td>Technical Knowledge</td>
<td>0.373</td>
<td>1.000</td>
<td>0.541</td>
</tr>
<tr>
<td>Technical Problems</td>
<td>1.289</td>
<td>1.000</td>
<td>0.256</td>
</tr>
<tr>
<td>Non-technical Problems</td>
<td>0.409</td>
<td>1.000</td>
<td>0.523</td>
</tr>
<tr>
<td>Training</td>
<td>0.0</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Meet Firms w/Similar Research</td>
<td>0.121</td>
<td>1.000</td>
<td>0.727</td>
</tr>
<tr>
<td>Meet Potential Buyers/Suppliers</td>
<td>0.0</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Conduct Non-constrained Research</td>
<td>0.116</td>
<td>1.000</td>
<td>0.733</td>
</tr>
<tr>
<td>Conduct Competitor Analysis</td>
<td>0.0</td>
<td>1.000</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Table 5.7 Cross-tabulation of length of tenure and the importance of Program offerings

Table 5.8 explores the cross-tabulation of size of the firm and firm rankings of the importance of Program offerings. In this situation the importance of two Program offerings show a significant association with firm size – access to state-of-the-art facilities and the opportunity to meet with potential customers and suppliers. Figure 5.4
provides a graphical representation in terms of the number of firms ranking the Program offerings high in importance and the size of those firms.

<table>
<thead>
<tr>
<th>Firm Size Crossed with</th>
<th>Value</th>
<th>df</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capability Assessment</td>
<td>0.0</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>State of the Art Facilities</td>
<td>4.525</td>
<td>1.000</td>
<td>0.033*</td>
</tr>
<tr>
<td>Technical Knowledge</td>
<td>1.061</td>
<td>1.000</td>
<td>0.303</td>
</tr>
<tr>
<td>Technical Problems</td>
<td>2.052</td>
<td>1.000</td>
<td>0.152</td>
</tr>
<tr>
<td>Non-technical Problems</td>
<td>2.877</td>
<td>1.000</td>
<td>0.090</td>
</tr>
<tr>
<td>Training</td>
<td>1.367</td>
<td>1.000</td>
<td>0.242</td>
</tr>
<tr>
<td>Meet Firms w/Similar Research</td>
<td>0.0</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Meet Potential Buyers/Suppliers</td>
<td>9.520</td>
<td>1.000</td>
<td>0.002*</td>
</tr>
<tr>
<td>Conduct Non-constrained Research</td>
<td>1.216</td>
<td>1.000</td>
<td>0.270</td>
</tr>
<tr>
<td>Conduct Competitor Analysis</td>
<td>0.264</td>
<td>1.000</td>
<td>0.608</td>
</tr>
</tbody>
</table>

*Yates corrected chi-square is significant at the p>.05 level

Table 5.8 Cross-tabulation of member firm size and importance of Program offerings

![State of the Art Facility](image)

Figure 5.4 Ranked importance of state-of-the-art facilities by size of firm
As can be seen in Figure 5.4, it appears that large firms are more concerned about state-of-the-art facilities than small firms.

Figure 5.5 is a graphical representation of how different size firms rank the importance of the opportunity to network with potential suppliers and customers.

![Customer/Supplier Networking Opportunities](image)

Figure 5.5 Ranked importance of customer/supplier networks opportunities by firm size

This graph suggests that smaller firms are much more concerned about opportunities to establish supply chain networks than larger firms when participating in an Edison Center.
Table 5.8 reveals the importance of Edison Program offerings to firms with high or low R&D intensities. This table shows there is not a significant association between level of firm R&D intensity and how a firm ranks the importance of Program offerings.

<table>
<thead>
<tr>
<th>R&amp;D Intensity Crossed with</th>
<th>Value</th>
<th>df</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capability Assessment</td>
<td>0.0</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>State of the Art Facilities</td>
<td>0.059</td>
<td>1.000</td>
<td>0.808</td>
</tr>
<tr>
<td>Technical Knowledge</td>
<td>2.618</td>
<td>1.000</td>
<td>0.106</td>
</tr>
<tr>
<td>Technical Problem Solving</td>
<td>3.275</td>
<td>1.000</td>
<td>0.070</td>
</tr>
<tr>
<td>Non-technical Problem Solving</td>
<td>0.134</td>
<td>1.000</td>
<td>0.715</td>
</tr>
<tr>
<td>Training</td>
<td>0.273</td>
<td>1.000</td>
<td>0.602</td>
</tr>
<tr>
<td>Meet Firms w/Similar Research</td>
<td>1.766</td>
<td>1.000</td>
<td>0.184</td>
</tr>
<tr>
<td>Meet Potential Buyers/Suppliers</td>
<td>0.0</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Conduct Non-constrained Research</td>
<td>0.134</td>
<td>1.000</td>
<td>0.714</td>
</tr>
<tr>
<td>Conduct Competitor Analysis</td>
<td>0.0</td>
<td>1.000</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Table 5.9 Cross-tabulation of member R&D intensity w/importance of Program offerings

**Question 5) What benefits do firms perceive they derive from participating in this program? Do these perceptions vary by type of firm?**

Survey respondents were asked to examine a list of potential benefits that were derived from the literature as well as the Mount Auburn Associates study (1992). The frequencies for their responses are found in Table 5.10.

Since the actual question topics are included in the table, there is no need to examine each item in detail at this point. However, three firms made similar claims about benefits under the ‘Other’ category. The firms stated that they had not utilized their membership in any formal way. Instead, they saw their membership as having a consultant under retainer for any type of problem.
Table 5.10 Availability of benefits within an Edison Center

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Yes</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improvements in existing products</td>
<td>51</td>
<td>26.3</td>
</tr>
<tr>
<td>Improvements in existing processes</td>
<td>98</td>
<td>50.5</td>
</tr>
<tr>
<td>Improvements in employee skills</td>
<td>67</td>
<td>34.5</td>
</tr>
<tr>
<td>Improvements in business practices</td>
<td>42</td>
<td>21.6</td>
</tr>
<tr>
<td>New products</td>
<td>26</td>
<td>13.4</td>
</tr>
<tr>
<td>New processes</td>
<td>37</td>
<td>19.1</td>
</tr>
<tr>
<td>New sales agreement with other members</td>
<td>27</td>
<td>13.9</td>
</tr>
<tr>
<td>New research agreement with other members</td>
<td>20</td>
<td>10.3</td>
</tr>
</tbody>
</table>

If problems occur, they feel comfortable knowing that they can utilize their Edison Center's problem-solving skills to handle it.

Benefits and Type of Firm

As was the case with the previous question, the Program benefits were cross-tabulated with firm demographic variables. However, the cross-tabulations for benefits against length of tenure, firm size, and R&D intensity contained no strong associations based on a Yates corrected chi-square ($p > 0.05$).

Question 6 Do firm perceptions vary by type of consortia?

Evan and Olk (1990) state that consortia can be divided into two broad categories - administrative and in-house. Both types exist within the Edison Program. To examine whether the type of consortium to which a firm belongs has an impact on firm perceptions, firm data responses were collapsed into these two types. Two of the Edison consortia possessed characteristics of both of these categories and for the purpose of this
analysis the data responses for these two consortia were set aside. This left a data set of 164 responses.

Utilizing cross-tabulation, it was found that consortia-type was not strongly associated with firm satisfaction or dissatisfaction with the Program. The cross-tabulations for consortia type and ranked importance of Program offerings revealed one association as shown in Table 5.11 and as graphed in Figure 5.6.

<table>
<thead>
<tr>
<th>Consortia-type Crossed with</th>
<th>Value</th>
<th>df</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capability Assessment</td>
<td>0.086</td>
<td>1.000</td>
<td>0.769</td>
</tr>
<tr>
<td>State of the Art Facilities</td>
<td>0.943</td>
<td>1.000</td>
<td>0.331</td>
</tr>
<tr>
<td>Technical Knowledge</td>
<td>0.952</td>
<td>1.000</td>
<td>0.329</td>
</tr>
<tr>
<td>Technical Problem Solving</td>
<td>3.197</td>
<td>1.000</td>
<td>0.074</td>
</tr>
<tr>
<td>Non-technical Problem Solving</td>
<td>0.443</td>
<td>1.000</td>
<td>0.506</td>
</tr>
<tr>
<td>Training</td>
<td>0.043</td>
<td>1.000</td>
<td>0.835</td>
</tr>
<tr>
<td>Meet Firms w/Similar Research</td>
<td>5.737</td>
<td>1.000</td>
<td>0.017*</td>
</tr>
<tr>
<td>Meet Potential Buyers/Suppliers</td>
<td>0.393</td>
<td>1.000</td>
<td>0.531</td>
</tr>
<tr>
<td>Conduct Non-constrained Research</td>
<td>0.003</td>
<td>1.000</td>
<td>0.959</td>
</tr>
<tr>
<td>Conduct Competitor Analysis</td>
<td>0.135</td>
<td>1.000</td>
<td>0.714</td>
</tr>
</tbody>
</table>

Yates corrected chi-square is significant at the p>.05

Table 5.11 Cross-tabulation of consortia-type & ranked importance of Program offerings

Figure 5.6 shows that firms participating in administrative consortia rank the importance of meeting firms with similar research interests much higher than firms participating in in-house consortia. Since administrative consortia offer fewer services due to the lack of a central lab, firms may focus more on consortial research projects which require enlisting other firms to participate.
Figure 5.6 Ranked importance of meeting other firms with similar research interests by consortia type

The cross-tabulation of consortia-type and perceived benefits received by the participating firms revealed a pair of associations. These results are found in Table 5.11

<table>
<thead>
<tr>
<th>Consortia-type Crossed with</th>
<th>Value</th>
<th>df</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improvements in existing products</td>
<td>0.946</td>
<td>1.000</td>
<td>0.331</td>
</tr>
<tr>
<td>Improvement in existing processes</td>
<td>0.0</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Improvements in employee skills</td>
<td>0.0</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Improvements in business practices</td>
<td>2.659</td>
<td>1.000</td>
<td>0.103</td>
</tr>
<tr>
<td>New products</td>
<td>0.166</td>
<td>1.000</td>
<td>0.683</td>
</tr>
<tr>
<td>New processes</td>
<td>0.283</td>
<td>1.000</td>
<td>0.594</td>
</tr>
<tr>
<td>New sales agreement w/other members</td>
<td>4.582</td>
<td>1.000</td>
<td>0.032*</td>
</tr>
<tr>
<td>New research agreement w/other members</td>
<td>11.112</td>
<td>1.000</td>
<td>0.001*</td>
</tr>
<tr>
<td>Other</td>
<td>0.0</td>
<td>1.000</td>
<td>1.000</td>
</tr>
</tbody>
</table>

*Yates corrected chi-square is significant at p>.05 level

Table 5.11 Cross-tabulation of consortia-type & ranked importance of Program benefits
Figure 5.7 graphically represents the whether firms have established new sales contracts as a result of their participation in an Edison Center. Although overall more firms have not established new contracts than those who have, it appears that based on the percentages, firms that participate in administrative consortia have established more new sales contracts than their counterparts in in-house consortia. This is likely due to the nature of the administrative consortium. Since the consortia staff simply coordinate projects that are carried out at member locations, firms often are required to communicate directly. If one firm is a manufacturer and the other a supplier, it could be expected that

![Bar chart showing received new sales contracts based on consortia-type](chart.png)

**Figure 5.7** Received new sales contract based on consortia-type

conversations about research would eventually lead to a sales contract.
Figure 5.8 Received new research agreement based on consortia-type

Question 7 Do firm perceptions vary based on previous R&D alliance experience?

Firms that have had previous experience in participating in collaborative R&D processes should have different expectations regarding their participation in the Edison Program. Participation was examined in three ways – firms that had other experiences with the Edison Program, firms that had participated in other R&D consortia, and firms that had been involved in other R&D collaborative forms. Satisfaction was examined first but there was no strong association between firms possessing any of these previous alliance experiences and satisfaction.

The next factor examined was the ranking of importance for Program offerings. Table 5.13 is a cross-tabulation of prior experience in the Edison Program and the ranked importance of Program offerings.
<table>
<thead>
<tr>
<th>Prior Edison Experience Crossed w/</th>
<th>Value</th>
<th>df</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capability Assessment</td>
<td>2.399</td>
<td>1.000</td>
<td>0.121</td>
</tr>
<tr>
<td>State of the Art Facilities</td>
<td>1.723</td>
<td>1.000</td>
<td>0.189</td>
</tr>
<tr>
<td>Technical Knowledge</td>
<td>0.107</td>
<td>1.000</td>
<td>0.744</td>
</tr>
<tr>
<td>Technical Problems</td>
<td>0.674</td>
<td>1.000</td>
<td>0.412</td>
</tr>
<tr>
<td>Non-technical Problems</td>
<td>2.302</td>
<td>1.000</td>
<td>0.129</td>
</tr>
<tr>
<td>Training</td>
<td>0.443</td>
<td>1.000</td>
<td>0.506</td>
</tr>
<tr>
<td>Meet Firms w/Similar Research</td>
<td>4.678</td>
<td>1.000</td>
<td>0.031*</td>
</tr>
<tr>
<td>Meet Potential Buyers/Suppliers</td>
<td>0.548</td>
<td>1.000</td>
<td>0.459</td>
</tr>
<tr>
<td>Conduct Non-constrained Research</td>
<td>2.776</td>
<td>1.000</td>
<td>0.096</td>
</tr>
<tr>
<td>Conduct Competitor Analysis</td>
<td>0.107</td>
<td>1.000</td>
<td>0.743</td>
</tr>
</tbody>
</table>

*Yates corrected chi-square is significant at p>.05 level

Table 5.13  Cross-tabulation of previous experience with an Edison Center and ranked importance of Program offerings

This association is graphically represented in Figure 5.9.

![Firms w/Similar Research Interests](image)

Figure 5.9  Ranked importance of meeting firms with similar research interests and previous Edison center experience
Firms with previous experience in other Edison centers understand the workings of an R&D center and realize that networking with other firms is a critical factor in conducting research in an R&D consortium. An organization which locates a firm that has similar interests is more likely to receive that firm's support on research proposals.

Since many R&D centers exist around the country, both state-based and national industrial, it is not surprising that the number of firms familiar with other R&D centers almost doubles (68 to 36) the number of firms with Edison experience. When this group was crossed with the ranked importance of Edison service and opportunity offerings, six associations were revealed – as seen in Table 5.14.

<table>
<thead>
<tr>
<th>Prior Experience w/Other R&amp;D Centers Crossed with</th>
<th>Value</th>
<th>df</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capability Assessment</td>
<td>0.084</td>
<td>1.000</td>
<td>0.772</td>
</tr>
<tr>
<td>State of the Art Facilities</td>
<td>11.168</td>
<td>1.000</td>
<td>0.001*</td>
</tr>
<tr>
<td>Technical Knowledge</td>
<td>4.363</td>
<td>1.000</td>
<td>0.037*</td>
</tr>
<tr>
<td>Technical Problem Solving</td>
<td>2.416</td>
<td>1.000</td>
<td>0.120</td>
</tr>
<tr>
<td>Non-technical Problem Solving</td>
<td>3.273</td>
<td>1.000</td>
<td>0.070</td>
</tr>
<tr>
<td>Training</td>
<td>4.492</td>
<td>1.000</td>
<td>0.034*</td>
</tr>
<tr>
<td>Meet Firms w/Similar Research</td>
<td>4.847</td>
<td>1.000</td>
<td>0.028*</td>
</tr>
<tr>
<td>Meet Potential Buyers/Suppliers</td>
<td>3.417</td>
<td>1.000</td>
<td>0.065</td>
</tr>
<tr>
<td>Conduct Non-constrained Research</td>
<td>12.768</td>
<td>1.000</td>
<td>0.000*</td>
</tr>
<tr>
<td>Conduct Competitor Analysis</td>
<td>5.400</td>
<td>1.000</td>
<td>0.020*</td>
</tr>
</tbody>
</table>

Yates corrected chi-square is significant at the p>.05 level

Table 5.14 Cross-tabulation of prior experience with other R&D Centers and the ranked importance of Program offerings.
Figure 5.10 Cross-tabulation for ranked importance of state-of-the-art facility and experience with other R&D centers.

In Figure 5.10, a strong association exists between previous experience with other R&D centers and stating that a state-of-the-art facility is important. This is probably due to the number of firms that have worked with the national industrial consortia and have experienced their high quality in-house labs. These firms have simply transferred this preference to the Edison Program.
Figure 5.11 Cross-tabulation for ranked importance of knowledge of the latest technical development and previous experience with an R&D center.

Firms with previous R&D center experience are more likely to be exploring ways to gain new knowledge or else they would not be in the Edison Program. For firms that can afford it, having multiple memberships in various R&D consortia is a way of making certain they do not miss the latest technology.
Figure 5.12 Cross-tabulation of previous experience with R&D and ranked importance of training and education.

Figure 5.13 Cross-tabulation of previous experience with R&D centers and the ranked importance of meeting firms with similar research interests.
For firms with less experience in the areas of R&D, it would be expected that these firms would place a higher importance on learning how to use the latest technology as compared to firms that are more experienced in R&D collaboration and may have multiple resources to draw upon.

Figure 5.13 is the same as Figure 5.9, locating firms with similar interests is critical to have projects approved within the consortium.

Figure 5.14 Cross-tabulation of previous experience with R&D centers and the importance of being able to carry out previously constrained research

The association between the two factors above is that large firms are looking for ways to leverage their research dollars. Camp and Ward (1990) found that large firms would be
less likely to participate in an Edison Center without the leveraging of state funds.

![Figure 5.15 Cross-tabulation of previous experience with R&D centers and ability to ascertain competitors' research interests](image)

Prahalad and Hamel (1991) stated that strategic alliances are learning races where each member tries to learn the other firm's core competency. This response rate suggests that experienced firms will use consortia for competitor intelligence.

Table 5.15 contains the cross-tabulation of firms that have had previous experience with other forms (non-consortial) of R&D collaboration and the ranked importance of Program offerings. Three associations are identified using the Yates corrected chi-square. However, upon examining the data, the relationships are the same
as found for the previous table. Therefore, these associations will not be explained further.

<table>
<thead>
<tr>
<th>Previous Experience w/Other Forms of R&amp;D Alliance Crossed with</th>
<th>Value</th>
<th>df</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capability Assessment</td>
<td>1.565</td>
<td>1.000</td>
<td>0.211</td>
</tr>
<tr>
<td>State of the Art Facilities</td>
<td>7.535</td>
<td>1.000</td>
<td>0.006*</td>
</tr>
<tr>
<td>Technical Knowledge</td>
<td>0.316</td>
<td>1.000</td>
<td>0.574</td>
</tr>
<tr>
<td>Technical Problem Solving</td>
<td>1.333</td>
<td>1.000</td>
<td>0.248</td>
</tr>
<tr>
<td>Non-technical Problem Solving</td>
<td>0.095</td>
<td>1.000</td>
<td>0.757</td>
</tr>
<tr>
<td>Training</td>
<td>1.172</td>
<td>1.000</td>
<td>0.279</td>
</tr>
<tr>
<td>Meet Firms w/Similar Research</td>
<td>7.480</td>
<td>1.000</td>
<td>0.006*</td>
</tr>
<tr>
<td>Meet Potential Buyers/Suppliers</td>
<td>3.702</td>
<td>1.000</td>
<td>0.054</td>
</tr>
<tr>
<td>Conduct Non-constrained Research</td>
<td>10.599</td>
<td>1.000</td>
<td>0.001*</td>
</tr>
<tr>
<td>Conduct Competitor Analysis</td>
<td>1.139</td>
<td>1.000</td>
<td>0.286</td>
</tr>
</tbody>
</table>

*Yates corrected chi-square is significant at the p > .05 level

Table 5.15  Cross-tabulation of prior experience with other forms of R&D alliance and ranked importance of Program offerings.

**Question 8**  Can firm satisfaction be predicted using the variables within this study?

Answering this question requires the use of logit regression due to the dichotomous dependent variable (satisfaction) and the large number of categorical variables (e.g. size). The final log-log estimate was 47.06 with 32 degrees of freedom. In order to have a predictive model, the double log must be near zero. Therefore it is reasonable to state that the categorical variables examined in this study are not useful in predicting firm satisfaction with the Edson Program. The output pages for the logit regression is in Appendix B.
CHAPTER 6

DISCUSSION AND CONCLUSIONS

Research in the area of R&D consortia has been sparse to date, however, the research that is available is primarily concerned with how participating in an R&D consortium can benefit the firm. Little or no work has been done from the point of view of the consortium. In the case of the national programs (e.g. MCC), it is difficult to separate the firm from the consortium. If you remove the firms from the consortium, little remains. In the case of state-based R&D centers, however, you still have an organization that possesses a state charter and a mandate to service firms that fall within that charter. Therefore, it is logical to examine strategy from the point of view of the R&D center or consortium.

Summary of Findings

The Value of the Edison Program to Its Members

To be successful under the state guidelines, an Edison Center has to maintain a certain level of support from its relevant industries. From the Center's membership's point of view, the key is to provide useful goods and services. A logical first question then is "How satisfied are the members with the Center?" According to the results of the survey, as a whole the member firms are highly satisfied with their Centers. Seventy-three
percent of the survey respondents categorized their participation in an Edison Center as successful. The fact that an even higher percentage of respondents (87%) would recommend their Edison Center to a similar firm suggests that their degree of satisfaction is sufficiently high to act in a manner that would benefit their Center. For many of the firms, their satisfaction may stem from an improvement in competitiveness (65%).

While overall satisfaction not in question, another relevant question to ask is “Does the data on satisfaction vary by length of tenure with the program, size of the participating firm, or R&D intensity levels?” The answer is that no significant association was found between satisfaction and firm demographics.

**Reasons for Dissatisfaction**

The success of the Edison Program is not in question. But, twenty-four percent of the firms in the survey stated that they were dissatisfied with their Edison Center. When asked why, three factors received the most responses – the cost benefit ratio, the lack of fit between the research agenda of the center and the needs of the firm, and a mismatch in terms of the type of expertise available as compared to the firms’ needs.

**Ranked Importance of Program Offerings**

However, the survey did reveal one major weakness. One hundred fifty-eight of the survey respondents (86%) ranked ‘knowledge of the latest technical developments’ as being at least moderately important but only eighty-three firms (45%) stated that this type of assistance was available through the center. This finding suggests that the Edison Centers are not a source for firms looking for cutting-edge technology. This may also explain why there were few participants in the sample with high levels of R&D intensity.
While this finding needs further exploration, two relevant points should be discussed. First, although a defining characteristic of the Edison Centers may be the diversity of their membership, this diversity also creates a wide range of firm interests. It may be impossible for the Centers to offer cutting-edge technology to every constituent. If this issue begins to affect participation, then the Centers may be forced to narrow their technological scope in order to maintain an acceptable level of expertise.

Second, this finding may expose a central paradox to the program. The directors of the Edison Program and the Center research directors have all said that members have requested a move toward applied research and away from basic research. However, applied research is less likely to be ‘cutting-edge’ research. Basic research is more likely to create radical breakthroughs, but provides these breakthroughs in ways that are difficult for firms to assimilate without additional application-oriented research. This paradox suggests that the centers need to find ways to service both ends of the research spectrum. An added benefit will be an improved attitude on the part of university researchers who have a preference for basic research.

In terms of demographics and Program offerings, a significant association was found between firm size and ‘access to state-of-the-art facilities’ and between firms size and the opportunity to network with potential customers and suppliers. The evidence suggests that large firms are more interested in the nature of the research facilities. This should be a concern for the Edison Program if funding sources begin to dry up since the larger firms pay the highest fees and are more likely to have extra R&D funds to invest in research projects.
Smaller firms are interested in the networking possibilities. While the sales contacts help boost the economy, the Centers may have to walk a fine line between being a research program as compared to a matchmaker service. If firms join strictly to gain contacts, the research agenda will become watered down.

**Derived Benefits**

The cross-tabulation of program benefits received to firm demographics revealed no significant associations. Firm responses reveal that the three most common benefits received were improvements in existing processes, improvements in employee skills, and improvements in existing products.

**Consortia-Type**

The concept of in-house and administrative consortia had not received a great deal of attention in the literature. This may partially be due to the difficulty in gaining access to mixed consortia datasets and to the preponderance of single-case studies in the field. Several significant associations existed. While no blanket recommendations can be made without further study, it appears that managers from the in-house consortia need to encourage greater communication between members. The opposite is true of administrative consortia where it appears the lack of a central lab encourages firms to communicate and establish contacts for additional research.

**Previous Experience**

A learning curve appears to be in effect for R&D consortia. Firms with previous experience with other R&D centers or other collaborative arrangements for conducting R&D are more likely to be seeking state-of-the-art facilities, knowledge of the latest technological developments, training and education, the opportunity to contact firms with...
similar research interests, to leverage their research dollars and to monitor their competitor’s research interests.

This has two implications for consortia. The first is that new entrants to the program may need some orientation to get them on the learning curve as soon as possible. Secondly, experienced firms appear to desire a great deal from this type of program. This may make it difficult to retain these firms in the long run if they do not see sufficient cause.

**Mapping the Research Process**

One of the major difficulties expressed in the National Research Council study (1990) and the Mount Auburn Associates study (1992) was the inability to evaluate the research process at the Edison Program beyond examining simple output measures such as new jobs created, employees trained, and cost reductions. Without more sophisticated measures, this task would appear hopeless.

However, the author and his advisor (Sven Lundstedt) have proposed a solution based on information gathered from two data sources. In developing a market study for one of the Edison Centers (Ward and Camp, 1990), the administrative staff provided insight into the consortial project formation process as it was practiced at that center. This was enhanced by conversation with the Edison Center research directors when securing access to member information. In addition, a similar project formation process was reported for the national R&D consortia (e.g. MCC, Sematech, SRC, etc.) by Corey (1997). These differing data inputs led to the creation of a model examining how firms utilize R&D centers to conduct research. The Ward-Lundstedt model is shown in Figures
Figure 6.1 The Decision to Use an R&D Center for Research
Figure 6.2 The Research Proposal
6.1 and 6.2. The model is based upon input-output studies have often been used in economics and decision sciences to determine the appropriate allocation of resources (e.g. the famous ‘guns vs. butter’ debate). An input-output model could map the various decision points within an R&D center’s research processes to examine ways to improve the research processes and improve the center's allocation of resources. This method is similar to developing flowcharts of computer programs in order to more easily design and debug programs.

Figure 6.1 diagrams a firm’s decision to use an R&D center for research. Block 1.0.0 states the initial assumption that the firm has proposed a new project to improve a product or process. The management team’s first decision (2.0.0) is whether or not the firm can develop the desired product internally. If the answer is yes, that decision moves the firm to the output of producing the product internally.

If the answer is no, management then moves to a decision on whether to have some firm produce it. But first management must determine if a firm exists with that capability (2.1.0). If so, then the question is asked if the desired product can be acquired (2.1.1). An affirmative answer moves the firm to the output point of attempting to acquire the product (3.1.0) through an outright purchase or some form of collaborative agreement such as licensing.

If the product cannot be acquired then management must decide if it wants to utilize an R&D center (2.2.0). If the answer is no then the firm has exhausted its options and therefore must abandon the project (3.2.0). If management does select the R&D center then it must then decide if it has sufficient funds to establish an R&D contract with the center. If the answer is yes then the firm moves to utilize the R&D contract (3.3.0). If
not the firm examines the option of a consortial project (2.4.0). The firm either pursues the consortial project (3.4.0) or drops it entirely (3.5.0).

Figure 6.2 examines the process required to establish a consortial project at an R&D Center including securing commitments from other firms as well as securing at least half of the funding (the state often will match the funds raised by the proposed consortium) necessary to carry out the project. At each decision point there are inputs and outputs. The key is to determine the most efficient level of outputs in order to complete the project.

Other R&D center processes can be modeled in a similar fashion. Confirmation of the models will be derived through surveying members who have participated in consortial projects and by examining completed projects in the archives of the Edison Centers. Upon revision, it may then be possible to run computer simulations to look for bottleneck conditions in the consortial process as well as determine best practices to ensure a successful project.

For example, a small supplier to the airframe industry may desire to propose a project to help improve their manufacturing process. If the firm is experienced in project proposals, this will not be difficult. However, the project will more likely to receive approval if it has the support of an airframe manufacturer. By this time the centers have had hundreds of accepted and rejected proposals. These could be analyzed to find what was the difference in the projects. A critical path system from the management sciences would be useful in looking for firms that serve as a hub for multiple projects as well as identifying critical resources (e.g. availability of a certain type of laser) where lack of access has killed the project. This deserves further study.
Contributions

Application-Oriented Contributions

This study offers a nice ‘snapshot’ of the Edison Program at this time. This is useful both to the Program and Center decision-makers as well as policymakers from outside the program who may be interested in creating an Edison-type program in their geographic region. The Edison Program decision-makers now have an up-to-date evaluation of the program. This is necessary both for future improvement as well as in generating support for continued funding by the state legislature.

Outside parties can see the strength of the program as well as possible areas for improvement. The positive findings on member satisfaction from this report as well as the economic multiplier effects found in the BMI report, suggest that other states may be able to boost their industrial performance by adopting such a program.

The lack of access to the latest technical developments along with the relatively low numbers reported for new product and process development prove that the Edison Program is not an innovation center as compared to California’s Silicon Valley or Massachusetts’ Route 128 complex. However, these centers are not subject to the economic and market fluctuations that seem to strike the more ‘high-tech’ complexes. In addition, this report did not include the Edison Biotechnology Center – which is charged with creating a biotechnology industry in Ohio. A survey of those firms will likely yield significant differences from the other Edison Centers.

The mapping process proposed may also prove to be a useful tool for evaluating this program and others similar to it. Although the model needs additional input from
industry members as well as statistical testing, it does offer a way to improve the

efficiency of the R&D center research process.

Theoretical Contributions

Although this dissertation is driven more by application than theory, it does offer

some contributions. First of all, this is possibly the first academic study on state-based

R&D centers. As such, it provides an initial baseline for additional work in this area.

Secondly, the differences between administrative consortia and in-house consortia

suggest that future research on R&D consortia should include consortia-type as a variable

when appropriate. While Olk and Young (1997) found that consortium performance is

not the sole determinant on whether a firm continues its participation, this study confirms

their report and should encourage future research on secondary benefits from these types

of programs. Finally, the significant associations found in examining previous

experience confirm that previous experience applies to consortia as well as other forms of

strategic alliance.

Limitations of the Study

Survivor Bias

As is often the case when surveying members of a strategic alliance, there is a

survivor bias. Members are more likely to endorse the program and give positive

commentary about it as compared to organizations that have left the program. While this

bias does exist in this study, it is somewhat mitigated by a number of firms that agreed to
respond to the survey despite their plans to discontinue their membership in the near future.

Sample Selection Bias

Although every effort was made to prevent selection bias, several factors exist which cannot be mitigated. First, the sample was based on the lists provided by the Center research directors. These lists may accidentally contain erroneous information or may not have been corrected recently to reflect changes in membership. In addition, the decision to not offer an incentive to complete the surveys or to conduct repeated mailings to non-respondents might have excluded some unique cases. Sample selection bias was somewhat mitigated by the high response rate and the phone calls made to non-respondents.

Validity and Reliability Issues

Both validity and reliability issues were addressed in the methodology section in Chapter 4. However, both validity and reliability could have been enhanced by having a larger pilot study to test validity and by having a larger number of respondents on the test-retest reliability study. These two problems are countered by using concepts developed in other studies and by the degree of care used in the design of this study.

Generalizability Issues

The Edison Program is relatively unique in its design and focus. While other states do have programs designed to enhance R&D in various industrial sectors, they are often smaller in scope. Therefore generalizability will be an issue until this study is extended to encompass other programs.
**Future Research**

Many areas of promising research exist in the wake of this study. One immediate project is the need to develop a predictive model for firm satisfaction. This study would be extremely useful in assisting programs like the Edison Program to learn what they can do to improve their programs and retain their members.

A study of the Edison Biotechnology Program would be interesting. This program is designed to encourage more high-tech or cutting-edge research, and as such, offers unique compare and contrast opportunities with the data gathered on the other Centers. It might also be useful to see if the profile of this program more closely matches the innovation enhancement activities in the Silicon Valley and Route 128.

A forgotten group in this study – the support companies holding associate memberships in several of the Edison Centers – should be examined to see what they contribute and what they gain from their membership. The support companies include law firms, banks, accounting firms, and consultants.

An interesting qualitative study would be to examine the charter documents filed with the Ohio Department of Development and then compare how the Centers have evolved over time. On a similar note, an interesting case study would be an examination of the AITREC Center in Columbus that was closed.

Another study could be undertaken to examine effectiveness of the Edison Program by developing a longitudinal study that compares the performance measures of firms participating in the program to a sample of non-members firms. This could provide greater evidence of the true impact of the Edison Program upon its members.
Finally, an exploration should be made into programs established in other states to examine similar and contrasting themes. The Ben Franklin Partnership in Pennsylvania would be an ideal place to start. It is hoped that the pursuit of any and all of these studies would lead toward a greater understanding of state-based R&D consortia and contribute to a model that would service both researchers and practitioners alike.
APPENDIX A

The Ohio Edison Technology Program Survey

Thank you for participating in this survey of the Ohio Edison Technology Program. Your answers are completely confidential and all data will be summarized for multiple firms.

Directions: Please answer the following questions by placing a checkmark or numbered response next to the appropriate answer. Please mark only one answer per question unless directed to do otherwise. The term ‘business unit’ applies to any business that is considered legally to be a sub-unit of a larger organization.

* Before you begin, please circle the name of the Edison Center(s) where your organization is a member:

<table>
<thead>
<tr>
<th>EMTEC</th>
<th>EPIC</th>
<th>EWI</th>
<th>EBTC</th>
<th>IAMS</th>
<th>EISC</th>
<th>CAMP</th>
</tr>
</thead>
</table>

Q1 Based on the categories below, how long has your organization been a member of an Edison Center?

___ Less than one year
___ One to three years
___ Four to six years
___ Seven to nine years
___ Ten to twelve years
___ Greater than twelve years

Q2 Based on the categories below, how many people are employed by your firm (business unit)?

___ Less than 20 employees
___ 20 to 99 employees
___ 100 to 249 employees
___ 250 to 499 employees
___ 500 to 999 employees
___ 1000 or more employees

Q3 Based on the categories below, what is your firm (bus. unit) current percentage of R&D spending to sales?

___ 2% or less
___ 2.1% to 4%
___ 4.1% to 6%
___ 6.1% to 8%
___ 8.1 to 10%
___ Greater than 10%
Q4 Using the scale below, please rank the importance of the following items to your organization. Then, please place a checkmark in the column labeled Available next to any of the items you believe are available through interaction with your Edison Center(s).

<table>
<thead>
<tr>
<th>Rank</th>
<th>Available</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

1 = not important  2 = slightly important  3 = moderately important  4 = highly important

- assessment of your product’s / process’ / company’s capabilities
- access to state-of-the-art research facilities
- knowledge of the latest technical developments in your industry
- assistance in solving technical problems
- assistance in solving non-technical problems
- opportunities to receive specialized employee / management training
- contacts / networking with other firms with similar research interests
- contacts / networking with potential suppliers / customers
- opportunities to conduct research previously considered unfeasible due to resource constraints
- insight into research interests / competitive capabilities of other firms within the industry

Q5 Has interacting with your Edison Center(s) improved your firm’s ability to compete?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q6 Would you recommend joining the Ohio Edison Technology Program to another firm that is similar to your own organization in size and capability?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q7 What benefits has your firm received from participating in the Ohio Edison Technology Program? Please examine the categories below and place a checkmark next to all answers that apply to your organization.

<table>
<thead>
<tr>
<th>Improvement in existing products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improvement in existing manufacturing processes</td>
</tr>
<tr>
<td>Improvement in employee skills</td>
</tr>
<tr>
<td>Improvements in business practices</td>
</tr>
<tr>
<td>New products created as a byproduct of research conducted through an Edison Center</td>
</tr>
<tr>
<td>New processes created as a byproduct of research conducted through an Edison Center</td>
</tr>
<tr>
<td>New sales contract with another organization through contacts established at an Edison Center</td>
</tr>
<tr>
<td>New research agreements (to be completed outside the Edison Program) with another organization through contacts established at an Edison Center</td>
</tr>
<tr>
<td>Other (please specify):</td>
</tr>
</tbody>
</table>

---

110
Q8 Which of the following has increased due to your firm (business unit) working with an Ohio Edison Technology Center? Place a checkmark next to all responses that apply to your organization.

___ Sales  ___ Product / Process Quality
___ Profits  ___ Employment in Ohio
___ Market Share  ___ Employment outside Ohio

Q9 Please examine the categories below and place a checkmark next to all responses that apply to your firm.

___ My firm (business unit) has participated in more than one Ohio Edison Technology Center
___ My firm (business unit) has participated in other R&D centers or consortia (multi-firm, collaborative research)
___ My firm (business unit) has participated in other types of alliances for the express purpose of conducting research (e.g. joint ventures, R&D limited partnerships).

Q10 Would the members of your organization rate their participation with your Edison Center a success?

___ Yes  ___ No

If your response was no, why is (was) your firm dissatisfied with its interaction with the Edison Program? Please check all responses that would apply to your organization’s experiences with the Edison Program.

___ Too costly for benefits received
___ Failed to offer appropriate educational/training programs for my organization
___ Failed to offer technical expertise/assistance that matched the needs of my organization
___ Quality of research reports was insufficient for our needs
___ Research agenda of the center did not match the needs of my organization

Other: (if you need more space, please continue on back)
APPENDIX B

LOGIT REGRESSION

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>S.E.</th>
<th>t-ratio</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 CONSTANT</td>
<td>3.336</td>
<td>7.069</td>
<td>0.472</td>
<td>0.637</td>
</tr>
<tr>
<td>2 &lt; 1 yr. tenure</td>
<td>0.782</td>
<td>1.365</td>
<td>0.573</td>
<td>0.567</td>
</tr>
<tr>
<td>3 1 - 3 yrs. tenure</td>
<td>0.905</td>
<td>1.135</td>
<td>0.798</td>
<td>0.425</td>
</tr>
<tr>
<td>4 4 - 6 yrs. tenure</td>
<td>1.594</td>
<td>1.182</td>
<td>1.348</td>
<td>0.178</td>
</tr>
<tr>
<td>5 7 - 9 yrs. tenure</td>
<td>0.018</td>
<td>1.407</td>
<td>0.013</td>
<td>0.990</td>
</tr>
<tr>
<td>6 10 - 12 yrs. tenure</td>
<td>0.695</td>
<td>1.852</td>
<td>0.375</td>
<td>0.708</td>
</tr>
<tr>
<td>7 &gt; 12 yrs. tenure</td>
<td>0.0</td>
<td>0.0</td>
<td>.</td>
<td></td>
</tr>
<tr>
<td>8 &lt; 20 employees</td>
<td>-0.711</td>
<td>0.978</td>
<td>-0.727</td>
<td>0.467</td>
</tr>
<tr>
<td>9 20 - 99 employees</td>
<td>-0.257</td>
<td>0.723</td>
<td>-0.356</td>
<td>0.722</td>
</tr>
<tr>
<td>10 100 - 249 employees</td>
<td>-0.970</td>
<td>0.779</td>
<td>-1.245</td>
<td>0.213</td>
</tr>
<tr>
<td>11 250 - 499 employees</td>
<td>1.015</td>
<td>0.730</td>
<td>1.390</td>
<td>0.165</td>
</tr>
<tr>
<td>12 500 - 999 employees</td>
<td>-1.543</td>
<td>1.406</td>
<td>-1.097</td>
<td>0.272</td>
</tr>
<tr>
<td>13 &gt; 1000 employees</td>
<td>0.0</td>
<td>0.0</td>
<td>.</td>
<td></td>
</tr>
<tr>
<td>14 RDI &lt; 2.0%</td>
<td>-0.320</td>
<td>0.813</td>
<td>-0.394</td>
<td>0.694</td>
</tr>
<tr>
<td>15 RDI 2.1 - 4%</td>
<td>-1.385</td>
<td>0.948</td>
<td>-1.461</td>
<td>0.144</td>
</tr>
<tr>
<td>16 RDI 4.1 - 6%</td>
<td>-1.498</td>
<td>1.041</td>
<td>-1.439</td>
<td>0.150</td>
</tr>
<tr>
<td>17 RDI 6.1 - 8%</td>
<td>-0.431</td>
<td>1.641</td>
<td>-0.263</td>
<td>0.793</td>
</tr>
<tr>
<td>18 RDI 8.1 - 10%</td>
<td>-1.210</td>
<td>1.457</td>
<td>-0.831</td>
<td>0.406</td>
</tr>
<tr>
<td>19 RDI 10.1 - 12%</td>
<td>0.0</td>
<td>0.0</td>
<td>.</td>
<td></td>
</tr>
<tr>
<td>20 ASSESSMENT_AVAILABE</td>
<td>0.196</td>
<td>0.141</td>
<td>1.388</td>
<td>0.165</td>
</tr>
<tr>
<td>21 A-1 FACILITY_AVAILABLE</td>
<td>0.516</td>
<td>0.183</td>
<td>2.822</td>
<td>0.005</td>
</tr>
<tr>
<td>22 TECH. KNOWLEDGE_AVAILABLE</td>
<td>0.295</td>
<td>0.167</td>
<td>1.767</td>
<td>0.077</td>
</tr>
<tr>
<td>23 TECH. PROBLEM SOLVING AV.</td>
<td>-0.153</td>
<td>0.173</td>
<td>-0.884</td>
<td>0.377</td>
</tr>
<tr>
<td>24 NON-TECH PROB_SOLVING AV.</td>
<td>0.398</td>
<td>0.213</td>
<td>1.870</td>
<td>0.061</td>
</tr>
<tr>
<td>25 TRAINING_AVAILABLE</td>
<td>-0.105</td>
<td>0.164</td>
<td>-0.637</td>
<td>0.524</td>
</tr>
<tr>
<td>26 MEET FIRM W/SIMILAR RESEARCH</td>
<td>0.240</td>
<td>0.166</td>
<td>1.447</td>
<td>0.148</td>
</tr>
<tr>
<td>27 MEET BUYERS/SUPPLIERS</td>
<td>0.019</td>
<td>0.147</td>
<td>0.133</td>
<td>0.895</td>
</tr>
<tr>
<td>28 NEW RESEARCH AGREEMENTS AV.</td>
<td>-0.074</td>
<td>0.165</td>
<td>-0.451</td>
<td>0.652</td>
</tr>
<tr>
<td>29 ABLE TO ANALYZE COMPETITORS</td>
<td>-0.246</td>
<td>0.202</td>
<td>-1.221</td>
<td>0.222</td>
</tr>
<tr>
<td>30 USED OTHER EDISON CENTERS</td>
<td>-1.339</td>
<td>0.599</td>
<td>-2.235</td>
<td>0.025</td>
</tr>
<tr>
<td>31 USED OTHER R&amp;D CENTERS</td>
<td>-0.191</td>
<td>0.535</td>
<td>-0.356</td>
<td>0.722</td>
</tr>
<tr>
<td>32 USED OTHER RESEARCH PROGRAMS</td>
<td>0.653</td>
<td>0.568</td>
<td>1.150</td>
<td>0.250</td>
</tr>
</tbody>
</table>

Log Likelihood of constants only model = LL(0) = -101.486

\[2^{*}[LL(N) - LL(0)] = 47.060\] with 31 df Chi-sq p-value = 0.032

McFadden's Rho-Squared = 0.232
BIBLIOGRAPHY


