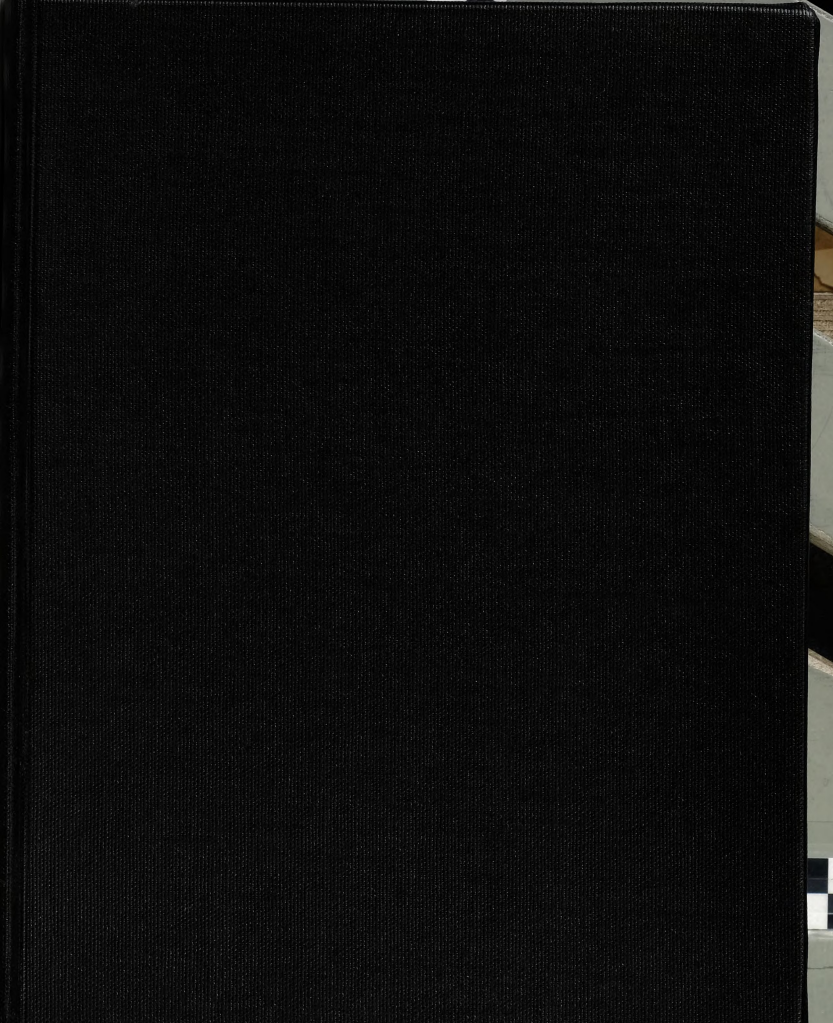




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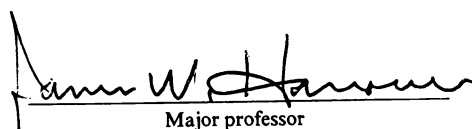
THE INFLUENCE OF INSTITUTIONAL STRUCTURE ON
FINANCIAL PERFORMANCE BY FIRMS WHICH
COMMERCIALIZE UNIVERSITY RESEARCH

presented by

Dikran Kashkashian

has been accepted towards fulfillment
of the requirements for

Doctor of Philosophy degree in Forestry


Major professor

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THE INFLUENCE OF INSTITUTIONAL STRUCTURE ON
FINANCIAL PERFORMANCE BY FIRMS WHICH
COMMERCIALIZE UNIVERSITY RESEARCH

By

Dikran Kashkashian

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Forestry

1988

ABSTRACT

THE INFLUENCE OF INSTITUTIONAL STRUCTURE ON FINANCIAL PERFORMANCE BY FIRMS WHICH COMMERCIALIZE UNIVERSITY RESEARCH

By

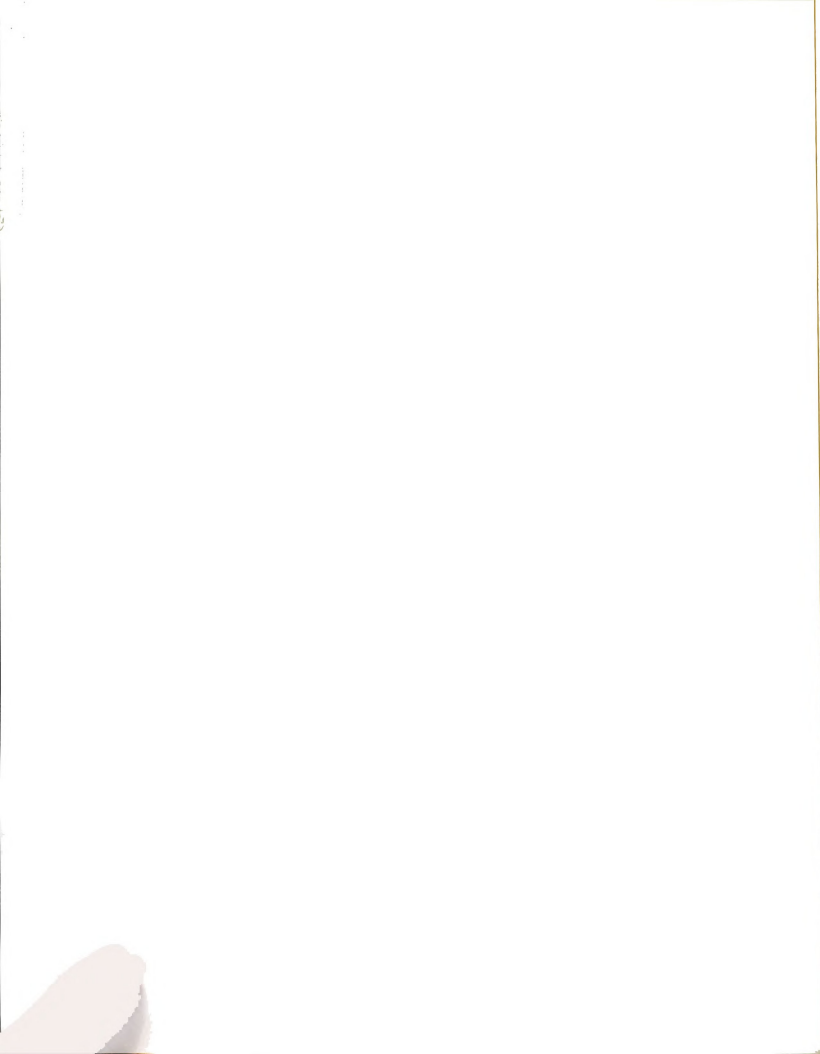
Dikran Kashkashian

Commercialization of university research is of widespread interest to public administrators, universities, and industry. Many studies address university-industry relationships but few quantitative assessments exist in the literature.

This study focused on the influence of institutional characteristics on financial performance by firms which commercialize university research. The public choice model of situation, conduct, structure, and performance was used to develop a framework for assessing the characteristics and performance of firms. Efficiency measures estimating the value of user cost savings represented by new technologies were used in the analysis.

This study was based on institutions associated with Michigan State University. University records, interviews with department chairpersons, and interviews with directors of firms were the data source. The data encompassed firm characteristics, user cost savings as rents, and policy issues. Because of the small sample size, and because the sample was selected to capture structural variability, statistical inference could not be made from these data.

The results indicated that firms with University supported situational variables may capture rents less efficiently than those with privately supported situational variables but they may enhance

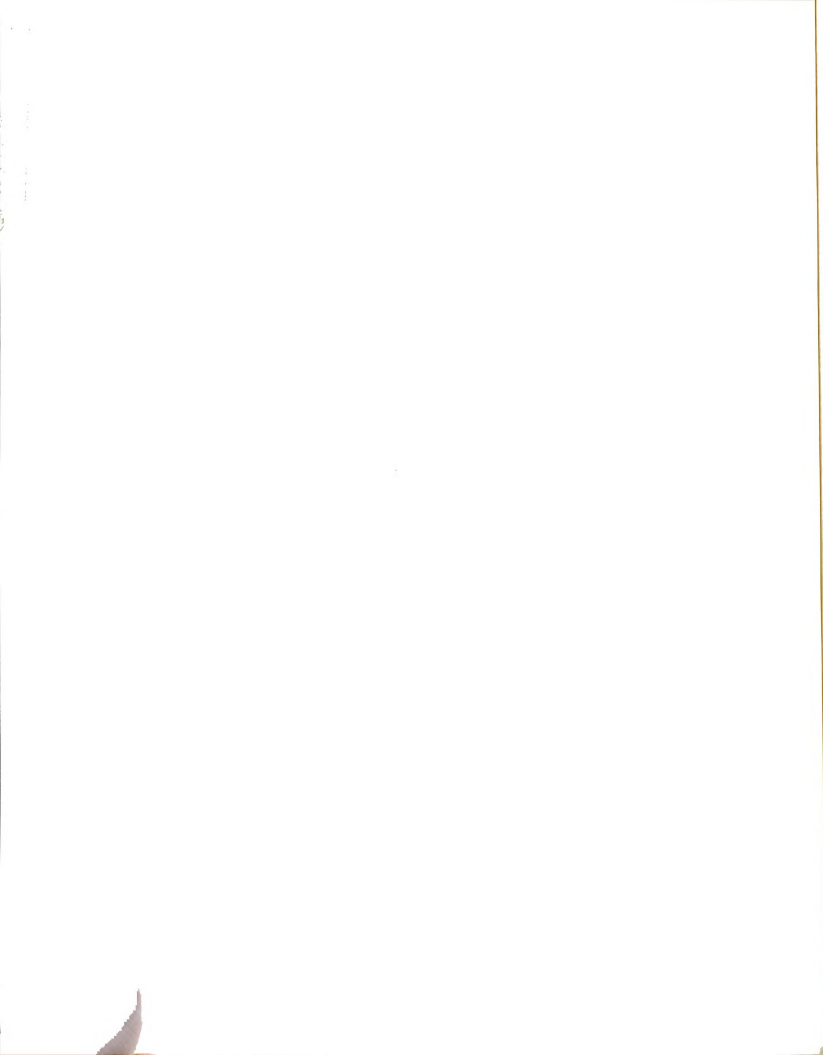


Dikran Kashkashian

returns to the University. The results also indicated that firms with University supported structural variables may capture rents more efficiently than firms with privately supported structural variables and they may enhance returns to the University. When efficiency of commercialization systems is one policy goal of University administrators (not absolute dollars) several program choices are evident. These include University controls, University marketing, quality objectives, and exclusive rights.

Firm directors and department chairpersons also called for encouraging commercialization efforts, increasing internal and external communication by the University administration, a better understanding of the business world by academics, maintaining structural flexibility in commercialization, and an internal program for assessing the commercial possibilities of University research.

Dedicated to my friends Bob and Bobette,
my model for energy and
the guide for my spirit.



ACKNOWLEDGMENTS

I would like to give particular thanks to my advisor Dr. James Hanover, who has stuck with me in my varied research interests. I would also like to thank the other members of my committee, Dr. Lee James, Dr. Larry Tombaugh, and Dr. Allan Schmid, who have provided me with support, criticism, and insight when I needed them.

A special thanks goes to the department chairpersons and firm representatives who participated in this study. Their time and cooperation were given generously for the completion of personal interviews. I must also thank the individuals who discussed the study and pretested the instruments with so much enthusiasm. Their help was essential. And many thanks to Dr. Henry Bredeck who has given his assistance throughout the course of this study.

Finally, for all of my friends, I'd like to thank them too: they helped the sun shine overhead during the last few years.

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CHAPTER 1

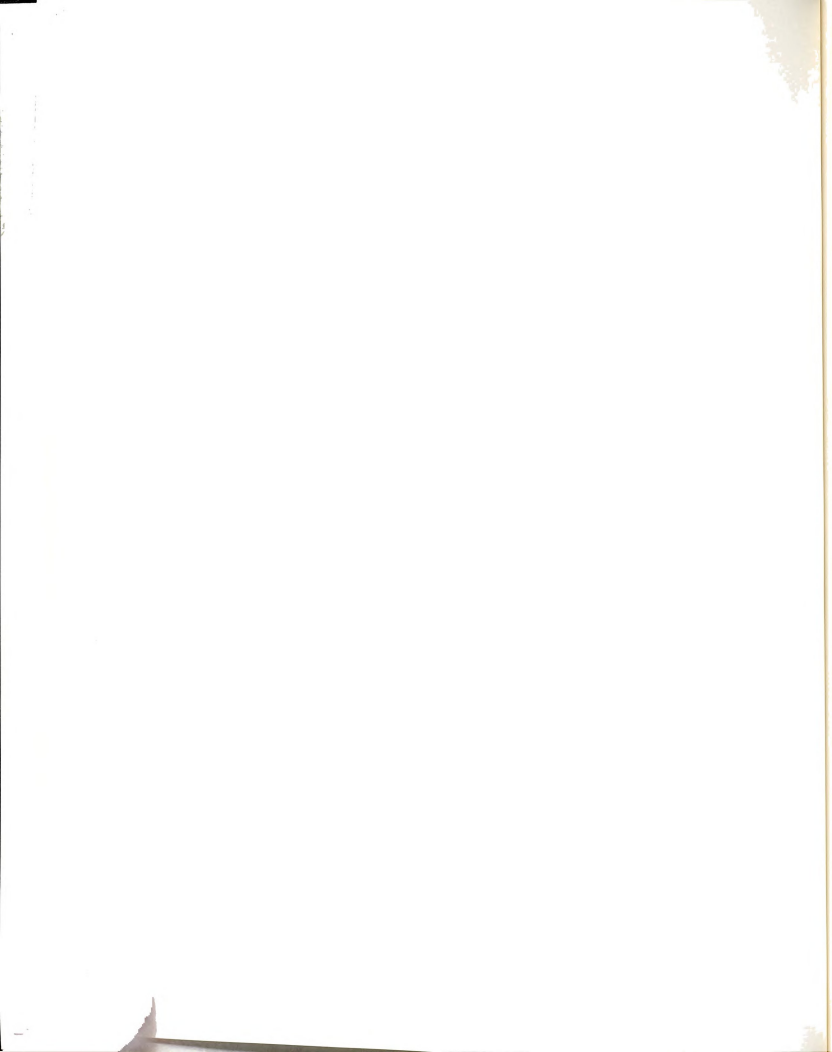
INTRODUCTION: BACKGROUND OF THE RESEARCH

1.1 Need for the Research

Gains in knowledge are often exhibited as a technical change which impacts the production function through increased returns to land, labor, or capital. Such technical change may emerge as process innovations, product innovations, or new products. Knowledge for technical change may come from the private sector, the public sector, or increasingly, a constructive combination of the two.

Public/private interactions are not new. However, the recent profusion of university-industry ties in the biotechnology and computer related fields has rekindled interest in how they can best serve economic and social interests. Within the confines of today's academic fiscal stress, increased emphasis is being placed by some university administrators on potential financial returns to the university from research output as a source of funds (Lubove, 1986; Blanchard, 1986; James, 1986; Peterson, 1987).

Commercial development of university research products and university-industry research ventures are two issues of concern in current science policy (Varrin and Kukich, 1985). Such concerns extend all the way from academic professors to industry leaders to the highest levels of the current administration (Clark, 1985). Recent publicity regarding university-industry ties has raised many questions about the purpose and structure of the university, the allocation of R&D resources to basic and applied research, the allocation of R&D resources to public and private institutions, the



structure and reformulation of intellectual property rights, the effect on university output by university-industry ties, and the possible outcome of these evolving relationships.¹

The tentative reformulation of operational standards among state, academia, and industry has introduced some profound changes in what has traditionally been a rather polite but reserved relationship (Abelson, 1986; Pings, 1986). As the distinction between private and public knowledge blurs, and the line between markets and universities wavers, it seems timely to review the structures found in today's university research facilities for the commercialization of research products. It might be helpful to understand how the array of institutional, product, and structural alternatives can be used to enhance university gains.

The State of Michigan has strengthened its economic development efforts during the last five or ten years. One pathway the State considered was increased university-industry ties in both technology assistance and product commercialization. A recent study funded by The National Science Foundation explored four universities in the State, a sample of small industries, and some of the ties among them (Koenig, 1986). Michigan State University administrators indicate that they could use a more comprehensive review of the ties the University has formed, or might want to form, for the outward movement and commercial development of research products in order to

¹Many references can be found in popular publications such as The Wall Street Journal, Business Week, and Science. University newspapers and bulletins also contain articles of local interest while professional publications such as The Journal of the Society of Research Administrators have devoted entire issues to the subject.

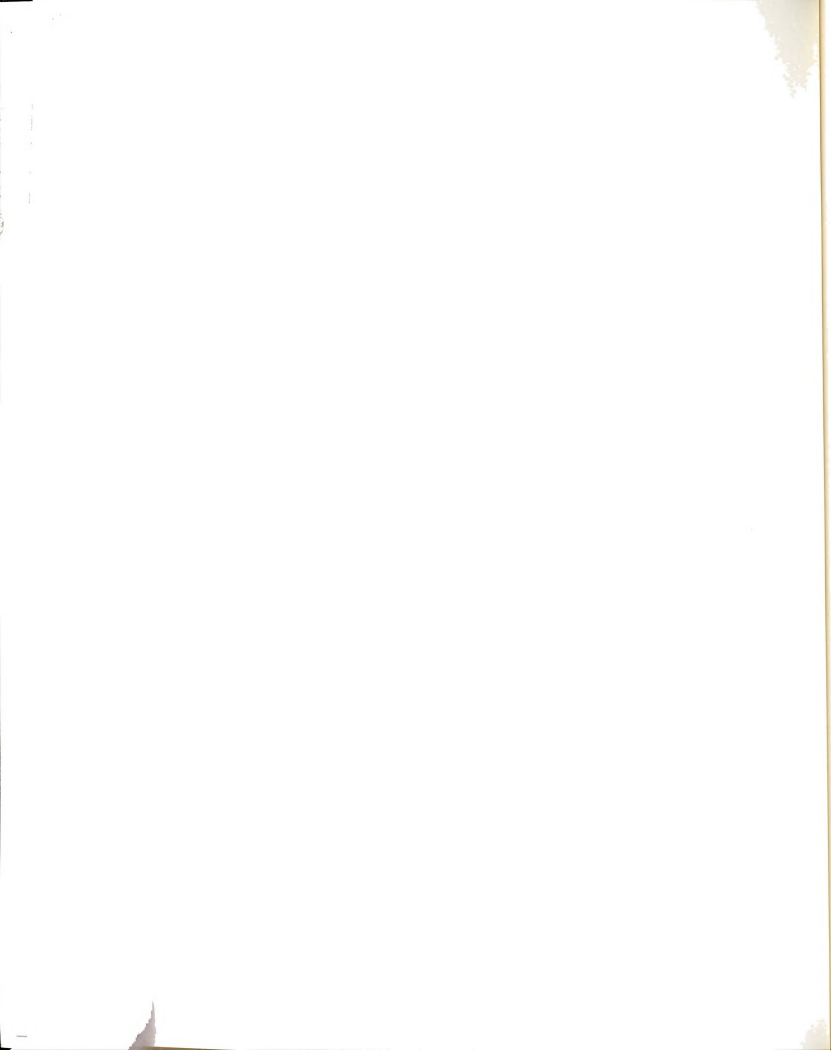
facilitate policy review (Cantlon, 1986). This review has been initiated (Koenig, 1987).

Many examples of university-industry ties are already in place at Michigan State University. Some of these ties are structurally different and how the inventor and/or university chooses one as a model for new product development remains an unresolved question. This is especially true when no precedent exists in a particular field which may have some attendant idiosyncrasies. One such field is tree breeding in forestry. Long rotation and generation times, seed orchard conversion and simultaneous management for both long-term research and short-term production goals, and the lack of established markets all make the forestry situation unique.

The Department of Forestry at Michigan State University is committed to making improved tree stock available to the Michigan forestry community. Commercial sales of tree seed from research plots converted to seed orchards has been proposed using a standard crop varietal release mechanism from the University. This potential relationship is still in the development stages. Identification of alternative structural mechanisms for the release of improved tree stock would be useful to the Department.

1.2 Problem Statement

Some innovations may be thought of as having a life cycle or time line which begins with an idea in someone's head, goes through research, development, and marketing, and ends with final product sales or production processes. This time line may be wholly within

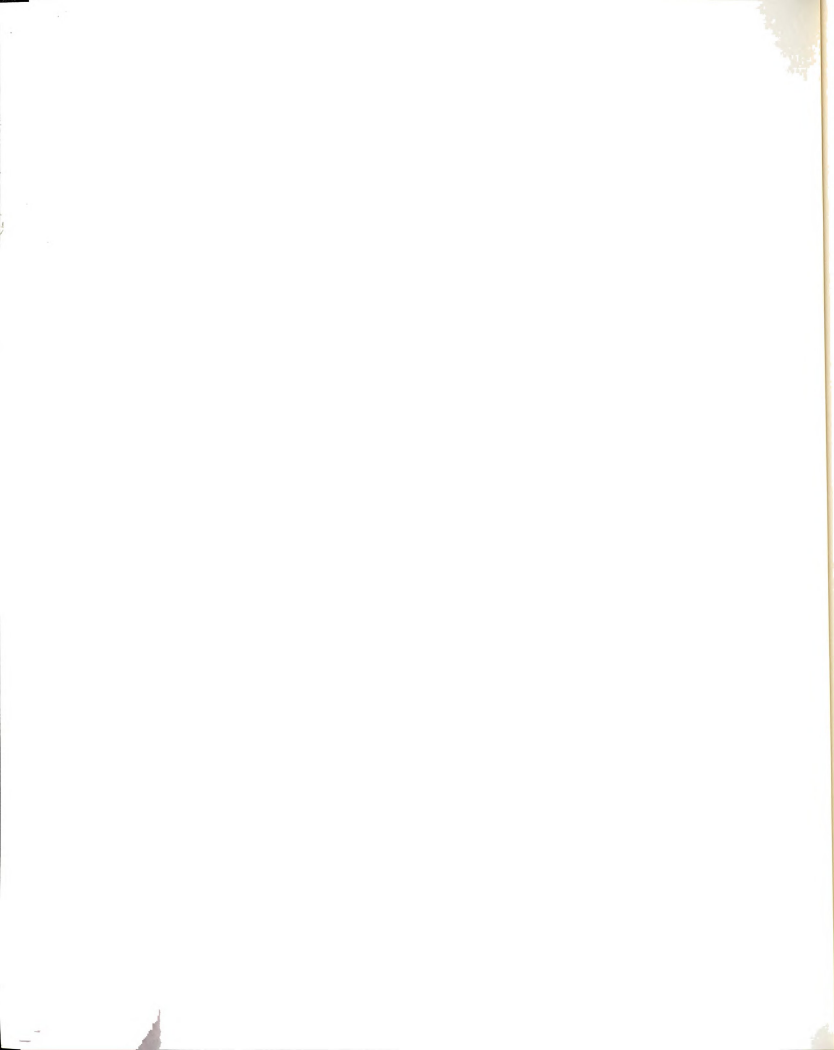


the public sector, wholly within the private sector, or may cross between the two. The administrative decision to change from public management to private management during the life cycle of an innovation and the general impact of this decision on all aspects of the educational institution, the success of technology transfer, and the attainment of public and private goals characterizes the general problem of studying university-industry commercial development.²

Public attention has recently focused on universities which are seeking to appropriate greater financial returns through commercialization of their research. Most university research products go outside the university sometime before final sales but the characteristics of the institution chosen by the university and their impact on the capture and return of revenues is not well understood.

University administrators may shift an innovation from the university to the private sector at a given point in its life cycle or shift an innovation from the university to a non-profit sector firm (which acts to a greater or lesser extent like a private sector firm) at a given point in its life cycle. This is an administrative choice. Once the university chooses to release research as a commercial product at some point in its innovation life cycle the

²Economic theory suggests that there are many differences between the public and the private sector. One major structural difference between firms (private) and universities (public) is their economic objective of being respectively for-profit and not-for-profit institutions. Private institutions tend to produce goods with non-attenuated property rights, capture greater economic rents, and appropriate full returns. Public institutions tend to produce goods with attenuated property rights, capture less economic rents, and appropriate partial returns.



characteristics of the mechanism used for its release might influence the attainment of various goals in both the public and the private institution.

This study focuses on the problem of how structural variability in university-industry commercial product development institutions influences their financial performance with respect to the capture and return of economic rents to the university. This study explores Michigan State University and some of its attendant institutions for the development of commercial products in the private sector in order to understand the influence of institutional structure on pre-identified performance criteria.

1.3 Objectives of the Study

The objectives of this study are to:

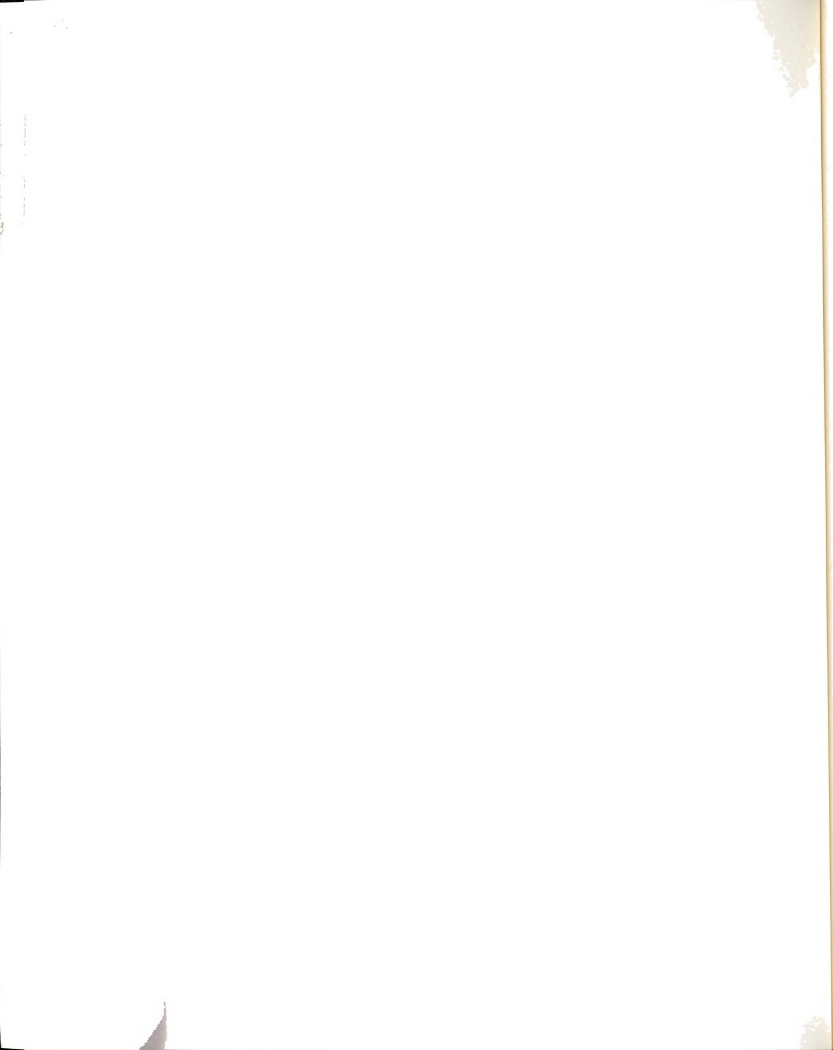
1. Develop a framework for analyzing the variability in institutions which are used for transferring innovations from the public sector to the private sector.

2. Apply the framework to identified institutions associated with Michigan State University.

3. Draw implications from the results of this study for the future agenda of research commercialization by the Department of Forestry at Michigan State University.

1.4 Research Plan

This study uses a public choice model of situation, structure, conduct, and performance. It was selected because it can be expanded



to include most aspects of the public choice problem of university research product development in one analytical framework. The use of an identifiable framework will allow comparative studies across institutions and universities in future work.

Situational characteristics of innovations which are of interest to this study focus on the cost aspects of the transfer of innovations from the university to non-profit agent to for-profit agent or directly from the university to for-profit agent. These characteristics include:

- investment costs
- transaction costs
- information costs
- exclusion costs
- production costs

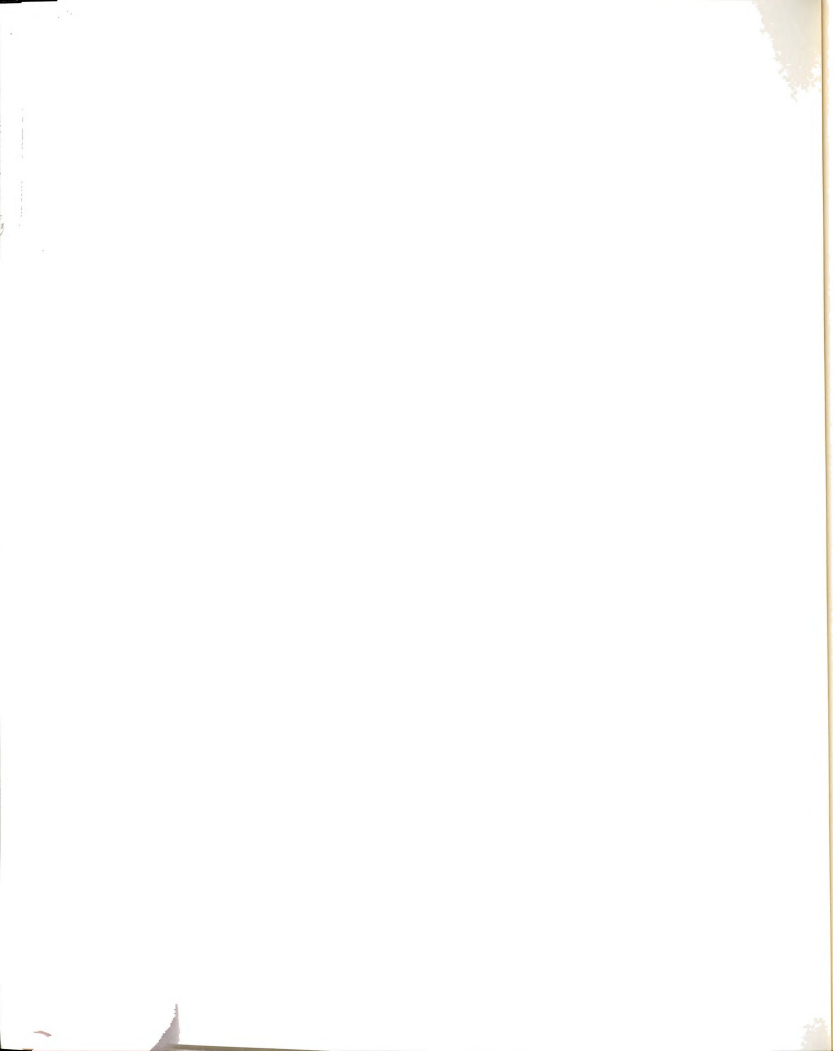
The relevant parties to the study form a line which parallels an innovation life cycle beginning in the public sector and ending in the private sector. These parties may include:

- university
- firm director (non-profit)
- firm director (profit)
- firm client

Due to the nature of university-industry ties the mix of relevant parties is often not complete and not unidirectional. Other important parties might include:

- researcher and technical support
- project director
- department or research center
- school or college

The structural characteristics this study focuses on are the set of contracts and controls between the university and non-profit and profit firms. These characteristics include:



- contracts
- administrative control
- financial control

Other environmental structural parameters might include:

- staff
- profit or non-profit status
- economic objectives
- market structure
- university rules
- organizational hierarchy

Conduct is the management practices of the various parties.

Performance is the result of conduct by the parties who are constrained by the interactions of situation and structure.

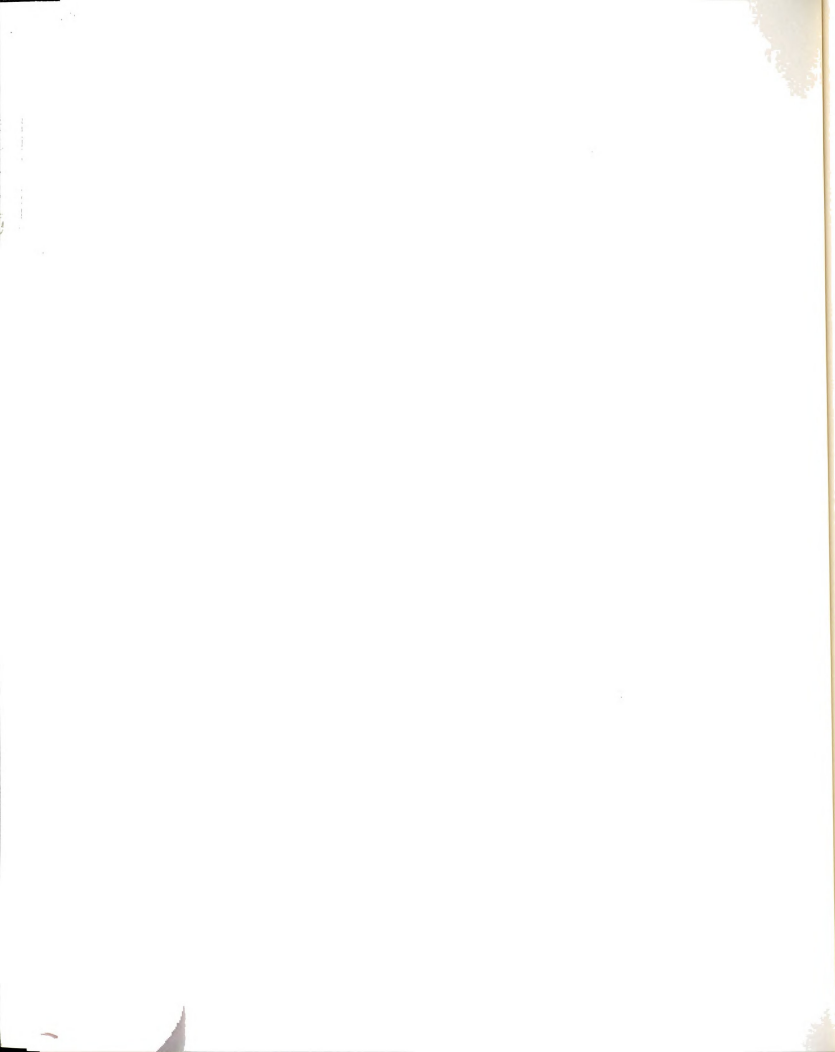
In this study situation and structure form an incentive for transfer firm management to capture economic rents from innovations and return revenues to the university. We are interested in how situation and structure can be altered to affect conduct and thus affect performance. The conduct is borne out by performance criteria including:

- percentage of rent captured by the firm
- percentage of rent returned to the university

1.5 Outline of the Dissertation

Chapter 2 outlines some of the literature on the economics of innovation. It also briefly reviews the history of university-industry ties, discusses some of the ethical conflicts which form the basis for today's academic debate, and presents a compendium of current trends in university-industry relationships.

Chapter 3 includes an analysis of how situational characteristics interact with the structure of transfer firm



contracts and controls to influence performance. These interactions are presented in a model which is useful in describing the capture and return of rents.

Chapter 4 presents the variables of university-industry relationships and outlines a framework for the study. It also presents five hypothesis, the expected influence on performance measures for alternatives of selected variables given these hypothesis, and the expected outcome of placing identified institutions within this framework.

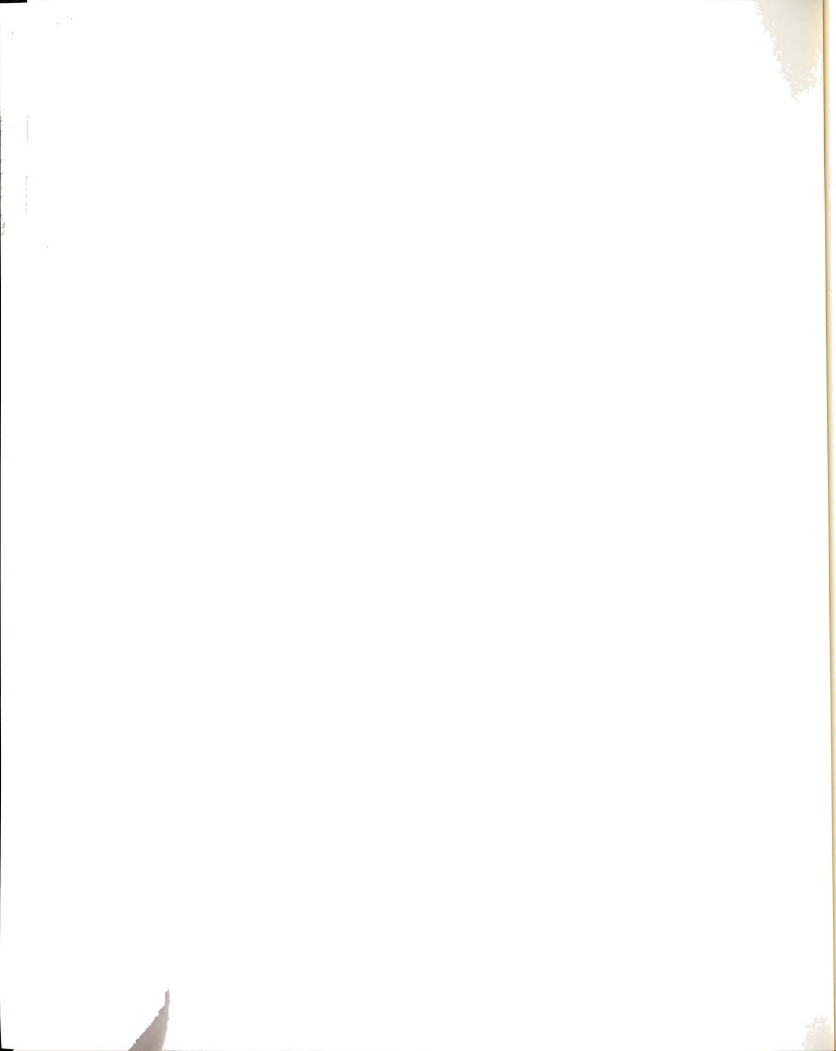
Chapter 5 discusses data problems, presents the design for an MSU inventory and policy interview, outlines a primary analysis of selected firms, and discusses methods used for estimating rents.

Chapter 6 presents the results of the MSU inventory and policy interviews, the results of the firm interviews, and discusses these results and compares them to the expected outcomes.

Finally, Chapter 7 summarizes the results, provides some conclusions, adds implications for the Department of Forestry, and suggests possibilities for further work.

1.6 Contributions of the Study

Completion of this study should add to the base of knowledge used by Michigan State University administrators in establishing and evaluating the campus/corporate connection. It should also provide a reference for the Department of Forestry and its immediate interest in developing the distribution of improved tree stock and its long term interest in silvichemical production. The results may also



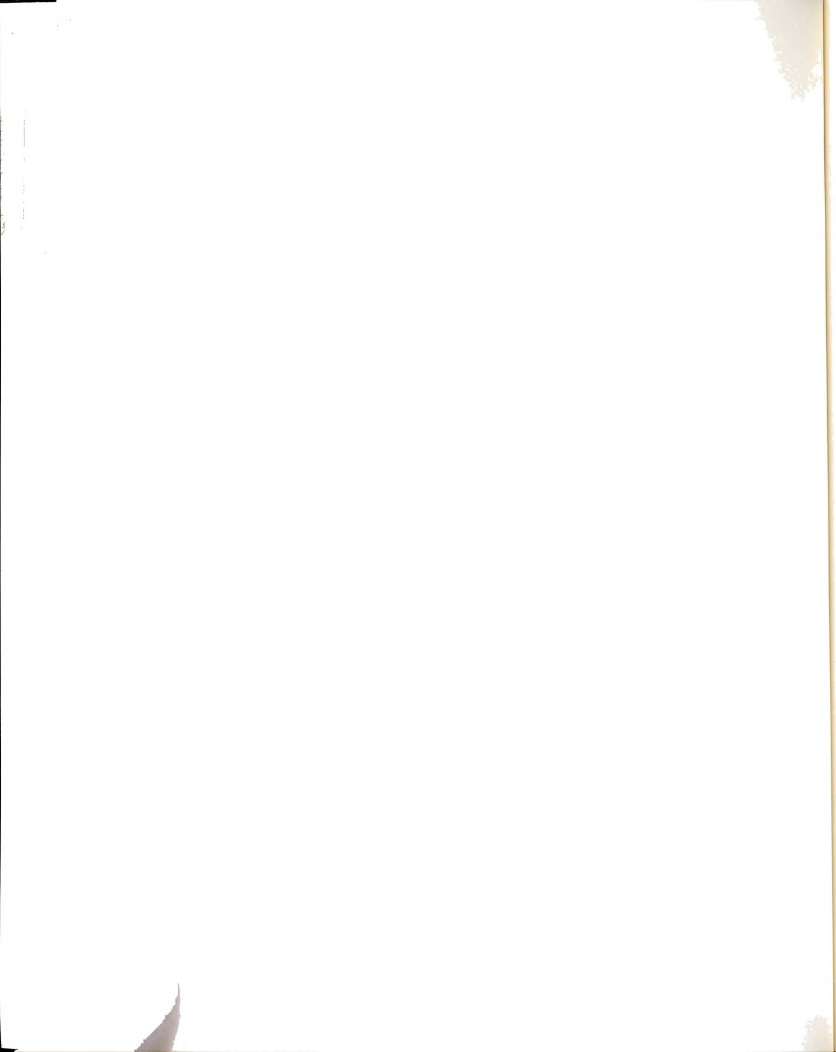
provide an incentive to other universities to review some of their traditional commercialization policies. Hopefully, this study will serve as a stepping stone towards further work in refining the framework and pursuing quantitative comparisons of institutions used for university research commercialization.

1.7 Definitions

Transfer firm: The institutions which this study is concerned with are organizations or firms that accept the outward movement of innovations from the university in the commercial development process for research products.

The institution may be public or private, nonprofit or profit, associated with the university or independent, act as transfer agent or production agent, and may return revenues directly or indirectly to the university.

The transfer firm is one of many different types of university-industry ties. A university-industry tie might receive an idea, a basic product, an undeveloped product, or a marketable product from the university. It might continue research, development, or marketing, or pass the innovation on to a third party. It might provide training for students, seek technological assistance through university consultants, donate equipment, provide facilities for training, or engage solely in non-capital product development activities with the university.

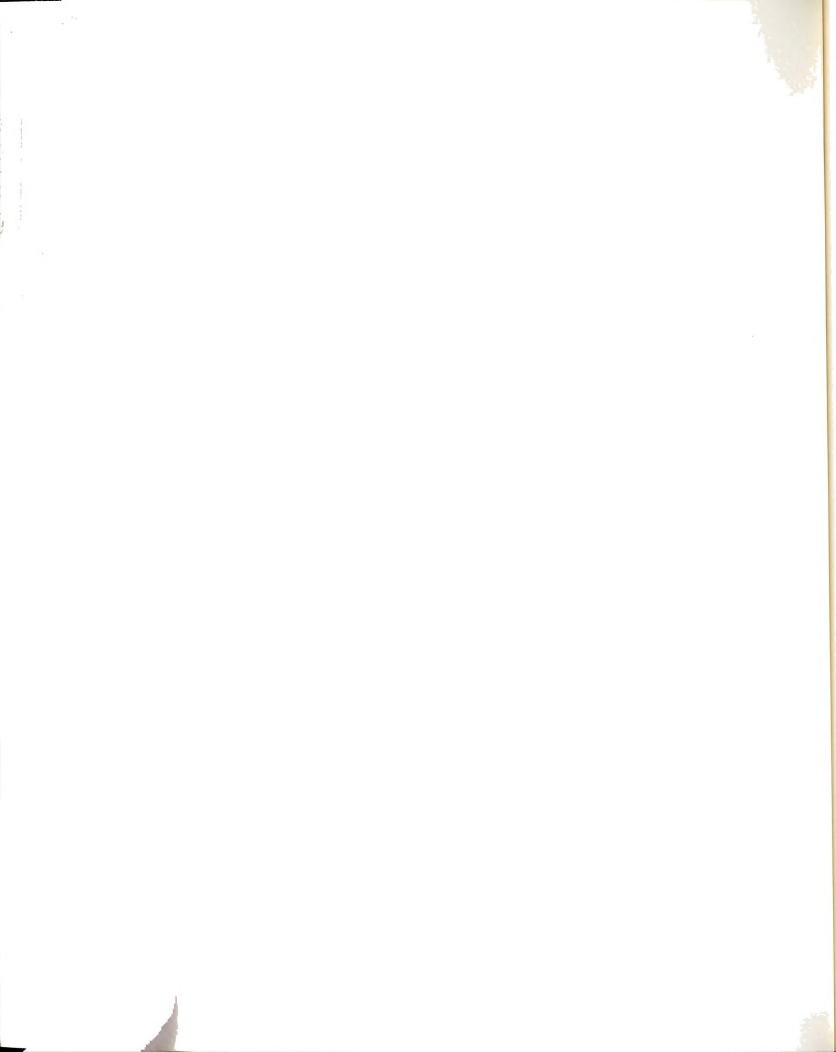


This study is concerned only with those institutions which are involved in the direct transfer of capital products from the university to the private sector.

Rent: This study defines rent to be the cost savings an innovation provides to the user as an input to the production process for the same level of output. An example is improved tree stock for Christmas tree growers. The costs saved by a faster growing tree are represented by time. Hence, a six foot salable tree is grown in fewer years. This may save the producer money and it may save the consumer money. Cost savings provide a measure of the rent which is ultimately available to the innovator.

Measuring the absolute value of rent requires a quality specification and a user value specification. The best Christmas tree stock might be abused by the grower or the consumer so that all cost savings represented by the technology are lost. However, from the point of view of the inventor or the university these are still available rents. Structuring the transfer of innovations so that these rents are realized is of concern to this study even though quality and user value specifications are not made.

Discussion of alternative performance measures is provided in Chapter 4 and of estimating user cost savings as a measure of rent in Chapter 5. This study uses the percentage of captured and returned rents in order to separate the effects of the institution from the product.



CHAPTER 2

INNOVATION AND TECHNOLOGY TRANSFER

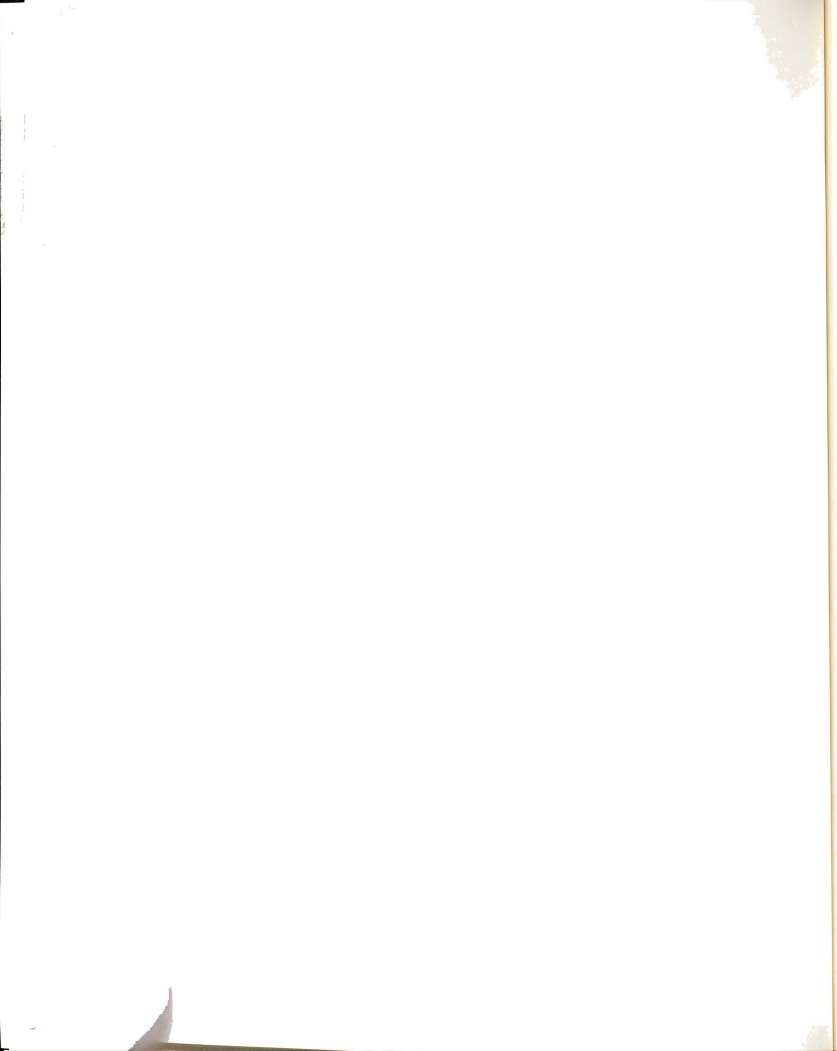
2.1 Innovation and Institutions

A great deal of economic literature examines the relationships between innovation, property rights, production, institutions, and markets.¹ This inquiry, for the most part, has focused on R&D in the private sector and an innovation's subsequent activities in the marketplace. Traditional recognition of the university as a bastion of basic research and the firm as a well honed tool befitting applied research has focused this inquiry on the private sector.

Nelson (1959) recognized the need for a shift in these traditional lines nearly 30 years ago and proposed the development of an intermediate research facility wherein "an increasingly important role should probably be played by industry oriented laboratories not owned by specific industries but doing research on a contract basis for a diversified set of clients." While Nelson did not advocate that universities play this role -- he maintained that their optimal use lies in basic research -- certain university associated institutions are beginning to establish such a role for themselves today.

A better understanding of the institutional structures emerging from the university is needed in studying the economics of innovation

¹ Kashkashian (1986b) prepared an introductory literature review before the selection of a dissertation topic. It covers some major ideas and findings regarding innovation, markets, production, and patents and asks questions about how the university might fit in with those findings. Most of this chapter is a synopsis of that work.

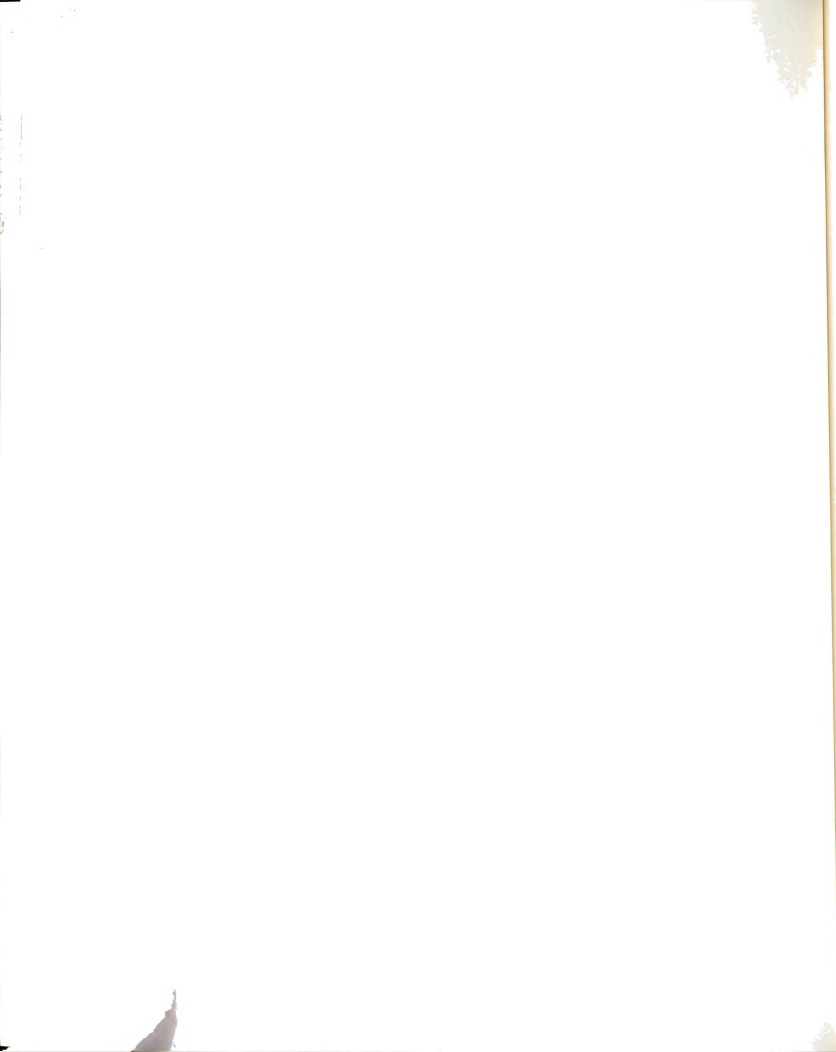


activity. The White House Conference On Productivity (Report to the President, 1984) concluded that one national goal was to "Reassess the adequacy of institutional arrangements and Federal incentives for the development and demonstration of technology and its transfer to those who will innovate and commercialize the technology."

Tornatzky et al (1983) emphasized the importance of institutional questions to understanding university-industry ties and the lack of answers to them by the current literature. In their study for the National Science Foundation they state that "While the literature does identify hypothesized barriers to successful (university-industry) interactions, it does not clearly define measures of success, and generally fails to provide data about which mechanisms transfer what kind of information best." This study makes an initial attempt to meet some of those needs.

2.2 Innovation Theory: Structure, Patents, and Returns

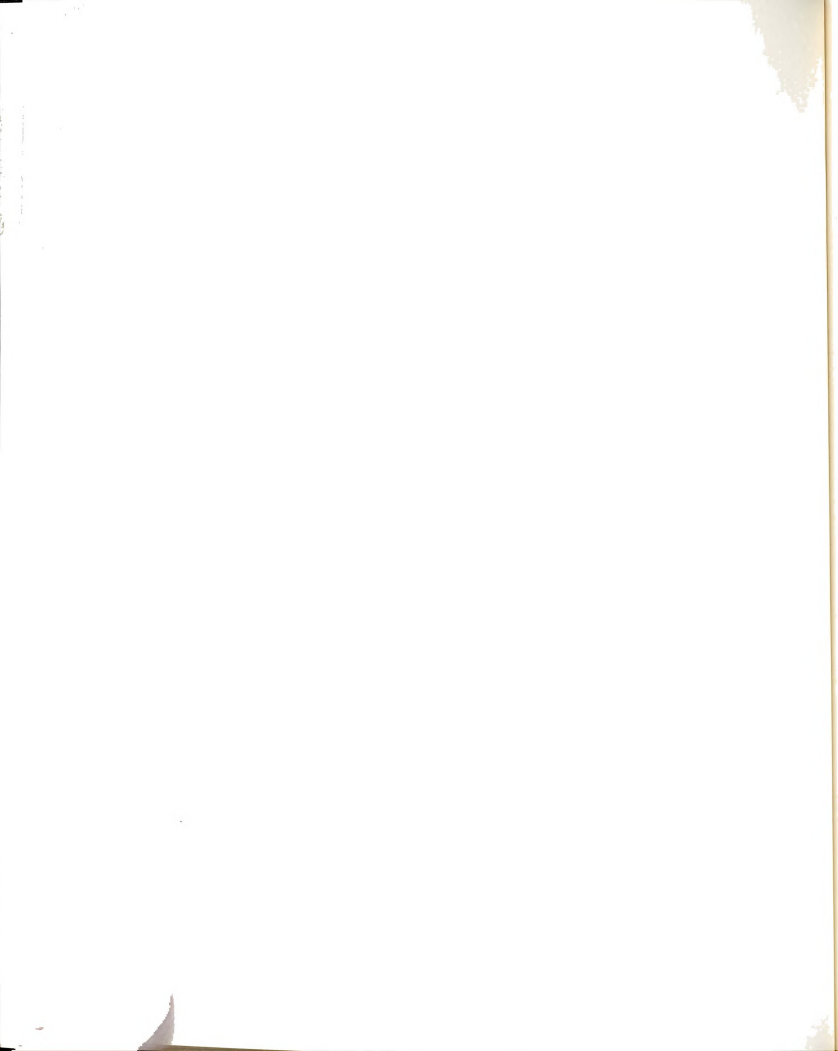
Three sets of literature apply to the economics of innovation. The first deals with product innovation and market structure (Schumpeter, 1950; Galbraith, 1952; Kennedy and Thirwall, 1972; Kamien and Schwartz, 1975 and 1982; Dasgupta and Stiglitz, 1980a and 1980b; Scherer, 1980a; Levin et al, 1985) and to a lesser extent, product innovation and firm structure (Comanor, 1964 and 1965; Mansfield et al, 1971; Kamien and Schwartz, 1975 and 1982; Bound et al, 1984; Culbertson and Mueller, 1985). These studies develop the Schumpeterian theme relating market power and innovative activity into a body of related hypotheses.



The second set of literature examines patent law and its applications to innovation (Plant, 1934; Palmer, 1957; Machlup, 1958; Melman, 1958; Usher, 1964; Kitch, 1980; Kitti and Trozzo, 1977; Scherer, 1980b). Of particular interest to this study is the literature that has some applications to plant breeding and genetics (Gerschman and Scafetti, 1980; Biggart, 1981; Gibbons, 1981a, 1981b, 1981c, and 1981d; Adler, 1984 and 1986; Engel, 1984; Schuman, 1984; Straus, 1984 and 1985; Williams, 1984; Byrne, 1985; Cadman, 1985; Doyle, 1985; Hamper, 1985; Krosin, 1985; Linck, 1985; Benson, 1986; Sun, 1985). Some of these works have recently been challenged (Schmid, 1985b, 1985c, and 1985d; Picot, 1985).

The third set of literature relates research expenditures to (aggregate) production functions. These studies focus on national productivity (Schmookler, 1955; Valavanis, 1955; Solow, 1957; Griliches, 1964, 1973, and 1980; Kennedy and Thirwall, 1972; Nordhaus, 1972; Gollop, 1985) and individual industrial sectors (Kendrick, 1961 and 1983; Minasian, 1962; Ullman, 1980; Griliches and Lichtenberg, 1984; Griliches, 1986). Some of the most detailed sector work has been completed in the agricultural community.

Economic analyses of agricultural research projects are somewhat unique in that they tie university research, more than in any other sector, to its performance in private markets. There is a broad and extended literature covering this subject (Westgate, 1984). Bengston (1985a) pointed out that these studies are mostly ex-post in nature and use either consumer surplus or production function measures. Furthermore, Bengston points out they focus on either crop production



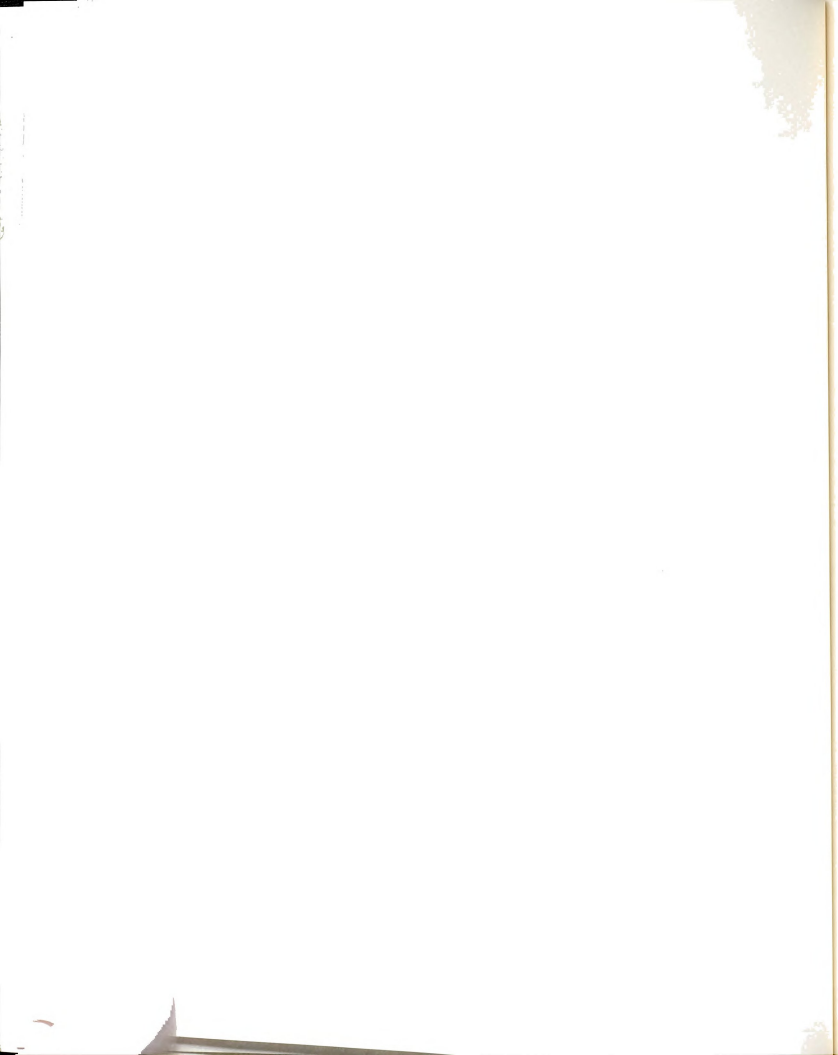
or aggregate agricultural production and the resultant rates of return are often of limited use to policy makers formulating decisions about future research programs.

This study does not attempt to survey the agricultural research evaluation literature (Griliches, 1957 and 1964; Fishel, 1971; Evenson et al, 1979; Huffman and Miranowski, 1981; Edleman et al, 1982; Ruttan, 1982). These studies have systematically demonstrated high rates of return to agricultural research expenditures. Initial work in forestry demonstrates similar results (Bengston, 1984 and 1985b; Seldon, 1985; Westgate, 1985; Haygreen et al, 1986). This study is not concerned with rates of return to research but rather with the efficiency of innovation transfer mechanisms.

2.3 Innovation Impetus: Knowledge or Profits

Once the positive relationship between innovation inputs and outputs was established, economists asked what forces were responsible for the relationship as it was understood. Two fundamentally different schools of thought respond to this query and both provide supporting empirical evidence.

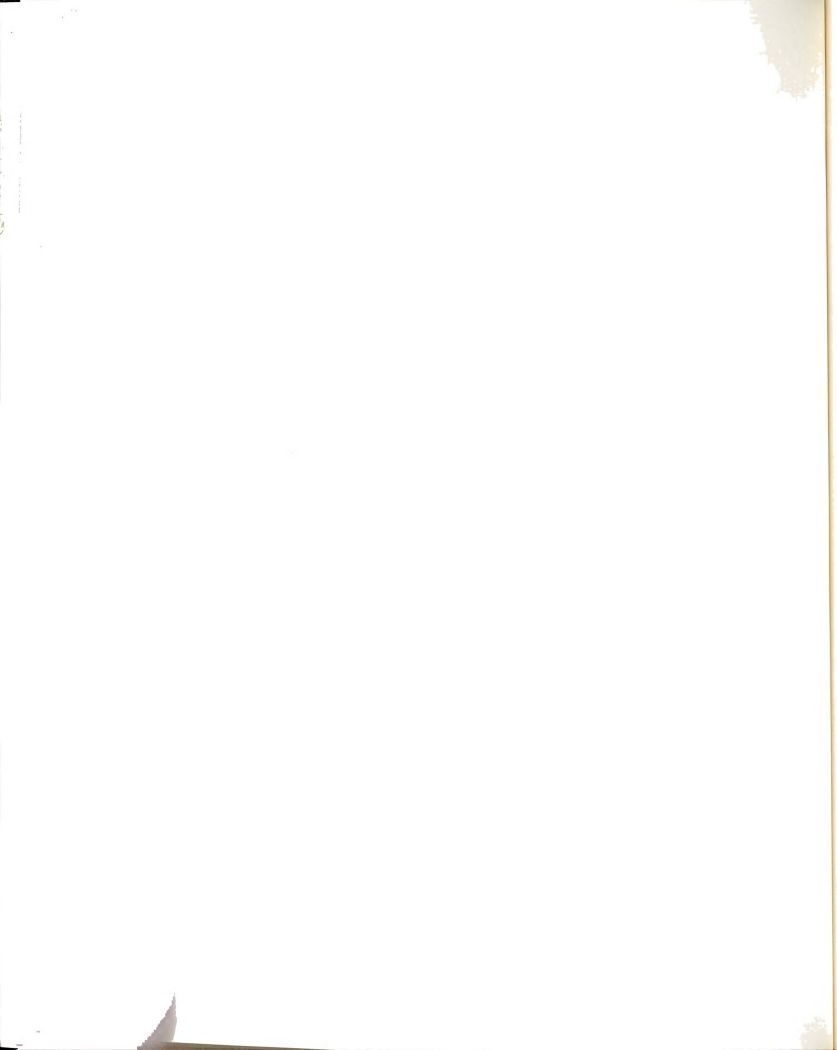
The first school of thought proposes that technological opportunity or the presence of basic knowledge provides an impetus for innovative activity. Both interindustry studies (Scherer, 1965; Kelly, 1970) and intraindustry studies (Comanor, 1964 and 1965) demonstrate that technological opportunity can be a force behind the rate of invention for firms or industries. Nelson (1982) models the role of knowledge in innovative activity considering both the source



and effects of a knowledge capital stock. The second school of thought proposes that the rate of invention is a function of economic factors and is driven by the profit motive. Schmookler (1966) exhaustively documents this philosophy and provides testimony against the first school. There is probably some truth in both arguments and unfortunately they provide contra-indications for the university setting.

Universities have long been recognized as a bastion of basic knowledge. While the publishing process quickly makes such knowledge available, there is at any given time a stock of fundamental technological opportunity contained within university walls which has not yet been converted to public property. Some never will be. Since universities are both the producer and proprietor of such basic knowledge, proponents of the first school might argue that we expect to find, *ceteris paribus*, a greater rate of innovation activity in universities than in industry. On the other hand industry has long been a champion of the profit motive. It has traditionally gleaned basic knowledge from its academic home when implementing an R&D strategy, and driven by the profit motive, the second school would argue that we expect to find a greater rate of innovation activity in industry.

The latter explanation probably presents an accurate historical picture. However, recent trends in the recognition of university researcher property rights, fiscal stress and inequity of funding programs in academia, and increased discourse between industry and academia, all point toward an encroachment of the profit motive on

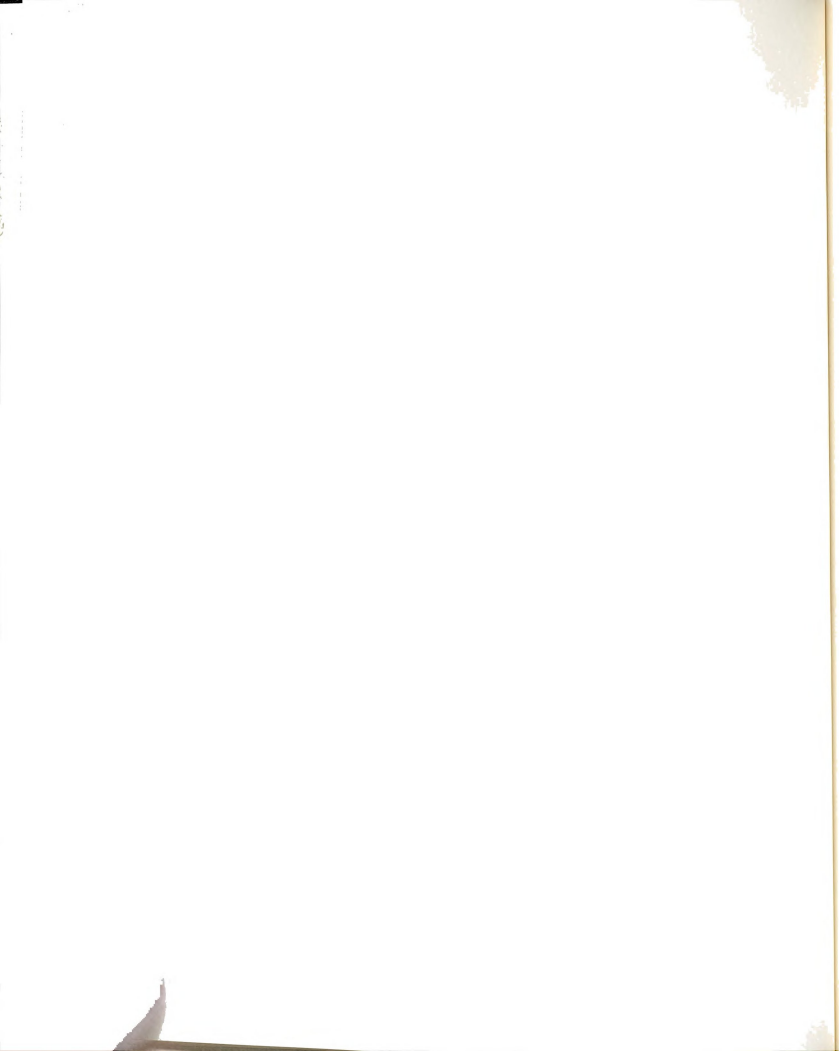


the university environment. Increased costs of scientific research and decreased appropriations to universities provide added incentive for income generating activities by faculty in certain disciplines. We might expect to find a rapid increase in university innovation activity even while certain institutional checks remain in place.

The questions here are: 1) How far has (will) the profit motive encroached upon the university and will the combination of technological opportunity and profit motive in the university give rise to a blossoming of innovation activity on campus; and 2) Will this same combination result in a restriction on the creation and flow of basic knowledge from the university to the public, thereby reducing some innovation activity in industry? Some recent evidence suggests that this may be happening in the biotechnology field (Blumenthal et al, 1986a and 1986b). This study examines some institutions which are used to transfer innovations from the university to private markets in anticipation of such a change.

2.4 History of University-Industry Interaction

There is a long history of university-industry research relationships but during much of this history the focus has not been on direct commercialization of university research. The modern research university began to evolve in the late 1800's and with it a group of highly trained researchers. In addition, the Land Grant System initiated an academic environment oriented to applied problems. Partly in response to this population of industrially



oriented graduates there was a proliferation of industry based research laboratories during the early 1900's.

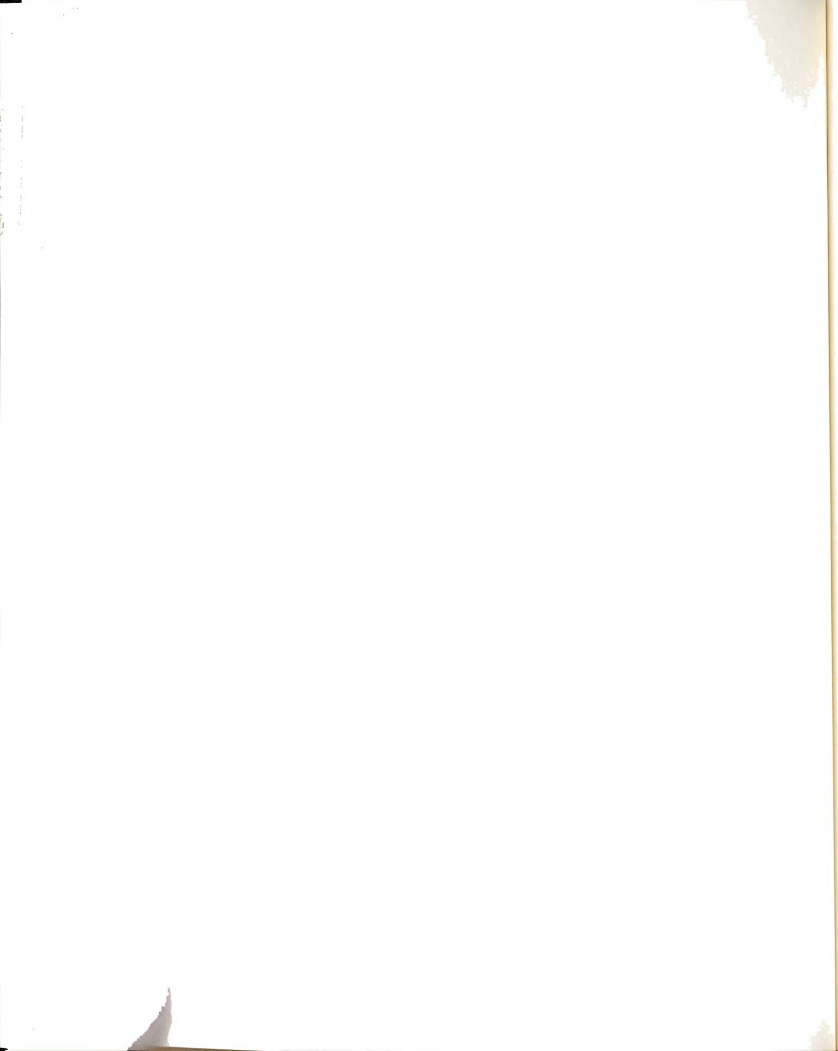
World War II initiated a great deal of cooperation between industry and academia and some of the newly formed relationships carried over into the post-war era. However, during the sixties and seventies, industrial support of university research remained relatively flat in constant dollar terms while federal support grew.

During the seventies, and again, in the mid-eighties, recurrent interest by national administrative agencies supporting the relationships between universities and industry has surfaced. A number of factors may have contributed to this renewed interest in the campus-corporate connection, including, the energy-supply shock, a decrease in American productivity, a perceived loss of technological superiority, a post-Vietnam war revitalization effort, and an increasing complexity and cost of doing modern research. Today, these interests are exemplified by the activities in structuring productive arrangements in the fields of biotechnology and computers.

This historical outline presents an extreme simplification of a complicated picture (National Science Foundation, 1983); however, a similar overview is provided by Wright (1986).

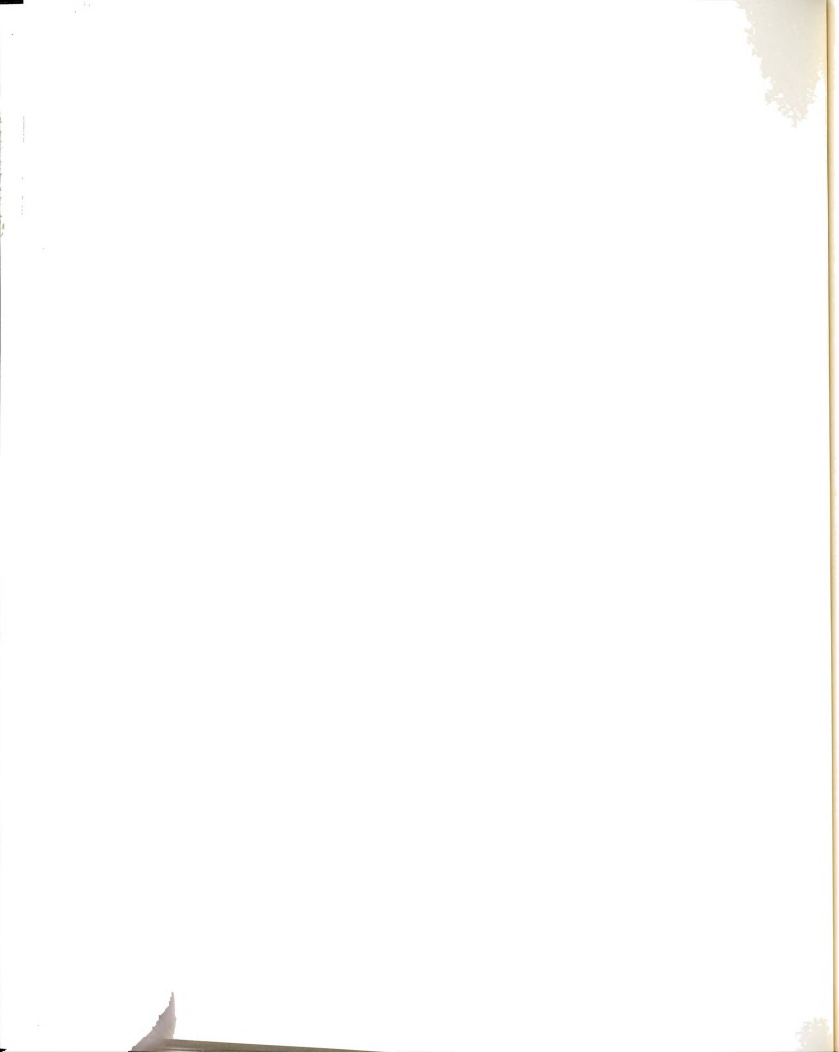
2.5 Conflicts in University-Industry Commercialization

A number of potential conflicts can arise in university-industry relationships. They might include philosophical differences, reliance on corporate sponsorship, exclusive access to public



knowledge, distribution of profits, secrecy in academia, scientists as teachers or entrepreneurs, publishing rights, basic versus applied research, short-term versus long-term approach to research, lack of peer review, proprietary rights, and other productivity and creativity issues. These are discussed in Murray and O'Connor (1983) while a brief review of those issues which confront industry is given by Maurer (1984/85) and those which confront academia by Newman (1984/85). A few examples of more pointed writers are discussed in this section.

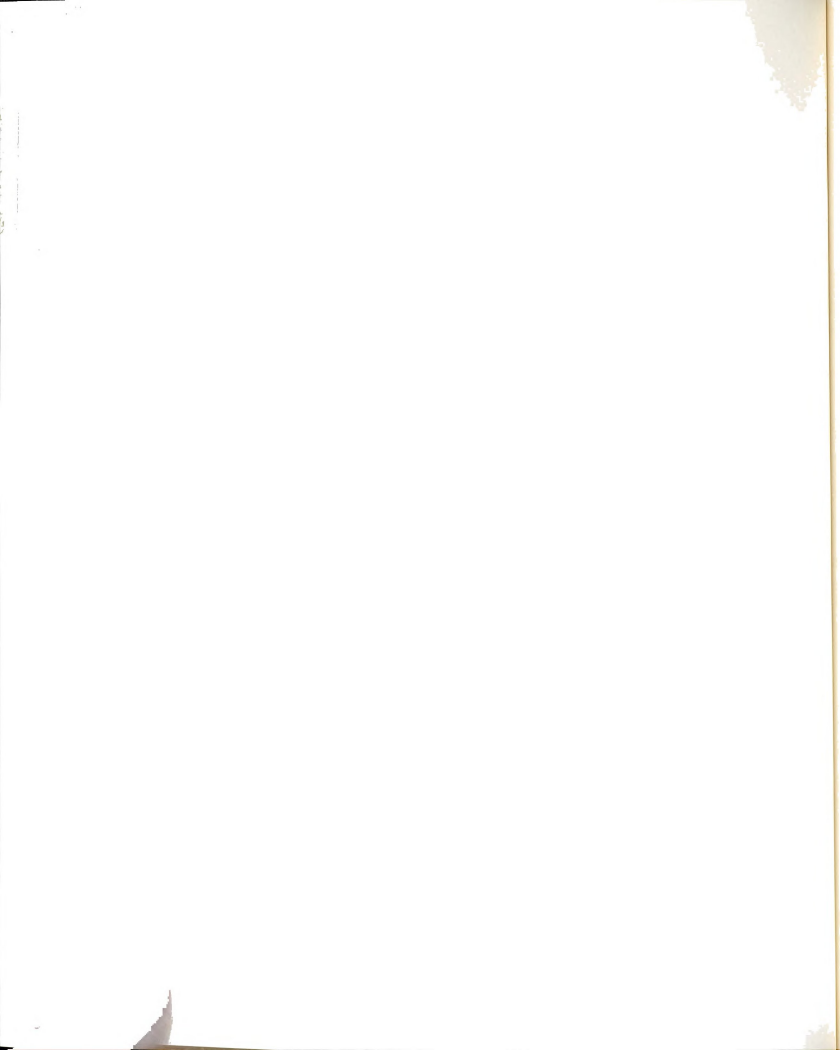
O'Boyle (1984) draws a parallel between the university researcher and the private entrepreneur. He points out that "The entrepreneur in the academic order paves the way for his counterpart in the capitalist order. It is this real-world drawing together which makes the analogy instructive. Indeed, it is not as if the two were alike; the two in fact are becoming one." This demonstrates O'Boyle's view that the university is choosing to embrace the idea of knowledge as power, giving in to institutions that want control of that knowledge and are more proficient at transforming that knowledge into some marketable good. His alternative is for the university to embrace the idea of knowledge as an end in itself, giving in to the traditional role of protecting radical thought. O'Boyle feels this is a no-win situation for the university: it either loses its ethics as the university researcher becomes a contract hustler or it loses its respect as it becomes increasingly distanced from social ideals. He seems to think the tides are turning toward the university embracing knowledge as power



but makes no judgement on whether this is a bigger loss than embracing knowledge as an end in itself.

Chermiside (1985a) identifies some ethical conflicts for the researcher who chooses to patent. One conflict centers around access to information and choice of whether to publish or patent. Another conflict centers around the objectivity of research choice, priority, and evaluation. A third conflict regards the duties of research, teaching, guidance, service, and administration. The final conflict regards the administrative focus of faculty evaluation. Will the academic rubric of publish or perish become patent or perish? Chermiside (1985b) also suggests that university patent exploitation can serve the public. He feels that the university needs help in realizing revenues from commercial development of low potential patents but should support in-house marketing capabilities for high potential patents. Where that line is drawn, particularly for smaller institutions with fewer researchers and resources to draw from, might make or break a university research program. Good university administration might not include taking such financial risks at the expense of losing some part of their institution.

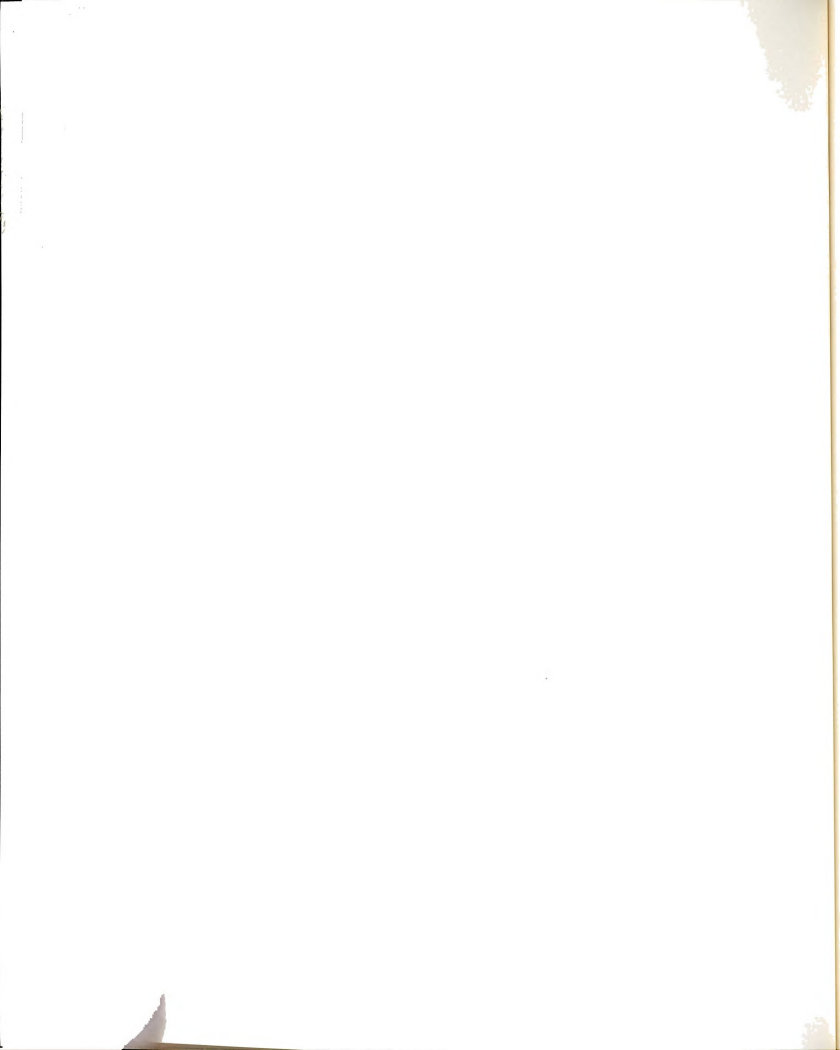
Roberts and Peters (1981) hold the usual view that innovation requires both invention and exploitation. They feel that most universities are high in invention and low in exploitation and suggest that "Collaborative pairings of idea-havers and idea-exploiters might be attempted at early stages of development, not just in industrial research laboratories but even in academic



departments." This is strong stuff. First it grates against the traditional role of the university as a center for basic research and then it grates against the traditional role of the tenured faculty position as a center for academic freedom. While it may be strong stuff, others have suggested similar collaboration at different stages of innovation. See Goldhor and Lund (1983) for their ideas on matching the donor, the transfer agent, and the recipient of university based innovations; and see Mehrez (1985) for a more general model of public intervention in R&D decisions.

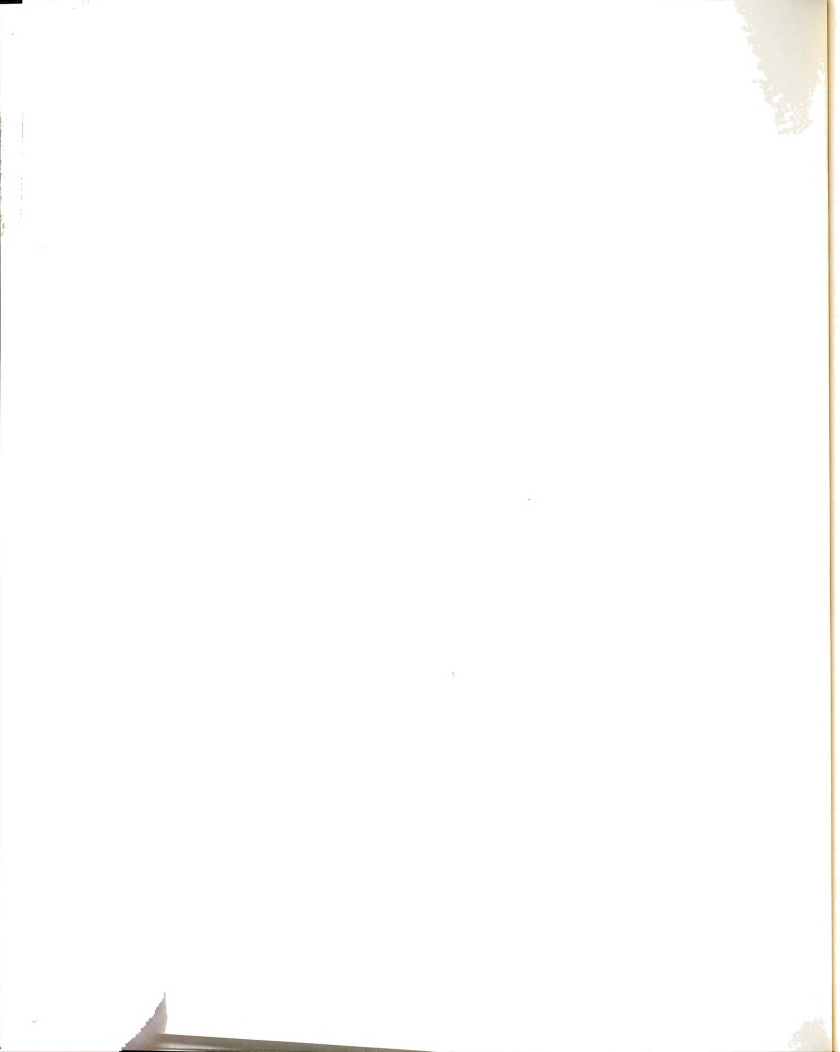
If Roberts and Peters' suggestion is to be taken seriously, management of university research for innovation might be extended to cover the probability of commercial success. Ettlie (1982) completed some work predicting the probability of commercial success in federally sponsored research projects using the size of technological increment, the pricing potential of the innovation, and the ease of implementation. The university research administrator or researcher could consider such factors when selecting and evaluating research projects if the university is to be the idea-exploiter. If the university continues to count on industry to provide idea-exploiter services it can attract industry by targeting these three factors in selecting and evaluating research projects. And if the university pursues research contracts it can count on industry to have pre-selected research projects which accommodate these three factors.

While Ettlie is proposing a more systematic approach to research evaluation for its innovative potential at the federal level, his



approach could be transferred from a public government agency to a public academic institution. The status of such a transfer may be determined by the strength of individual university objectives and their philosophy of academic inquiry. This problem is not unlike the question of some universities accepting large contracts for defense research and their critics whose arguments often center around educational objectives and philosophy. Because these ideas are evolving from a position that is neither well defined nor generally embraced, the future educational objectives and philosophy of the university may be influenced to a greater extent by the practices which they embrace today (defense research or evaluation of research for commercial potential) rather than by a meritorious consideration and refinement of old objectives and philosophies.

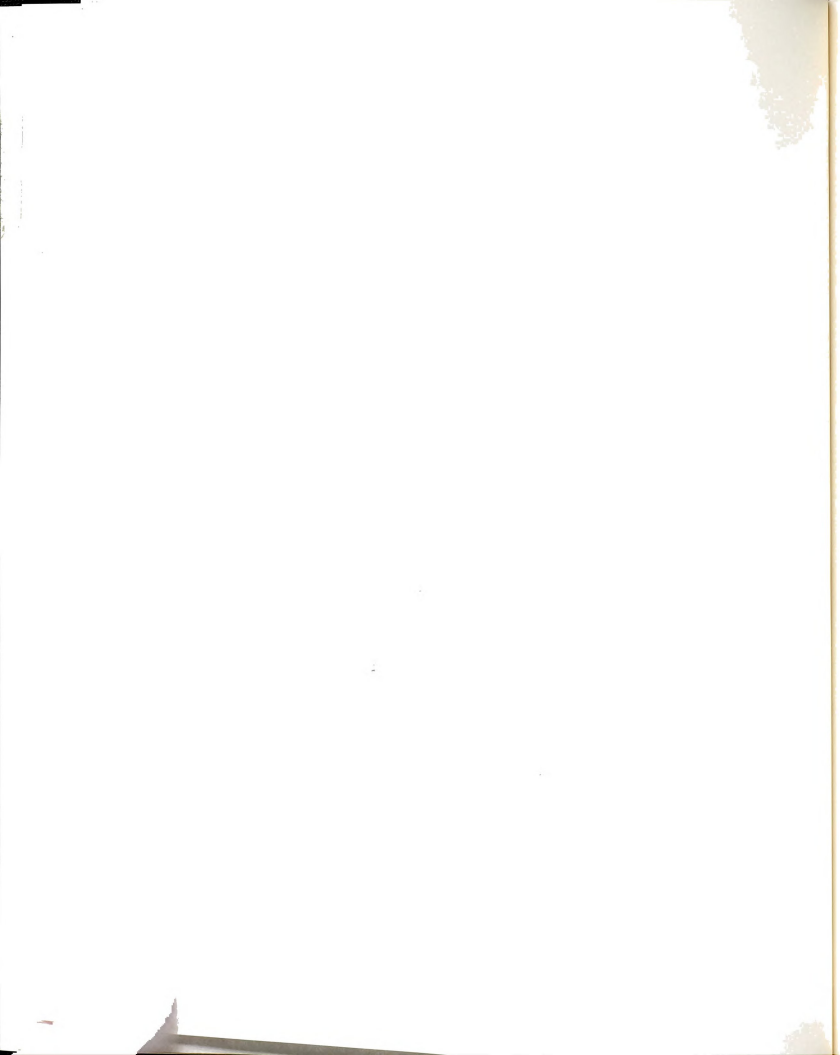
The roles of the faculty member as teacher, researcher, consultant, administrator, and counselor are discussed by Muller (1983/84) and Lederberg (1983/84). Both support university-industry ties. Muller focuses on the faculty member who is not really an employee and retains the freedom to do what he wants as long as he teaches and remains "proficient and distinguished." Lederberg focuses on justifying the consulting activities of faculty members and on resolving some faculty-university conflicts stemming from these consulting activities. Personal experience with the abuse of the teaching role by faculty members in the consulting role was documented by a graduate student at Michigan State University (Kashkashian, 1986a).



None of these issues will be resolved quickly or easily. Definition of university goals and objectives in their industry relationships may help clarify which are truly issues to the academic. In addition, such definition could provide the setting for policy formulation and regulation which would resolve the issues on a singular and institutional basis.

2.6 Current Trends in University-Industry Relationships: Local

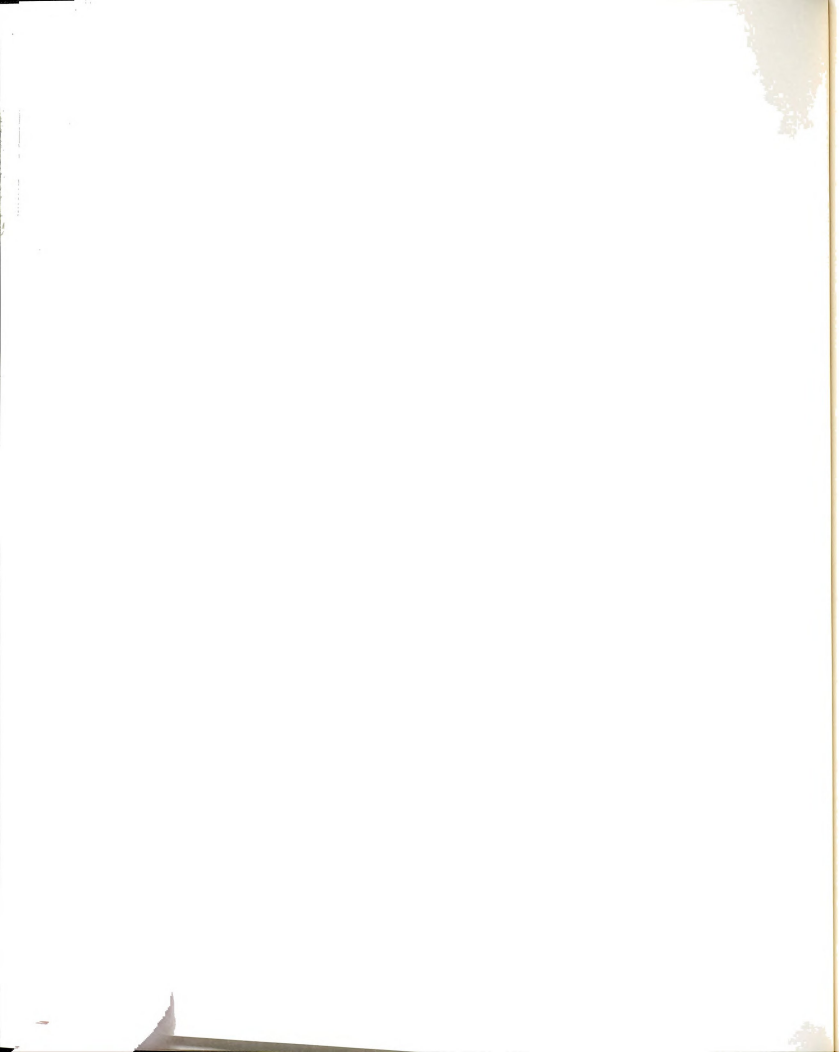
The director of The Michigan Cooperative Tree Improvement Program (MICHCOTIP) and Michigan State University (MSU) professor of forest genetics and tree physiology, Dr. J. Hanover, is currently formulating a plan to manage the MSU test plantations both for commercial seed production and continued research interests. Dr. Hanover recently received a patent on the Spartan Spruce, a hybrid he developed while at MSU, and the Department of Forestry markets it to the public sector through a non-exclusive licensing agreement with Armintrouts Nursery (Wink, 1986). He will receive a certain percentage of the royalties that come back to the University through this arrangement. In addition, Dr. Hanover privately co-owns Better Trees, a tree nursery consulting business, and actively pursues industry contracts for tissue-culture research in its laboratories. He also acts as a private consultant from time to time for special projects, litigation, etc.. He has an outstanding teaching and research record and this is reflected through active participation in research administration at the national level. This is not an unusual profile of today's busy academic.



The director of The Michigan Agricultural Experiment Station (MAES), Dr. R. Gast, recently asked an interdepartmental committee to review MAES policy that affects patenting, release, and plant breeders' rights for research products developed by MAES scientists. The review reflects today's regional and national interests in examining varietal release policies of public institutions (Kelly and Schmid, 1986; Gast, 1987). This activity resulted in a revised draft varietal release policy for Michigan State University which gives more voice to the University community in choosing development alternatives.

Three years ago the MSU Foundation provided funds to help launch a private off-campus biotechnology venture-capital start-up firm, which focuses on the commercialization of University research products developed through direct research contracts between the firm and MSU faculty. Their plans to license developed processes to commercial growers brought some strong dissension from the agricultural community regarding the traditional role of Land Grant Colleges, Extension Services, and the availability and cost of information they provide to the public (Lehnert, 1986).

The State of Michigan has also demonstrated its support for commercial development of university research products through allocation of funds to several closely tied off-campus concerns such as The Michigan Biotechnology Institute (MBI) in Lansing and The Industrial Technology Institute (ITI) in Ann Arbor (Milliken, 1982).



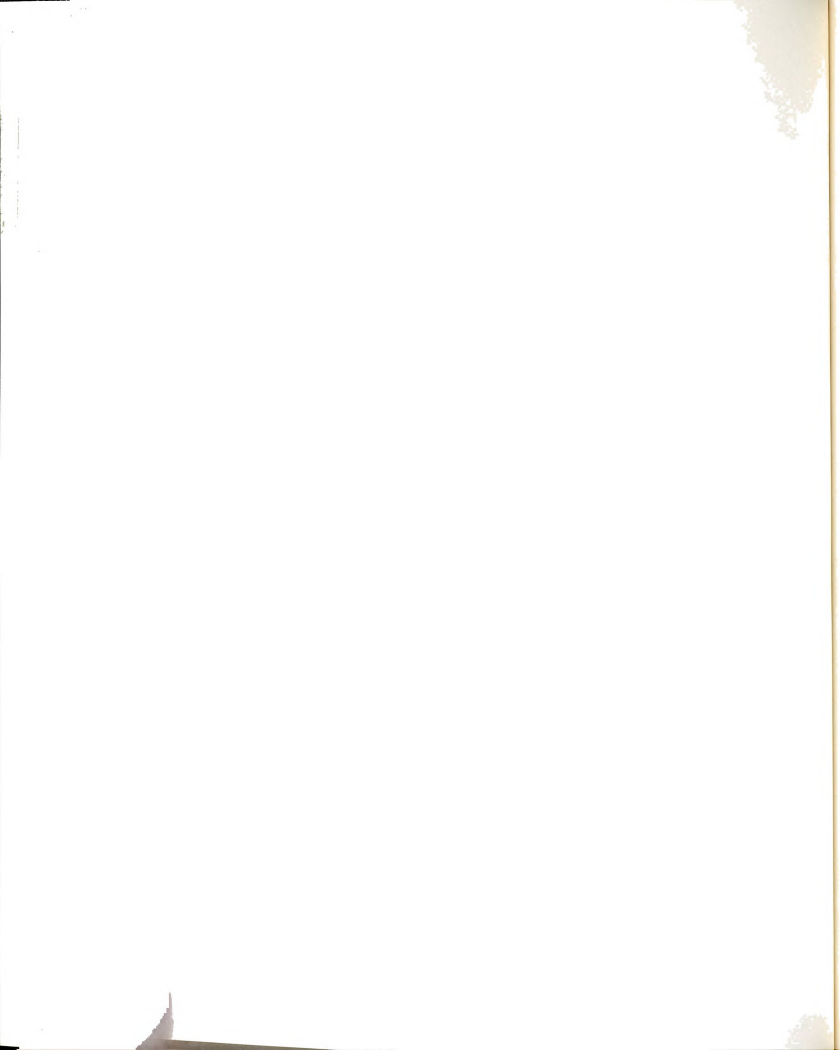
The examples given here of academic entrepreneurs, research policy revision, and university- and state-supported commercialization centers represent a national trend.

2.7 Current trends in University-Industry Relationships: National

Industry has escalated its support of on-campus research in the hopes of increasing R&D output through an enhanced exchange of information and new products between (from) academia and (to) industry (Barnes, 1985; Blumenthal et al, 1986a and 1986b; Smith and Clark, 1986).² David (1983/84) outlines industry's perspective of this activity. Additional encouragement by the highest levels of the current administration facilitates the new exchange (Clark, 1985; Bloch, 1986).

FIDIA S.p.A. of Italy gave Georgetown University \$3 million per year for twenty years to establish and maintain a research facility without any specified product applications (Barnes, 1985). This shows that basic academic research funded by industry may be an economic possibility. The research institute's foci, do however, go hand in hand with the company's commercial interests. A more product-oriented example of industry support of university research is Monsanto's commitment of \$62 million in research funds to Washington University. Here, only thirty percent of the funds are stipulated for basic research (Ellis, 1985; Smith, 1986). Other

²The National Science Foundation indicates that industrial support as a percentage of total academic R&D has gone from 3% in 1965 to 4% in 1980 for nominal dollars and from 3% in 1965 to 6% in 1980 for 1972 constant dollars (National Science Foundation, 1982).

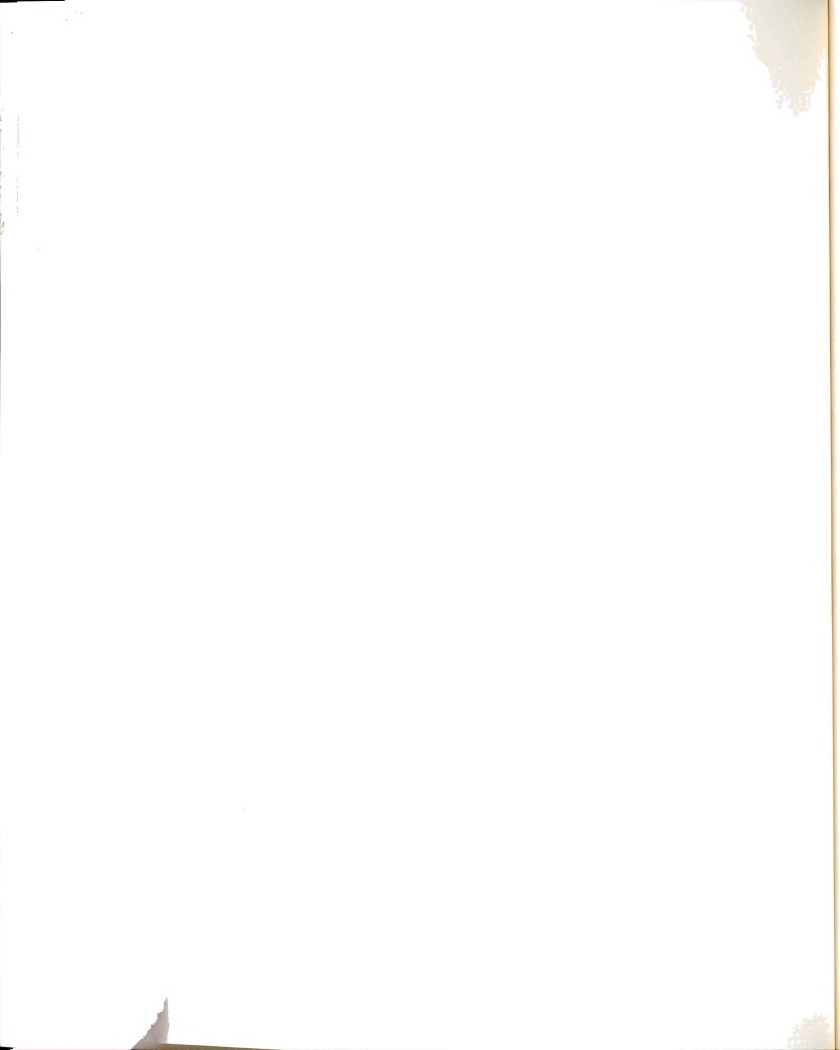


institutional combinations of large-scale industry support for university research include Bristol Meyers Company and Yale University and General Electric Company and Rensselaer Polytechnic Institute. Both companies have established separate R&D facilities on or near the campus (Smith and Clark, 1986).

The trend is not just national, but international, in scope. Upjohn plans to spend about \$10 million per year on European university collaborative programs (Genetic Technology News, 1987). Country specific efforts are in evidence. An interesting evolution of university-industry cooperation in Sweden which focuses on economic development is outlined by Lapping (1987). Five different institutional approaches are in evidence there. Finally, nineteen European countries have pooled efforts in a \$5.8 billion effort designed to link Europe's industrial and academic scientists and engineers in the development of market-oriented technologies (Dickson, 1987).

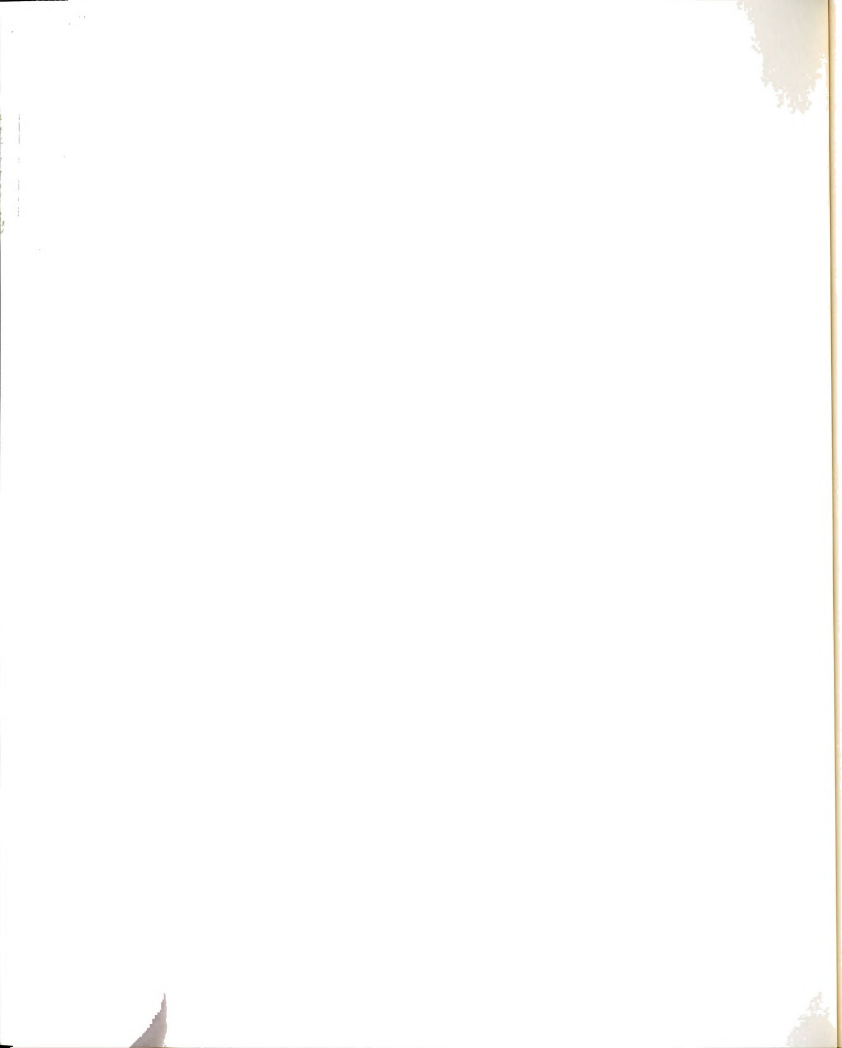
While the trend in activity is clear, the institutional structures which may evolve is not. A variety of structures are surfacing which expand the possibilities for university commercialization. This seems to be preferable to limiting the structures to those which work well. Many new structures are failing and many are thriving and this is an intense time of evolutionary processes.

An historical typology of university-industry relationships is developed by Baba (1985). He finds that today's new relationships incorporate two unique features not present in earlier relationships.



One is the use of university funds to stimulate capital formation and the other is commercial extension of university resources into the private sector for the purpose of financial gain. He also suggests that structural changes include increasing complexity, multi-disciplinary linkages, and a shift of these activities away from the central academic core.

Other papers which discuss a broad range of university-industry research relationships include Peters and Fushfeld (1983) and Doyle and Brisson (1985). Another helpful document is the annotated bibliography on university-industry research relationships (Kruytbosch, 1983). There is a computer literature search completed on "university and patent or industry" which provides additional material (Kashkashian and Hanover, 1986). None of these have the specific focus on university research commercialization which this study attempts to maintain.



CHAPTER 3

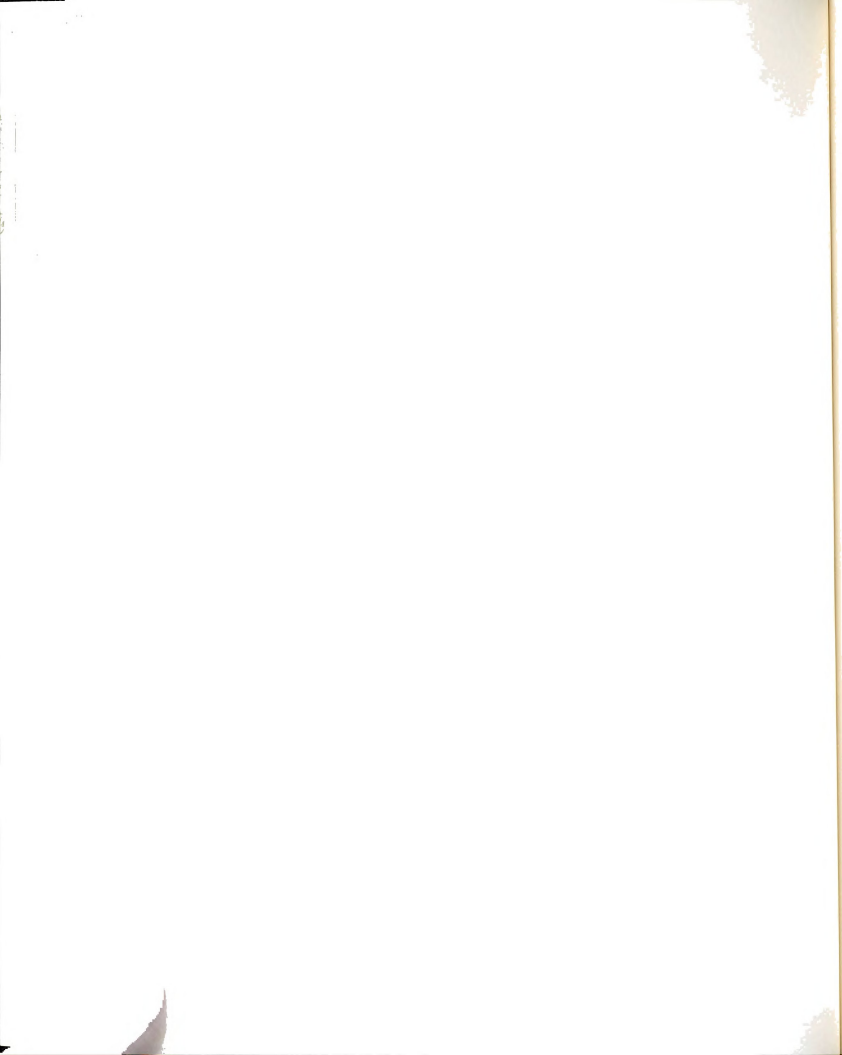
THE ECONOMICS OF PRODUCT TRANSFER

3.1 Product Transfer

Three key elements affect the performance of product, researcher, and innovation: administrative rules, product markets, and socioeconomic pressures. Administrative rules are contractual in nature and concern the structure of the institution, patent arrangements, the firm used to release the product, the licensing arrangement, receipt of compensation, and the form of the research incentive. The nature of the product and its attendant markets concern market structure, geographic applicability of the product, ease of copying the product, and the potential competition and their relative marketing advantages. And finally, socioeconomic pressures concern governmental regulation and political impact, relevant tax laws, environmental regulations, and local or state interests in development.

The public choice model of situation, structure, conduct, and performance (Schmid 1985a) is used to develop a general model that encompasses some of these three elements. It is useful in explaining how they influence the increasingly profit-oriented public sector transfer of innovations in the form of commercial products.

Two economic criteria can be used to distinguish the performance of various university transfer firms. One is the percentage of rent the firm captures and the other is the percentage of rent the firm returns to the university. Rent has been defined in Chapter 1 as the

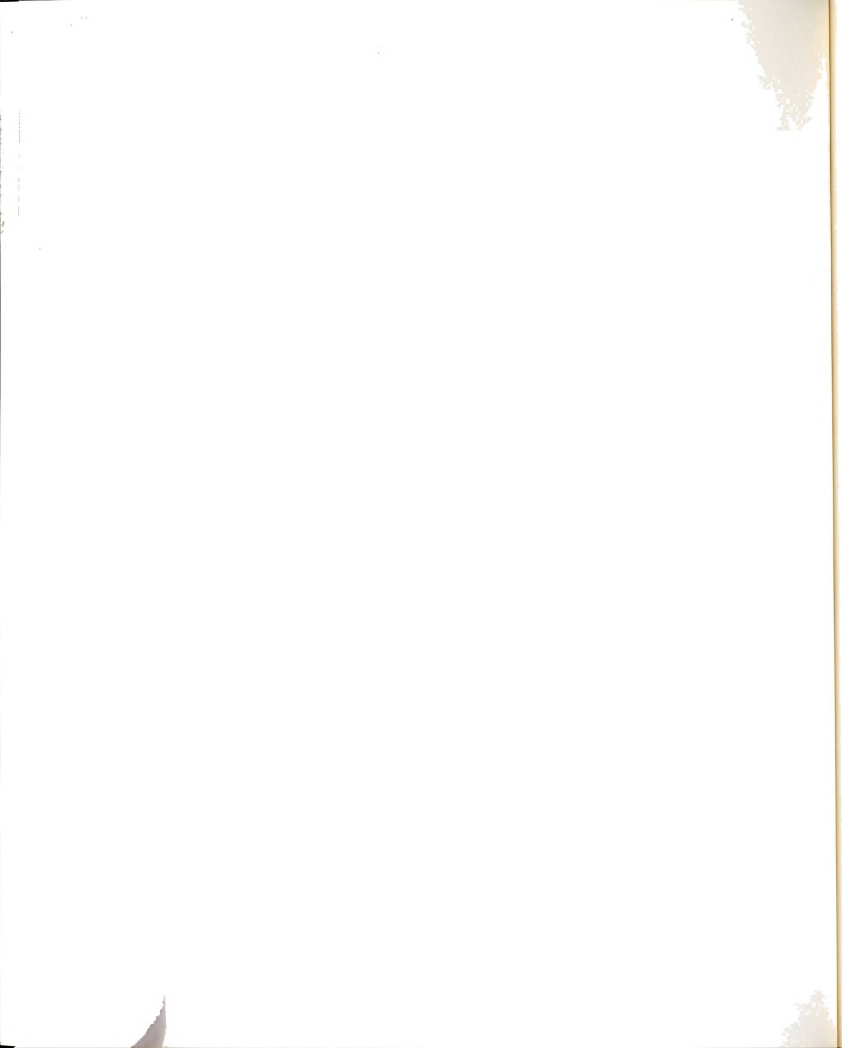


potential user cost savings which an invention or technology represents.

Of the different types of university transfer firms, which one captures what portion of the rent, what portion of the captured rent is returned to the university, and why, is the fundamental economic question this study tries to understand. What incentive a transfer firm director has to capture and return more or less rent, and what incentive the university has to choose a firm that captures and returns more or less rent, is of primary importance to the administrator concerned with the return of revenues to the university.

The transfer firm receives many benefits from the university. One of these may be a set of research products for commercial development. Subsequent development can lead to many additional benefits for the transfer firm. Among these are the possibility of direct economic gain through the sale of products or indirect economic gain through association with the university. This study focuses on how situation and structure influence the possibility of direct economic gain to the firm. No claims are made as to the size and relative importance of direct economic gain relative to other potential benefits.

On the other hand the university receives many benefits from transfer firms. Among these are economic benefits. The economic benefits may be direct return of revenues or indirect return of funds through outside forces. This study focuses on how situation and structure influence the direct return of revenues to the

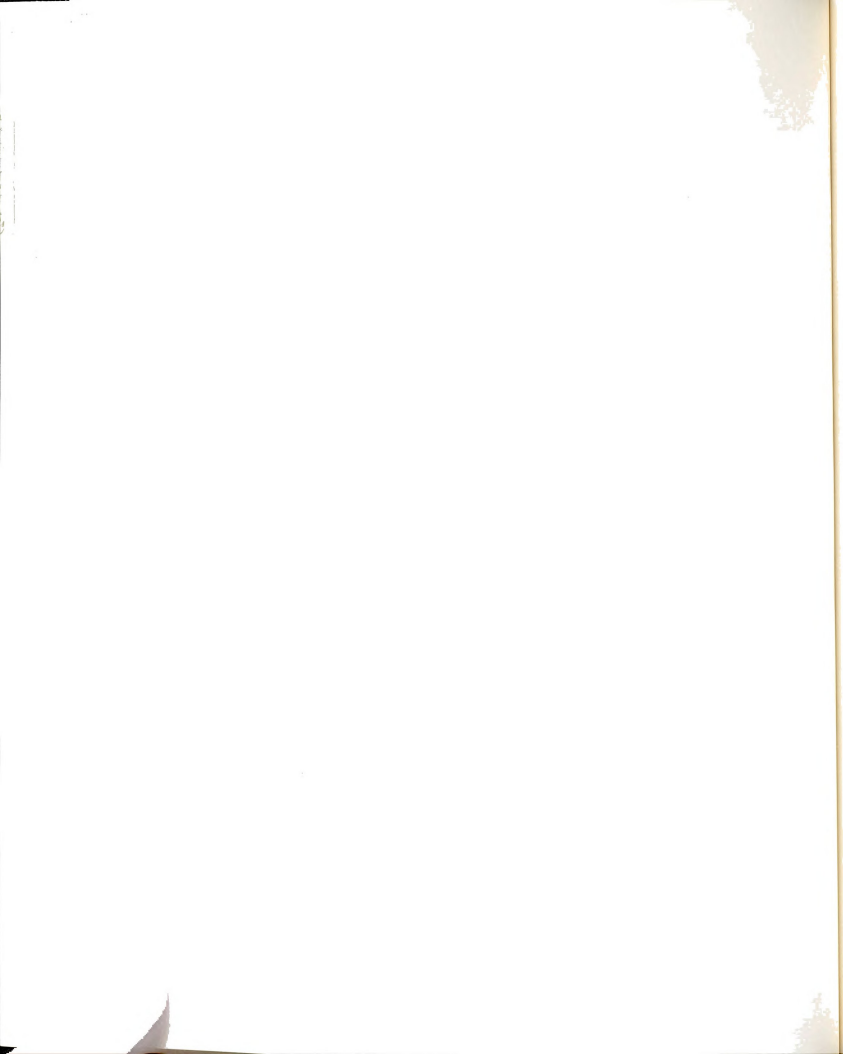


University. No claims are made as to the size and importance of direct return of revenues relative to other potential benefits.

3.2 Rent: A General Model

A simple example using improved tree seed will lead to a better understanding of cost savings as a measure of rent and how it fits in with the framework. Each theoretical step in the general model will be followed by an empirical example. An attempt has been made to keep this model as simple as possible, developing a single equation linear form for initial understanding. Since the model is not empirically tested, concern with functional form and other specification change is not an issue.

Imagine a tree breeder (the university), a seed producer (the transfer firm), a seedling producer, and a tree producer. They have the opportunity to increase yield ten percent with improved tree stock. Yield could be an increased growth rate for a pulpwood species or improved quality for a Christmas tree or ornamental species. The increase in product value or the cost savings to the user is the important criterion. The unimproved seed sells for \$0.01, the seedling for \$0.25, and the tree for \$5.00. A ten-percent improvement or reduction in costs for the marginal tree producer represents a \$0.50 cost savings. He will pay up to \$0.75 for the new seedling, *ceteris paribus*. The seedling producer will pay up to \$0.51 for the new seed, *ceteris paribus*. Since the cost saving occurs in the future for the tree producer the \$0.50 should be appropriately discounted and the other payments adjusted accordingly.



The remainder of this example does not use discounting for clarity of presentation.

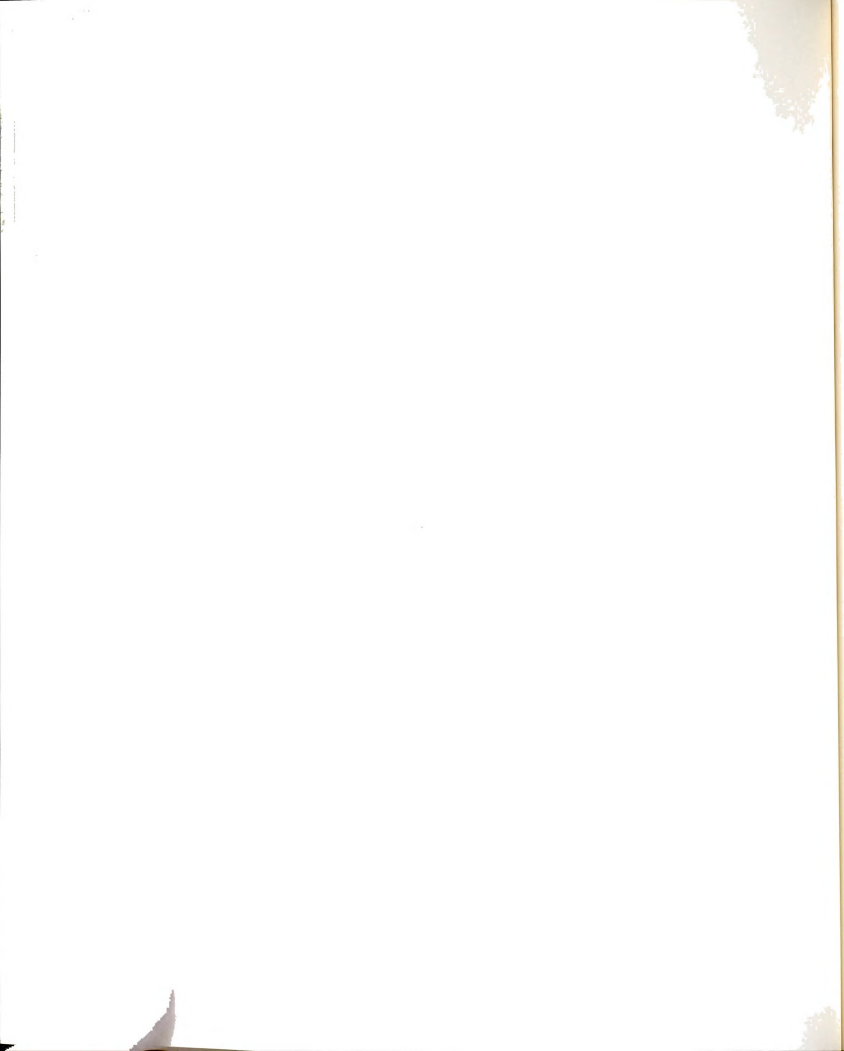
The transfer firm (the seed producer) captures some portion of this cost saving as rent. Does it represent some portion of total market demand, market share, or some adjusted quantity?

When total market demand is one million trees, with a cost saving of 10% growth or \$0.50 per tree, the total obtainable economic rent is \$500,000. If the transfer firm has 25% market share the obtainable rent for the firm is \$125,000. This study is interested in how situation and structure influence the firm to capture some portion of the \$125,000 and return some portion to the university.

A change in market share caused by the introduction of improved product should be separated from the portion of rent captured by the firm. Suppose situation and structure allow the firm to capture 50% of the obtainable rent or \$62,500. At the same time market share increases 5% so the obtainable rent from the new market share totals \$150,000. The firm now captures \$75,000 but the percentage of captured rent has not changed and the structure has not changed. It is important to retain this distinction.

The notation in Figure 3.1 will be used to complete this example in the context of the economic framework.

This study measures rent separately from the effect of market share because it is interested in how situation and structure influence the percentage of rent that can be captured by the firm,



Notation

O	Cost savings available
C	Cost savings captured
R	Cost savings returned
E	Percentage cost savings captured
P	Price of good at the transfer firm
S	Sum of costs to the transfer firm
Q	Quantity of goods sold from the transfer firm
G	Gross sales of the transfer firm
M	Market share of the transfer firm
T	Total market demand
D	Discounted cost savings to end user per market
d	Discounted cost savings to end user per unit
p	Production costs
f	Information costs
v	Investment costs
e	Exclusion costs
t	Transaction costs
c	Public charge
s	Public subsidy

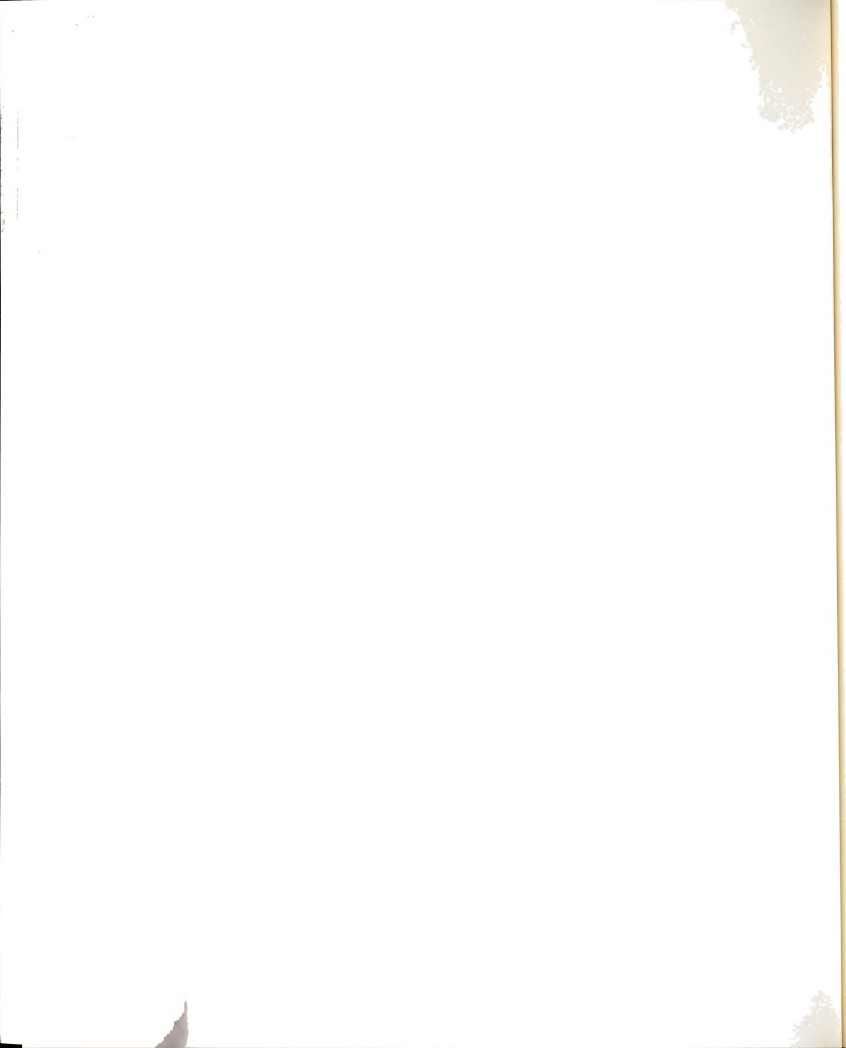
Subscripts

n	New product or policy
o	Old product or policy
u	Unit of the innovation
m	Market of transfer firm
t	Total market
a	Administration
c	Transfer firm
b	Buyer of good from transfer firm

Signs

*	denotes change or "delta"
	denotes sum or "sigma"

Figure 3.1 Definition of notation used in the model of Chapter 3.



not the amount of sales or revenue. The percentage of rent captured by a transfer firm can be measured on a per unit basis or on a per firm basis.

Equation 3.1:

$$E_u = \frac{C_u}{Q_u} = \frac{P_n - P_o}{d}$$

For Example:

$$\begin{aligned} P_o &= \$0.01 \\ P_n &= \$0.26 \\ d &= \$0.50 \end{aligned}$$

$$E_u = \frac{.26 - .01}{.50} = \frac{.25}{.50} = .50 \text{ or } 50\%$$

If market share change is accounted for explicitly E_m will always be less than E_u unless the total market demand is one unit or the transfer firm has a monopoly.

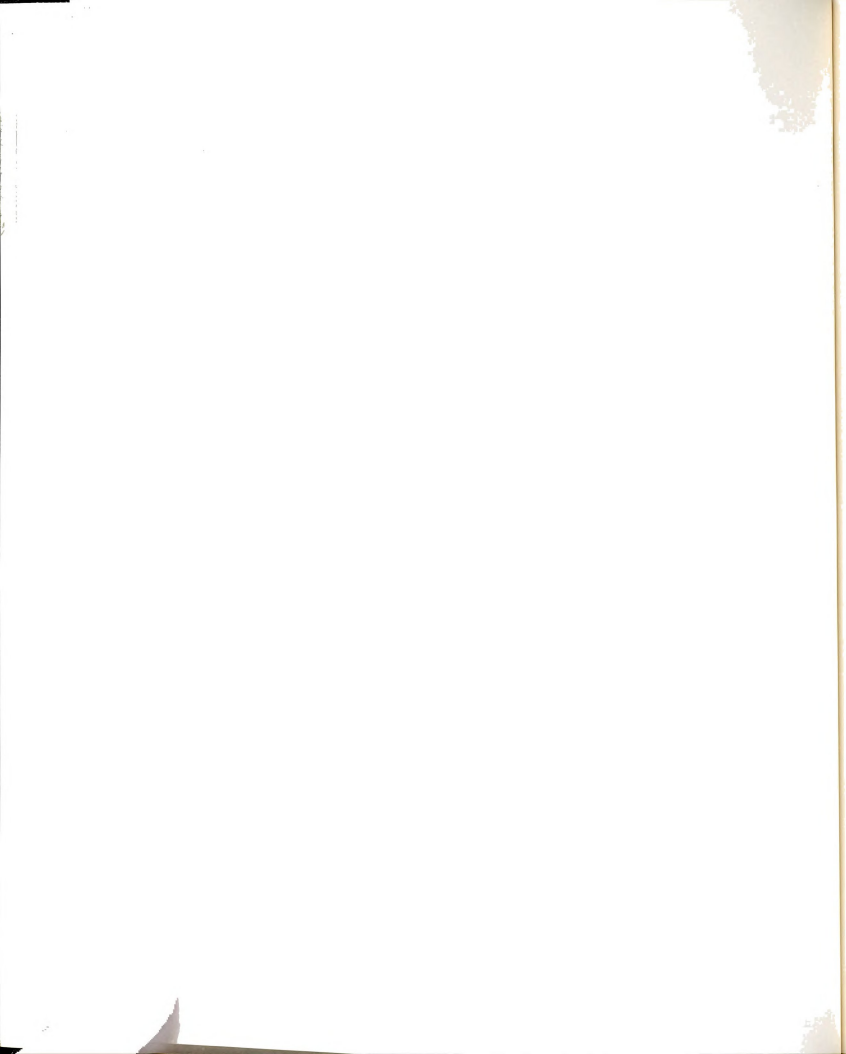
Equation 3.2:

$$E_m = \frac{*G_c - *M_c}{O_t} = \frac{G_n - G_o - (M_n - M_o)}{D} = \frac{P_n Q_n - P_o Q_o - (M_n - M_o)}{d(T)}$$

For Example:

$$\begin{aligned} P_o &= \$0.01 \\ P_n &= \$0.26 \\ Q_n &= 300,000 \\ Q_o &= 250,000 \\ d &= \$0.50 \\ T &= 1,000,000 \\ M_n &= .30 \\ M_o &= .25 \end{aligned}$$

$$\begin{aligned} E_m &= \frac{(.26)(300,000) - (.01)(250,000) - (.30 - .25)}{(.50)(1,000,000)} \\ &= .30 - .05 = .25 \text{ or } 25\% \end{aligned}$$



If market share change is accounted for implicitly the percentage of rent captured by the firm is adjusted as follows.¹

Equation 3.3:

$$E_m = \frac{*G}{O_t} = \frac{G_n - G_o}{D} = \frac{G_n}{D} - \frac{G_o}{D}$$

Factoring new and old gross sales by the new and old market shares:

$$E_m = \frac{G_n}{D} \times \frac{1}{M_n} - \frac{G_o}{D} \times \frac{1}{M_o}$$

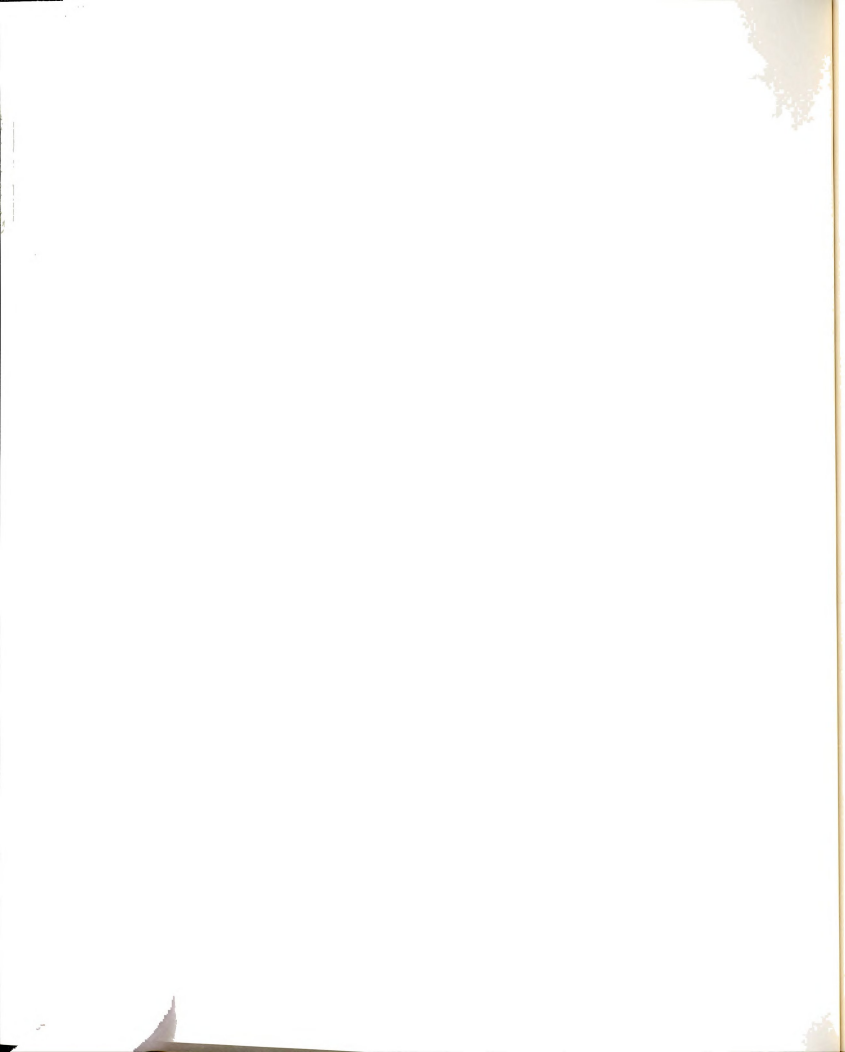
Multiplying both sides to get a common denominator:

$$\begin{aligned} E_m &= \frac{G_n}{D} \times \frac{1}{M_n} \times \frac{M_o}{M_o} - \frac{G_o}{D} \times \frac{1}{M_o} \times \frac{M_n}{M_n} \\ &= \frac{P_n Q_n M_o}{d(T) M_n M_o} - \frac{P_o Q_o M_n}{d(T) M_o M_n} \end{aligned}$$

¹By factoring new and old gross sales by new and old market shares (treating market share change implicitly) the E_m on a transfer firm basis will always equal the E_u on a per unit basis. The proof that $E_u = E_m$ follows:

Equation 3.4

$$\begin{aligned} E_u &= P_n - P_o = \frac{P_n Q_n M_o - P_o Q_o M_n}{d(T) M_n M_o} = \frac{P_n Q_n M_o}{d(T) M_n M_o} - \frac{P_o Q_o M_n}{d(T) M_n M_o} \\ &= \frac{P_n Q_n}{d(T) M_n} - \frac{P_o Q_o}{d(T) M_o} \\ &\quad \text{since } \frac{Q_n}{(T) M_n} = 1 \text{ and } \frac{Q_o}{(T) M_o} = 1 \\ &= \frac{P_n - P_o}{d} = E_m \end{aligned}$$



$$= \frac{P_n Q_n M_o - P_o Q_o M_n}{d(T) M_n M_o}$$

For Example:

$$\begin{aligned} P_o &= \$0.01 \\ P_n &= \$0.26 \\ Q_n &= 300,000 \\ Q_o &= 250,000 \\ d &= \$0.50 \\ T &= 1,000,000 \\ M_n &= .30 \\ M_o &= .25 \end{aligned}$$

$$\begin{aligned} E_m &= \frac{(.26)(300,000)(.25) - (.01)(250,000)(.30)}{(.50)(1,000,000)(.25)(.30)} \\ &= \frac{19,500 - 750}{37,500} = .50 \text{ or } 50\% \end{aligned}$$

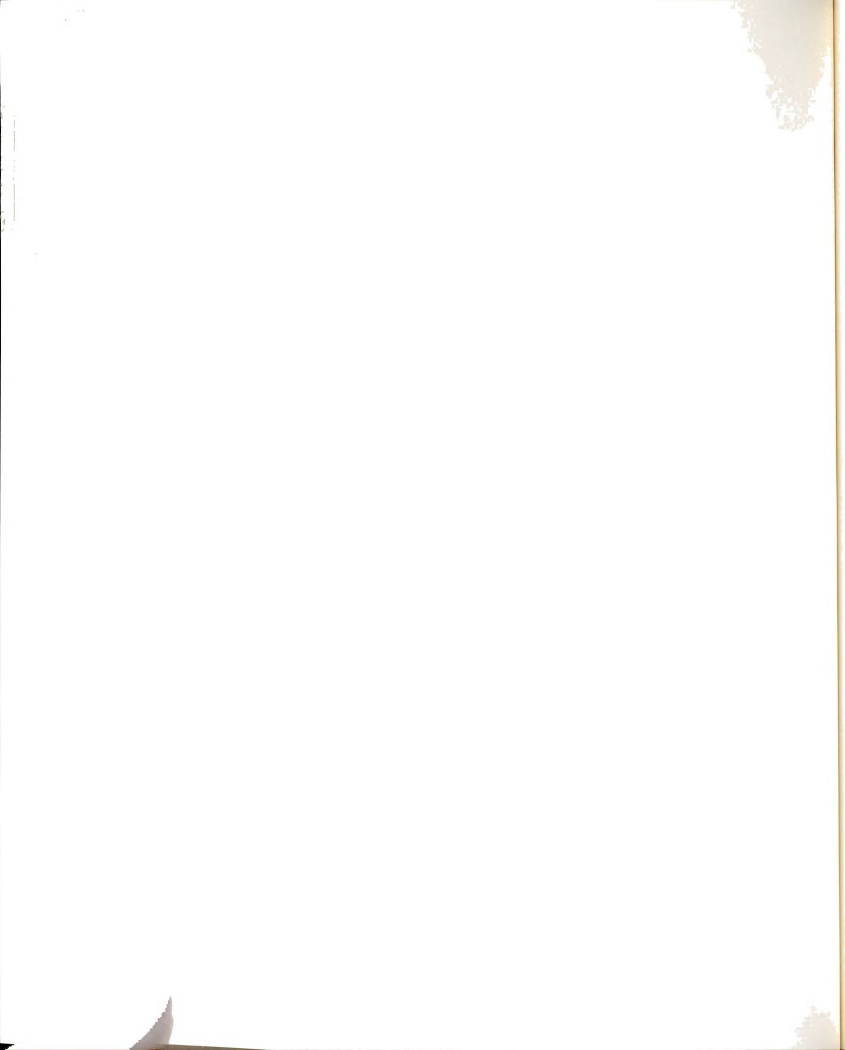
Further exploration using this example demonstrates how situation and structure interact and influence performance within the economic model developed so far. The initial step depends on the assumption that a transfer firm will not incur a net loss in the transfer of an innovation. This says that the change in price for a new innovation is greater than or equal to the change in cost. If the innovation is not an improved variety, but rather a new product, the old price and costs are equal to zero. On a per unit basis:

Equation 3.5:

$$*P_u \geq *S_u \quad \text{or} \quad P_n - P_o \geq *(p + f + v + e + t + c + s)_u$$

Dividing both sides by the sum of the cost savings to put the expression in terms of the percentage of rent:

$$\frac{P_n - P_o}{d} \geq \frac{*(p + f + v + e + t + c + s)_u}{d}$$



To continue the preceding example:

$$P_n = \$0.26$$

$$P_o = \$0.01$$

$$d = \$0.50$$

$$*p = \$0.05 \text{ (production costs increase .05 per seed)}$$

$$*f = \$0.05 \text{ (advertising costs increase .05 per seed)}$$

$$*v = 0$$

$$*e = \$0.05 \text{ (exclusion costs increase .05 per seed)}$$

$$*t = \$0.01 \text{ (transaction costs increase .05 per seed)}$$

$$*c = 0$$

$$*s = 0$$

$$E_u = \frac{.26 - .01}{.50} \geq \frac{.05 + .05 + .05 + .01}{.50}$$

$$= .50 \text{ or } 50\% \geq .32 \text{ or } 32\%$$

On a transfer firm basis rather than on a per unit basis:

Equation 3.6:

$$*G_c \geq *S_c \quad \text{or} \quad G_n - G_o \geq S_n - S_o$$

Dividing both sides by the sum of cost savings to put the expression in terms of percentage of rent:

$$E_m = \frac{G_n}{D} - \frac{G_o}{D} \geq \frac{S_n}{D} - \frac{S_o}{D}$$

Factoring new and old sales and costs by new and old market shares:

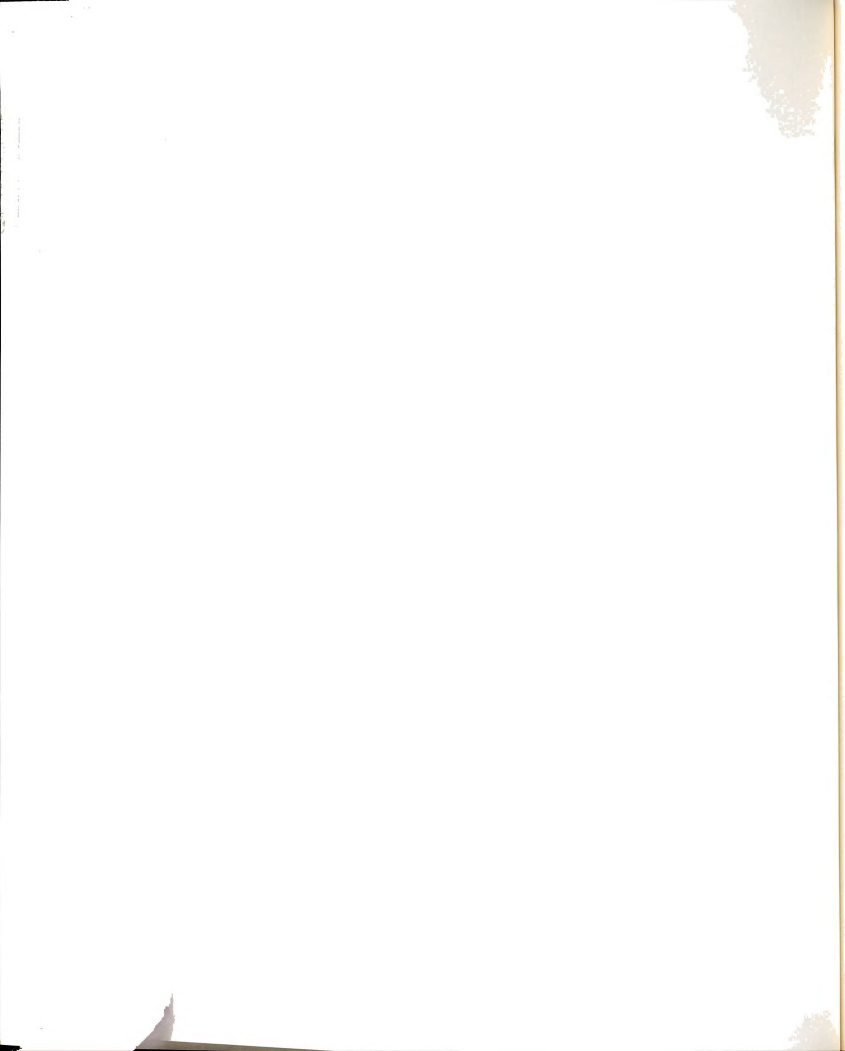
$$E_m = \frac{G_n}{DM_n} - \frac{G_o}{DM_o} \geq \frac{S_n}{DM_n} - \frac{S_o}{DM_o}$$

Multiplying both sides to get a common denominator:

$$E_m = \frac{G_n M_o}{DM_n M_o} - \frac{G_o M_n}{DM_o M_n} \geq \frac{S_n M_o}{DM_n M_o} - \frac{S_o M_n}{DM_o M_n}$$

Expanding the numerator and contracting the expression:

$$E_m = \frac{P_n Q_n M_o - P_o Q_o M_n}{d(T) M_n M_o} \geq \frac{S_{nu} Q_n M_o - S_{ou} Q_o M_n}{d(T) M_n M_o}$$



To continue the preceding example:

$P_n = \$0.26$	$*p = \$0.05$	$S_{nu} = \$0.16$
$P_o = \$0.01$	$*f = \$0.05$	$S_{ou} = 0$
$d = \$0.50$	$*v = 0$	
$Q_n = 300,000$	$*e = \$0.05$	
$Q_o = 250,000$	$*t = \$0.01$	
$T = 1,000,000$	$*c = 0$	
$M_n = .30$	$*s = 0$	
$M_o = .25$		

$$\begin{aligned}
 E_m &= \frac{(.26)(300,000)(.25) - (.01)(250,000)(.30)}{(.50)(1,000,000)(.30)(.25)} \\
 &\geq \frac{(.16)(300,000)(.25) - (0)(250,000)(.30)}{(.50)(1,000,000)(.30)(.25)} \\
 &= \frac{19,500 - 750}{37,500} \geq \frac{12,000}{37,500} \\
 &= .50 \text{ or } 50\% \geq .32 \text{ or } 32\%
 \end{aligned}$$

A proof of $S_u = S_c$ similar to that presented for $E_u = E_m$ is not presented here since the comparison is direct.

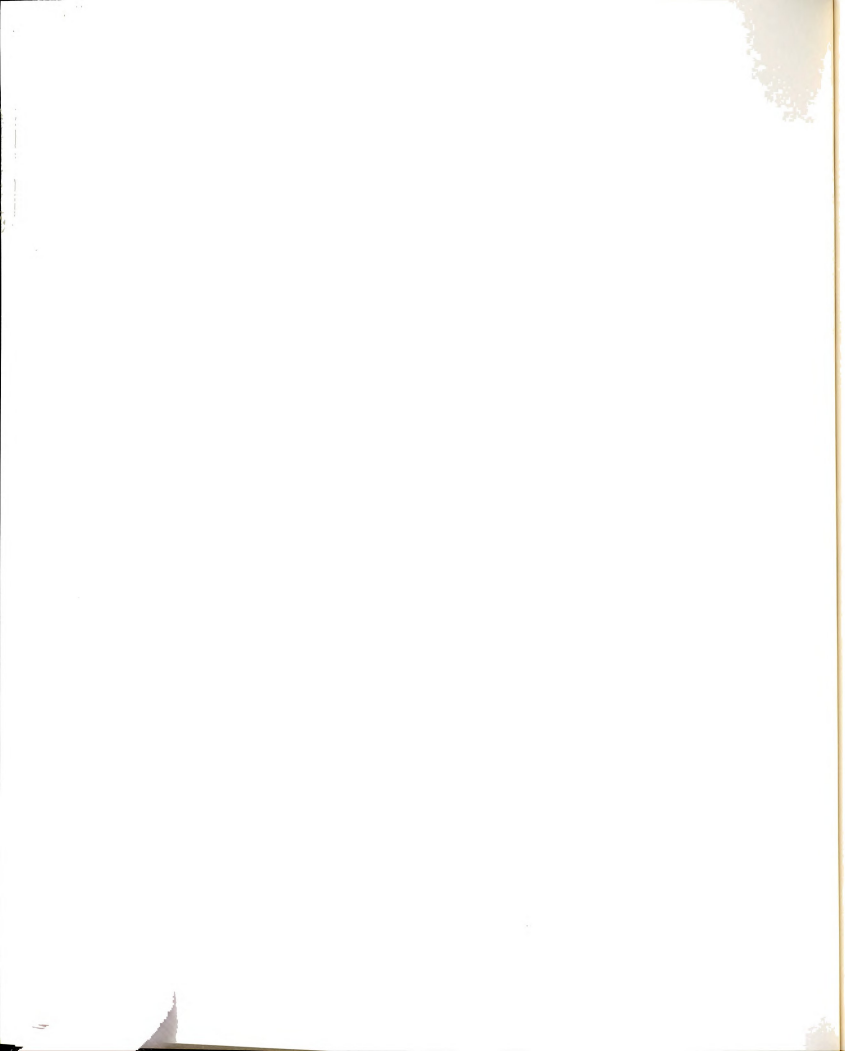
The situational and structural interaction and their influence on performance can be seen in Equation 3.7 which is a restatement of Equation 3.5 or 3.6.

Equation 3.7:

$$E_u = \frac{P_n - P_o}{d} \geq \frac{*(p + f + v + e + t + c + s)_u}{d}$$

The right hand side of the inequality can be rewritten to give it both situational and structural components.

$$E_u = \frac{P_n - P_o}{d} \geq \frac{*(p + f + v + e + t)_u}{d} + \frac{*(c + s)_u}{d}$$



Four important percentages can be derived from Equation 3.7. They are all percentages of the total available rent of an innovation.

1. The total rent captured by a transfer firm as a percentage of the total available rent is the left hand side of the inequality:

Equation 3.8:

$$E_u = \frac{P_n - P_o}{d}$$

2. The total rent given up to the consumer by the transfer firm as a percentage of the total available rent in its pricing decision is:

Equation 3.9:

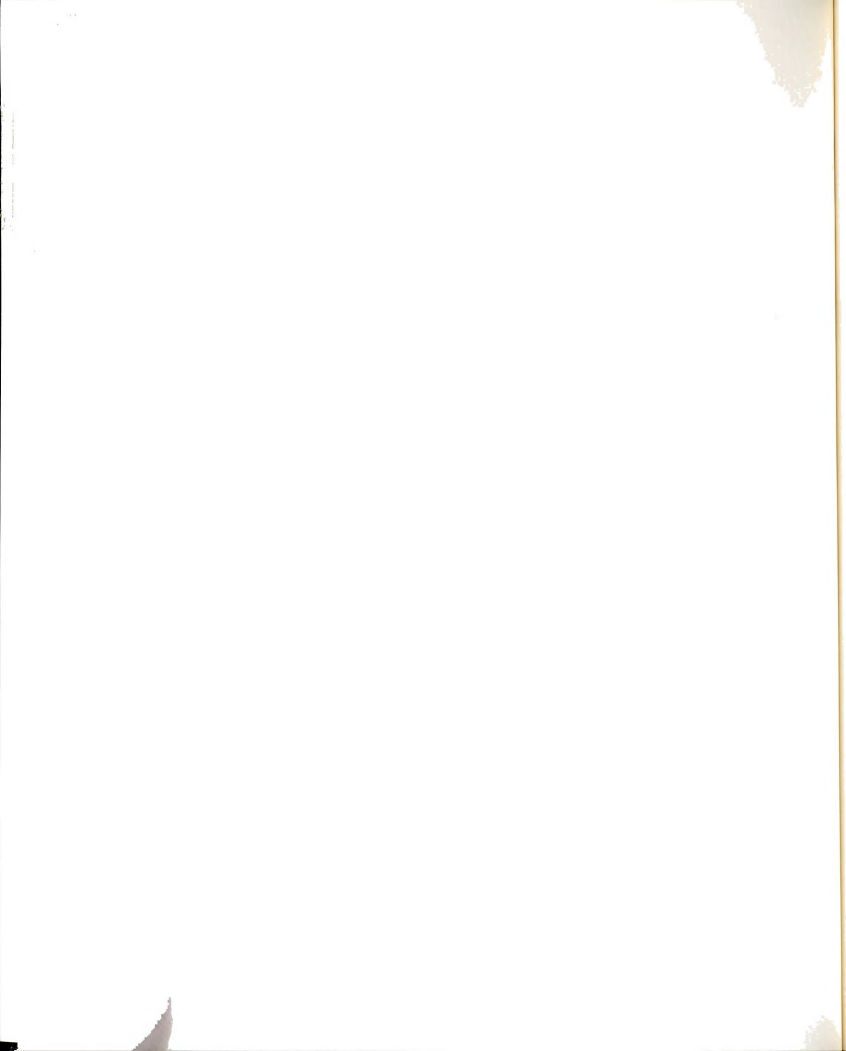
$$E_b = 1 - \frac{P_n - P_o}{d}$$

E_b is an important term. The amount of indirect support the university receives via legislative pressure, goodwill, prestige, etc., may all be positively correlated with the amount of rent given up to consumers by the transfer firm. In other words the public will be more likely to support the university if they are not charged their maximum willingness to pay for the goods coming out of the university through various transfer firms.

3. The total rent left over to the transfer firm as a percentage of the total obtainable rent after all costs are incurred represents an amount for bargaining between the firm and the university:

Equation 3.10:

$$E_c = \frac{P_n - P_o}{d} - \frac{*(p + f + v + e + t)_u}{d}$$



4. The total rent returned directly to the university by the transfer firm as a percentage of the total available rent is:

Equation 3.11:

$$E_a = \frac{*(c + s)_u}{d}$$

To change the inequality of Equation 3.7 to an equality, a profit component is added on.

Equation 3.12:

$$E_u = \frac{P_n - P_o}{d} = \frac{*(p + f + v + e + t)_u}{d} + \frac{*(c + s)_u}{d} + \frac{*PR_u}{d}$$

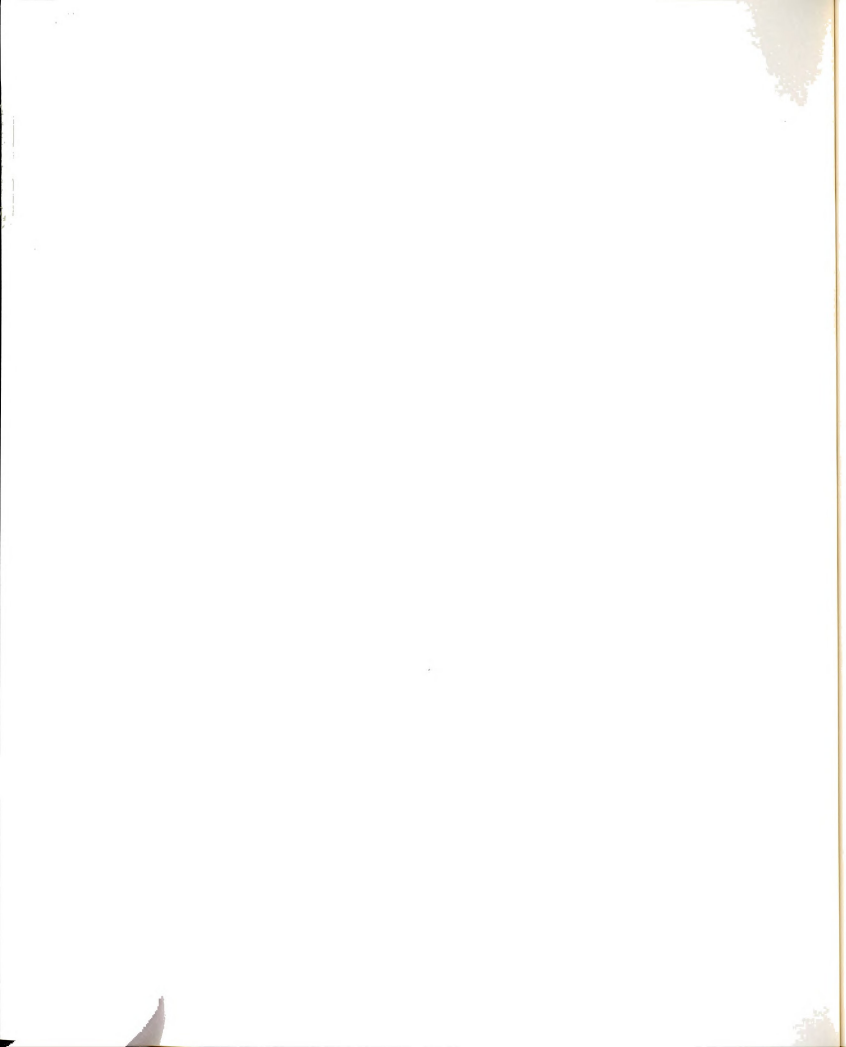
Continuing the preceding example with a monetary return to the university the four percentages are calculated as follows.

$$\begin{aligned} P_n &= \$0.26 \\ P_o &= \$0.01 \\ d &= \$0.50 \\ *p &= \$0.05 \\ *f &= \$0.05 \\ *v &= 0 \\ *e &= \$0.05 \\ *t &= \$0.01 \end{aligned}$$

The total rent captured by the transfer firm on a percentage per unit basis is: $E_u = \frac{.26 - .01}{.50} = .50$ or 50%

The total rent given up to the consumer on a percentage per unit basis is: $E_b = 1 - \frac{.26 - .01}{.50} = 1 - .50 = .50$ or 50%

The total rent left over to the transfer firm after all costs are incurred as an amount for bargaining with the university on a percentage per unit basis is:



$$E_c = \frac{.26 - .01}{.50} - \frac{(.05 + .05 + .05 + .01)}{.50} = .50 - .32 = .18 \text{ or } 18\%$$

If the firm returns \$0.06 per seed to the university the total rent returned to the university on a percentage per unit basis is:

$$E_a = \frac{.06}{.50} = .12 \text{ or } 12\%$$

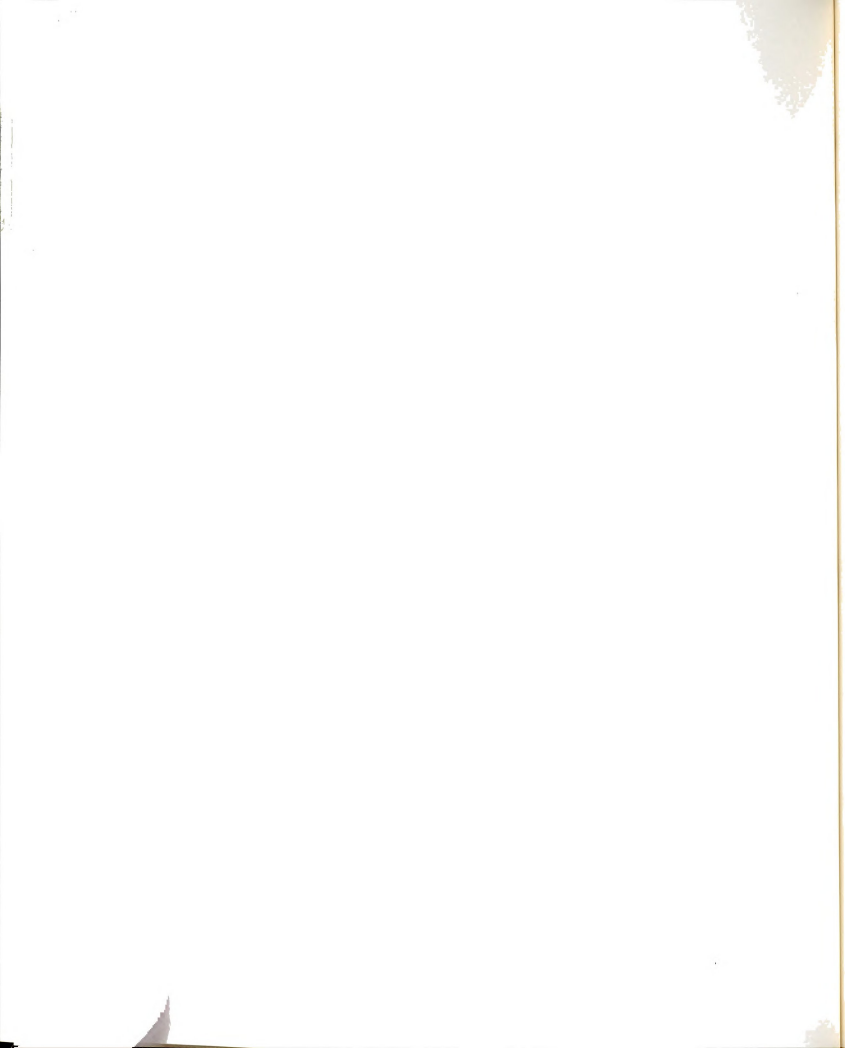
To finish the equality, profits are found on a percentage per unit basis:

$$*PR_u = .50 - .32 - .12 = .06 \text{ or } 6\%$$

In other words the transfer firm shares its net revenue with the university on a 1:2 ratio.

3.3 Interaction of Situation and Structure

The model developed in this chapter allows some of the complex interactions of situation and structure to be viewed as they influence performance. The situational characteristics of the public choice model are contained in the cost component of Equation 3.12. Any reduction in the firm's cost of transfer can reduce the cost percentage and increase the amount of rent left over to be bargained for between the university and the firm. The structural characteristics of the public choice model can interact with situational characteristics in Equation 3.12. They can be expanded to include various alternatives outlined in the framework of Chapter 4. The model and the framework are useful tools for thinking about how these interactions might influence performance.



CHAPTER 4

FRAMEWORK: THE VARIABLES OF PRODUCT TRANSFER

4.1 The Variables

The apparent complexity of situation and structural interactions and their influence on performance can be relieved by further consideration of a set of relevant variables. The first part of this chapter establishes a framework that presents workable categories of variables for university/industry ties, performance criteria, and situational and structural characteristics. This framework helps to focus the research and identify areas for further questioning. The variables discussed in this section are listed in Figure 4.1. The alternatives for each variable are not listed. It is important to remember that some of the variables have more alternatives than are discussed. All possible combinations of structure and situation are too numerous to be worked out by this research.

Selection of various economic objectives can be made and expected returns rationalized using this framework once specific institutions and their variability are identified. The second part of Chapter 4 presents the expected influence of alternatives for selected variables on pre-identified performance measures. The third part presents the expected outcome for selected institutions given identified structural alternatives.

<u>University-industry Ties</u>	
Labor ties	Royalties
Technology ties	Termination
Capital ties	Confidentiality
	Reporting
	Competing research
	Liabilities, etc.
	Use of Name
<u>Performance Criteria</u>	
Economic development	Legal status
User cost savings	Incorporated
Producer surplus	Profit or non-profit
Consumer surplus	Economic objective
Production function	Profit
Financial measures	Revenue
University funding	Quantity
Donations and gifts	Quality
Technologies and jobs	Market structure
Education	Monopoly
Undergraduate degrees	Concentration
Graduate degrees	University rules
Institutional prestige	Allocation
Employment of graduates	Property rights
Extension	Hierarchies
Public agencies	Organization
Private firms	Transactions
Private individuals	Staff
Technology	Size
Innovation	Composition
Technology transfer	
Publication	<u>Situation</u>
Exchange of materials	Investment costs
Interunit research	Basic research
	Applied research
	Developmental research
<u>Structure</u>	Transaction costs
Financial resources	Administrative
Total budget	Overhead
Source of funds	Information costs
Controls	Extension
Administrative	Advertising
Financial	Publications
Contracts	Disclosures
Scope of research	Exclusion costs
Investigator	Patents
Length	Licensing
Payments	Policing
Publication	Technical
Patents and licenses	Production costs

Figure 4.1 A list of variables presented in Chapter 4 which establishes a working framework for studying university-industry relationships.

4.1.1 University-Industry Ties

Many types of university-industry ties exist. Some are old and some are new. A classification system proposed by Baba (1985) is valuable as a tool that encompasses most types of transfer firms. Other classification systems exist (Peters and Fufeld, 1983) but none has become predominant for recent inquiries.

Three categories of university-industry ties are included by Baba (1985). A labor tie is concerned with the improvement of human capital and is characterized by organized learning activities that enhance the productivity or creativity of individuals. The common thread is education or training and the distinction between variables is who gets trained and by whom. A technology tie is concerned with the expansion of the science and technology base and is characterized by invention and technological innovation flow from the base of knowledge created by research activities. The common thread is industrial support of research and the distinction between variables is where the research is conducted and what "class" of research it fits. A capital tie is concerned with product, process, and economic development and is characterized by capital formation through the creation of new products, processes, or business firms. The common thread is university support of innovation and the distinction between variables is where and to whom this support is focused.

Most transfer firms, as defined by this study, fit into the categories of technology or capital products development. The separation is not necessary for this study. In fact, situation,

structure, conduct, and performance can make all of the distinctions of Baba's framework but in a fashion that is more conducive to analytical examination.

4.1.2 Performance Criteria

Many types of performance criteria can be used to analyze university industry ties. One purpose of economic analyses is to assess the success of allocating the distribution of limited resources across time or space. Choice of performance criteria can dictate the definition of success used in any particular study.

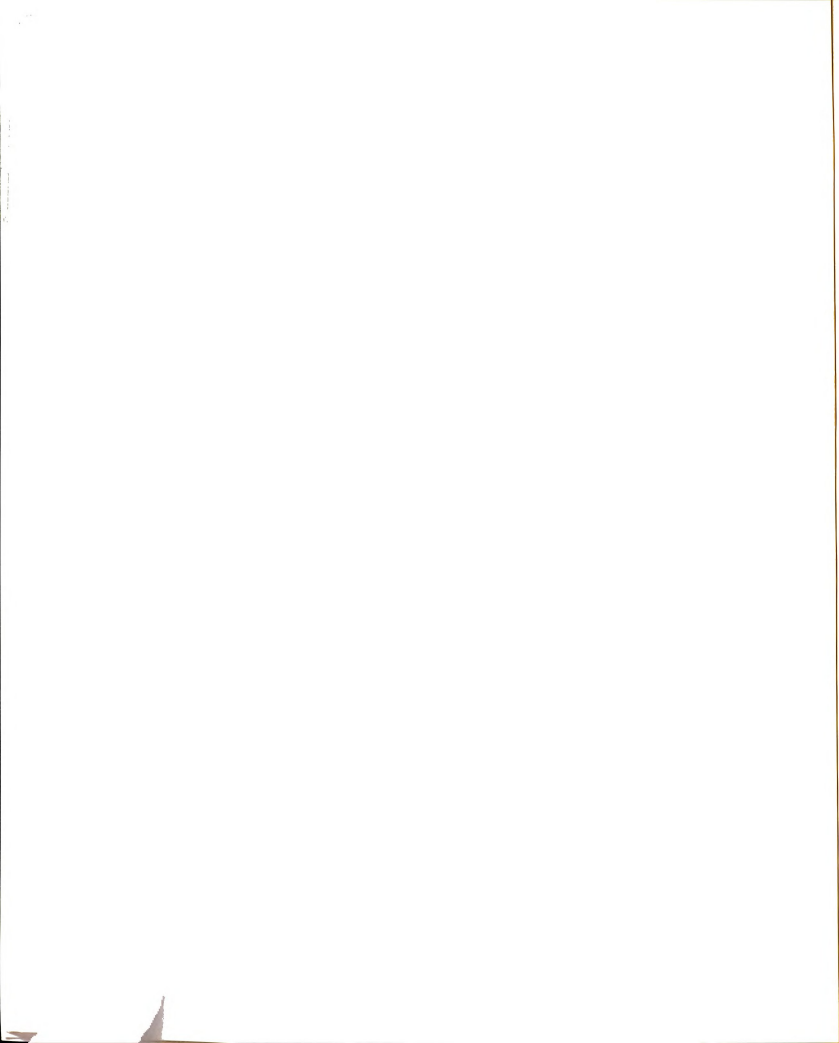
In this outline performance criteria are divided according to function. These are economic development, education, extension, and technology. The complete list is provided to put some perspective on what is measured in this study which focuses on the financial aspects of research product transfer outcomes.

A. Economic Development.¹

1. User cost savings

The idea of rent as a measure of cost savings to the producer or consumer is the primary performance criterion considered in this study. It is adequate for structural comparisons of institutions and encompasses several important financial criteria as demonstrated in

¹The distributional aspects of each measure of economic development as performance criteria are not discussed separately. Allocation of rents, however they are measured, may not be the same for all criteria. Distribution to the consumer, the firm, the university, the school, the department, the project, the researcher, and the local economy may differ depending upon how economic outcomes are measured. Consideration of the allocation of rents in the university/crossover/market chain by this study is minimal, however this subject provides ample material for further investigation.



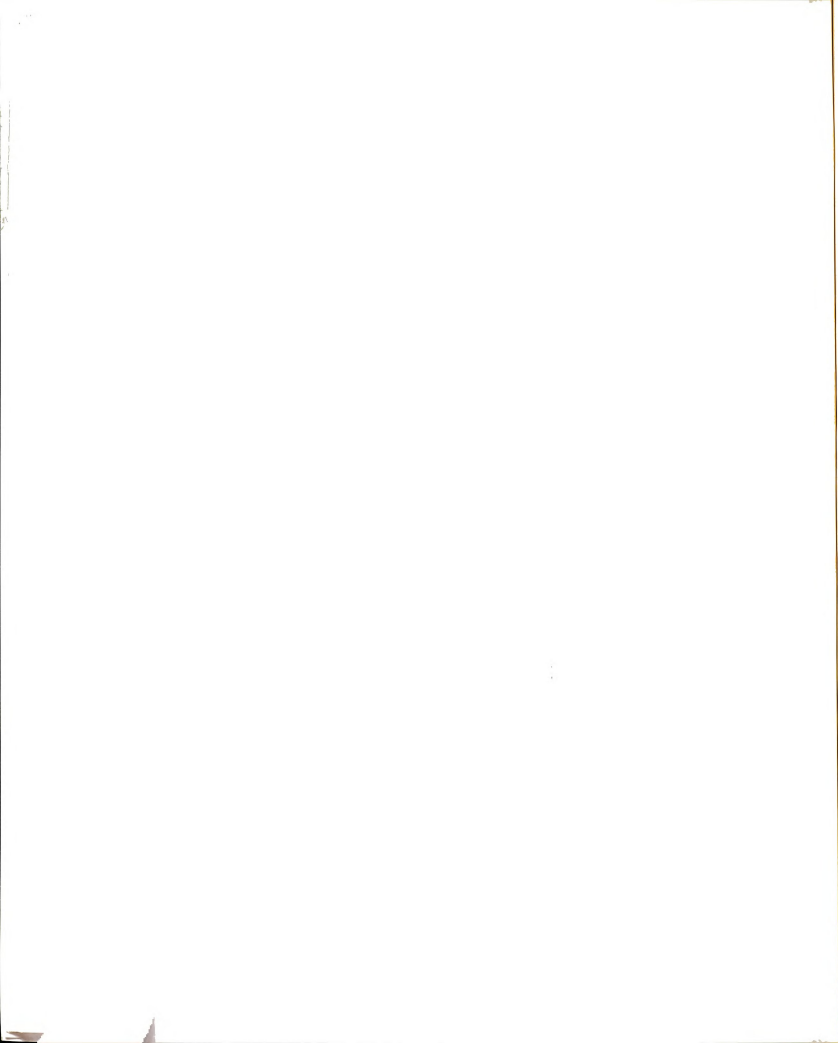
Chapter 3. Among these are the percentage of rent captured in pricing, the percentage of rent returned to the university, and the percentage of rent as profit to the transfer firm.

2. Producer surplus.

Producer surplus is the classic Ricardian rent. It is a measure of the amount earned by any factor of production above the minimum amount necessary to keep it in its current use. Because it builds on the firm's marginal cost curves, it strongly reflects differences among firm's internal characteristics. It might be an appropriate measure to use as a performance criterion if a university wanted to compare firms for a multiple-licensing policy. Producer surplus has not received the same attention in the general research evaluation literature as consumer surplus.

3. Consumer surplus.

Consumer surplus is the amount people would pay in excess of what they do pay for a good in equilibrium markets. This rent is not capturable because discriminatory pricing is not possible. Consumer surplus is, however, one of the most common measures used in research evaluation, and in particular, in agriculture and natural resources. It is typically used to measure potential returns to research and would be a candidate for the performance measure in this study if the analysis were of the innovation and not of the situation and structure of transfer institutions. It would also be more appropriate if the analysis were concerned with market clearing functions but it is not.



4. Production function.

The production function is the other common measure used in research evaluation. It is used in aggregate or by sector. To be useful for an analysis of situation and structure each sector's production function would be needed for estimating benefits and measuring capturable rents. Cost savings is an alternative to measuring complete production functions for the purposes of this study.

5. Financial measures of the transfer mechanism.

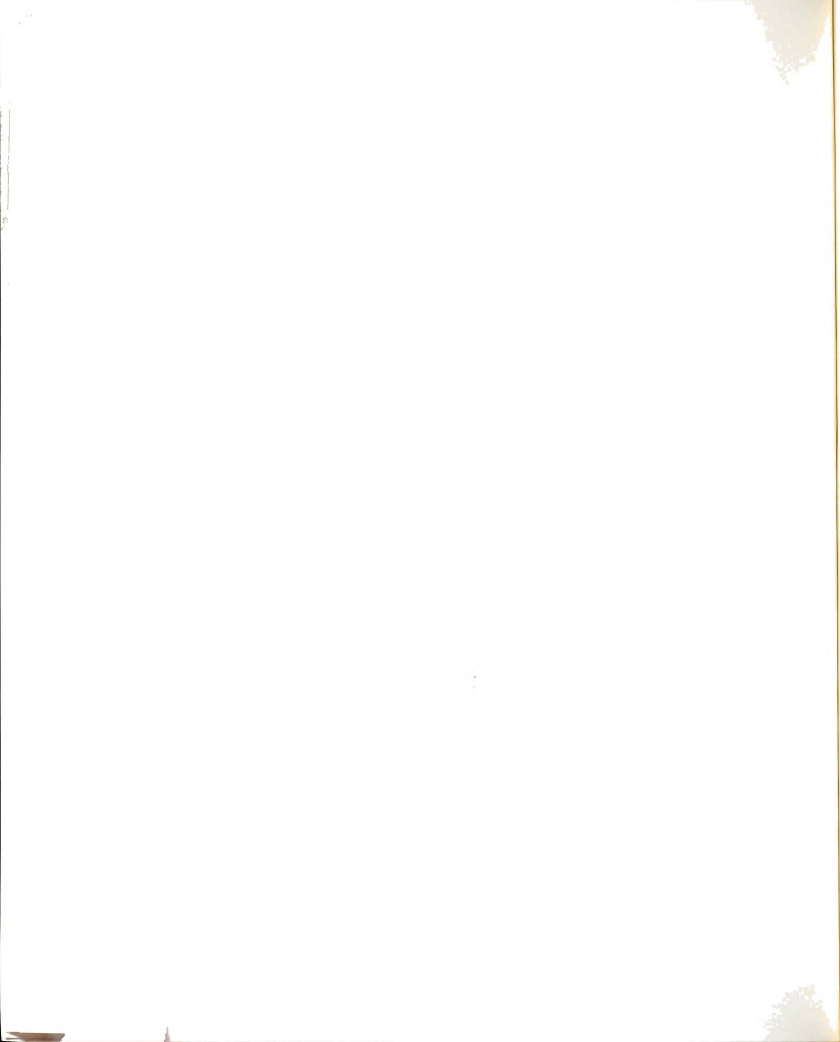
Many financial measures of a firm serve as performance criteria for a transfer firm. These include profits, sales, market shares, or equity of the firm. They are not comparable measures across institutions or products and that becomes a problem in studying an array of university products. The idea of profits, net sales, and market share can all be incorporated in this study on a percentage basis.

6. University funding.

Another measure that can be used as a performance criterion in the study of university transfer institutions is the university or college budget. Concern has been expressed that high returns to the transfer of university innovations will lead to either legislative budget cuts to the university or to administrative budget cuts to the college (Gast, 1987).

7. Donations and alumni gifts.

Donations and alumni gifts are also university performance criteria and it can be argued that they may increase or decrease



with large returns to the university. If a donor feels the university should not engage in commercial enterprises or feels that the university is gaining large returns from commercial sales and no longer needs his help, the donation might be decreased. On the other hand, if a successful commercial enterprise at a university brings it prestige and well-known faculty members, the donation might be increased.

8. New technologies and jobs in the local economy.

Another important measure of university product transfers is the outcome of development efforts in the local economy. This might be in the form of new technologies, new industries, or new jobs. In addition, it could be centered around a local economy or an entire state. While difficult to measure, using development as a performance criterion could potentially have the greatest impact on policy decisions by legislators and state administrators.

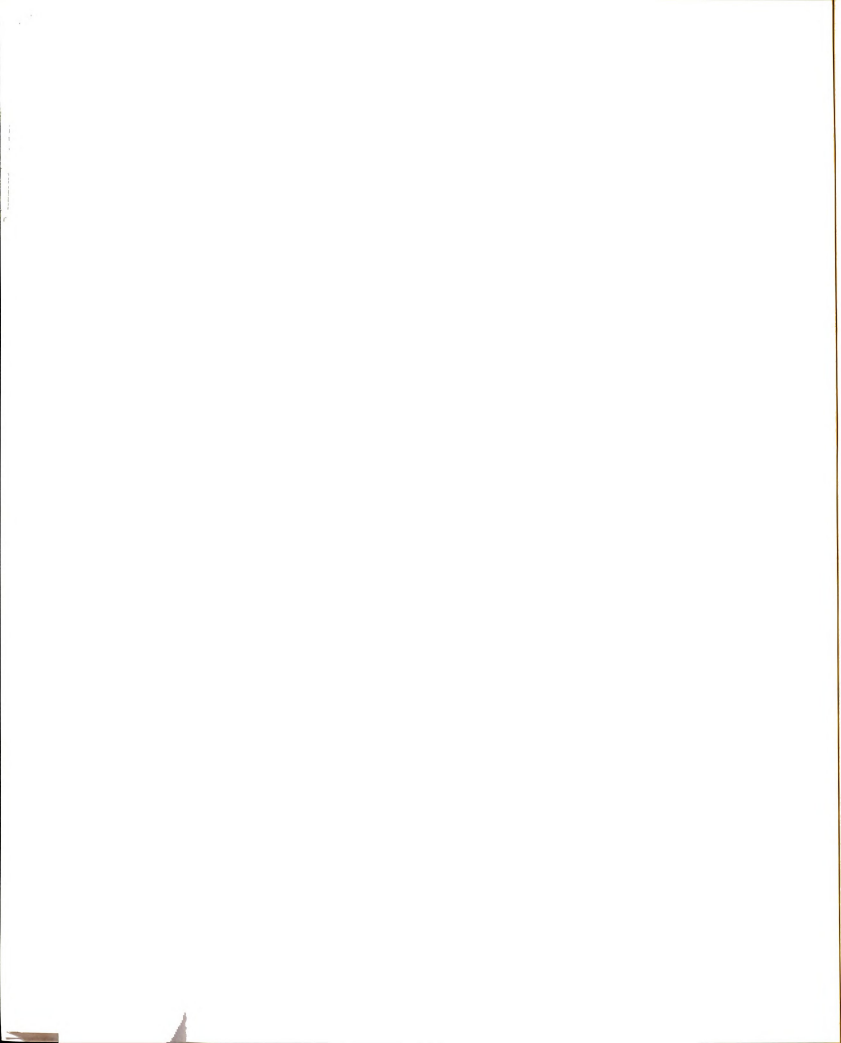
B. Education

1. Undergraduate degrees.

Undergraduate degrees could be a useful performance criterion across departments or universities to for an understanding of the impact university-industry ties have on education.

2. Graduate degrees.

Graduate degrees could also be a useful performance criterion across departments or universities for an understanding of the impact of university-industry ties. In addition they could be dissected to follow what portion of graduate training has shifted from course work and basic research to applied projects.



3. Institutional prestige.

Many measures of institutional prestige exist. Two which are pertinent to the subject of this study are the recruiting and retaining of faculty and the recruiting and retaining of students. Greater financial flexibility and higher institutional acclaim will tend to attract and retain larger numbers of better-qualified faculty and students. Faculty salaries, numbers of assistantships, or similar performance measures could be used to look at these effects.

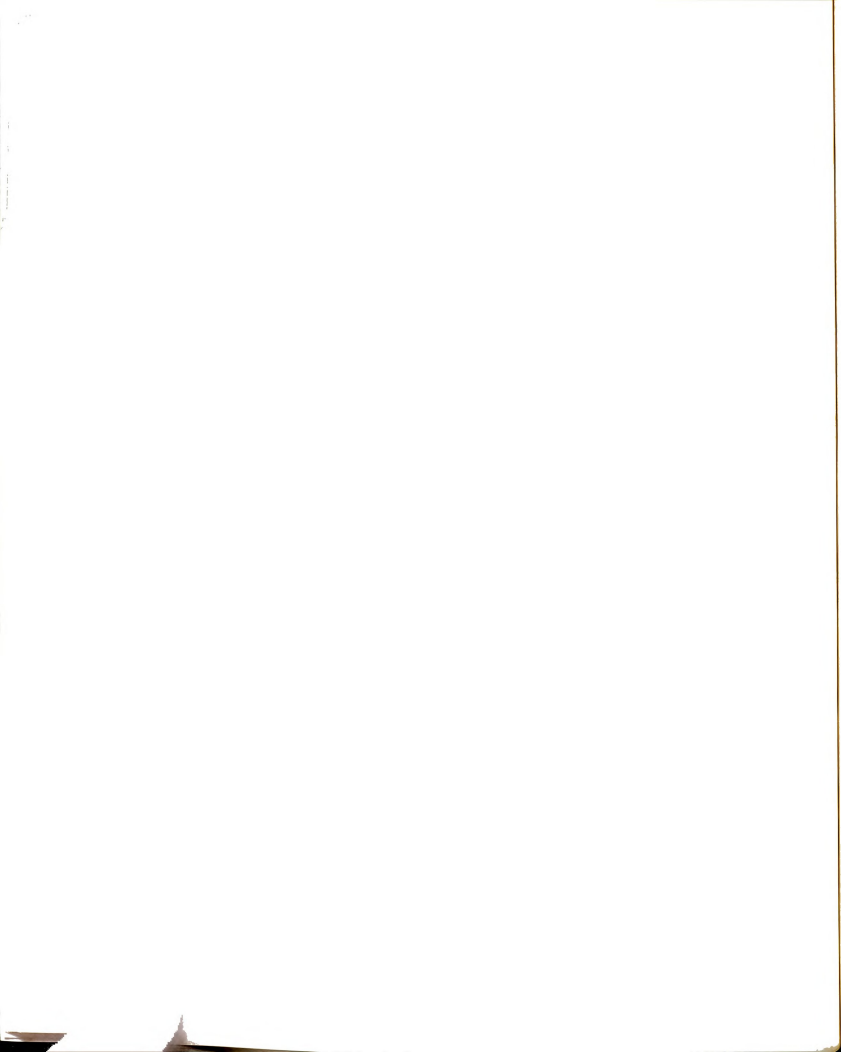
4. Employment of graduates.

Another potential performance criterion of the impact of university-industry ties might be the employment record of recent graduates. Presumably, some training of students occurs in university-industry ties and this makes graduates more employable. This should translate into shorter job searches, more actual recruiting or positions available, shifts in employment by sector or towards industry, and higher starting salaries for recent graduates.

C. Extension

1. Public agency contacts.

Visibility of the university and its activities is extremely important to the budget it gains from both the private sector and the public sector. Several contact points exist in the public sector which might feel the impact of university-industry ties. These include any governmental administrative branch, certain public agencies, and the legislature.



2. Private firm contacts.

Private firms are one major outreach point for university extension. The number of firm contacts and the nature of firm contacts are important performance criteria of university-industry ties. A shift from traditional firm contacts might occur with an increase in university transfer interactions.

3. Private individual contacts.

Private individuals are the other major outreach point for extension. Again, a shift from traditional individual contacts might occur with an increase in university transfer interactions. This is important because individuals feed back to the legislative point of public agency contacts and should be considered in university policy shifts.

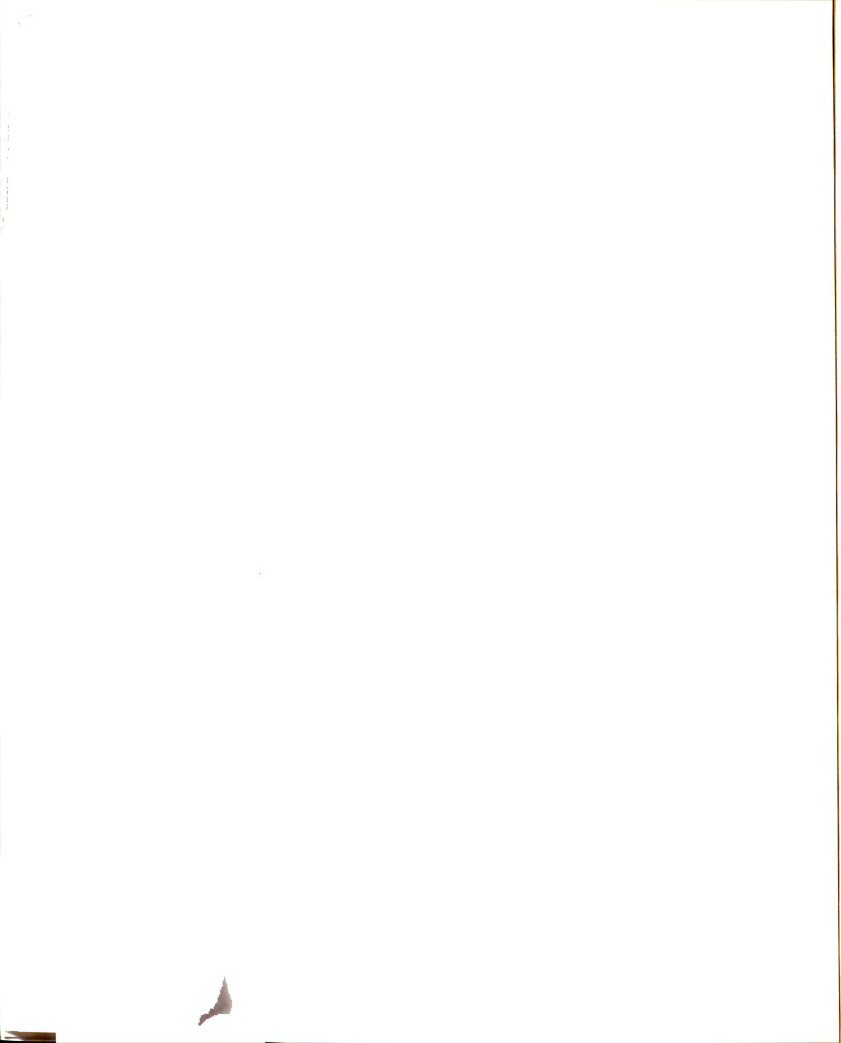
D. Technology

1. Rate of innovation.

Several measures of the rate of innovation can be considered as performance criteria in an analysis of university-industry ties. These include the number of patent applications, number of patents granted, and number of important patents. They represent common measures of rates of innovation in the private research and development literature. Blumenthal et al (1986a) have provided evidence that the rate of university patent applications may increase with stronger university-industry ties.

2. Rate of technology transfer.

Some innovations are not patented. The rate of technology transfer might capture a lot of innovations that reach markets from



the university which have not been patented. In the private sector the number of patents serves as an adequate proxy for the rate of innovation. Little evidence was found in the literature that this holds true in the public sector.

3. Rate of publication.

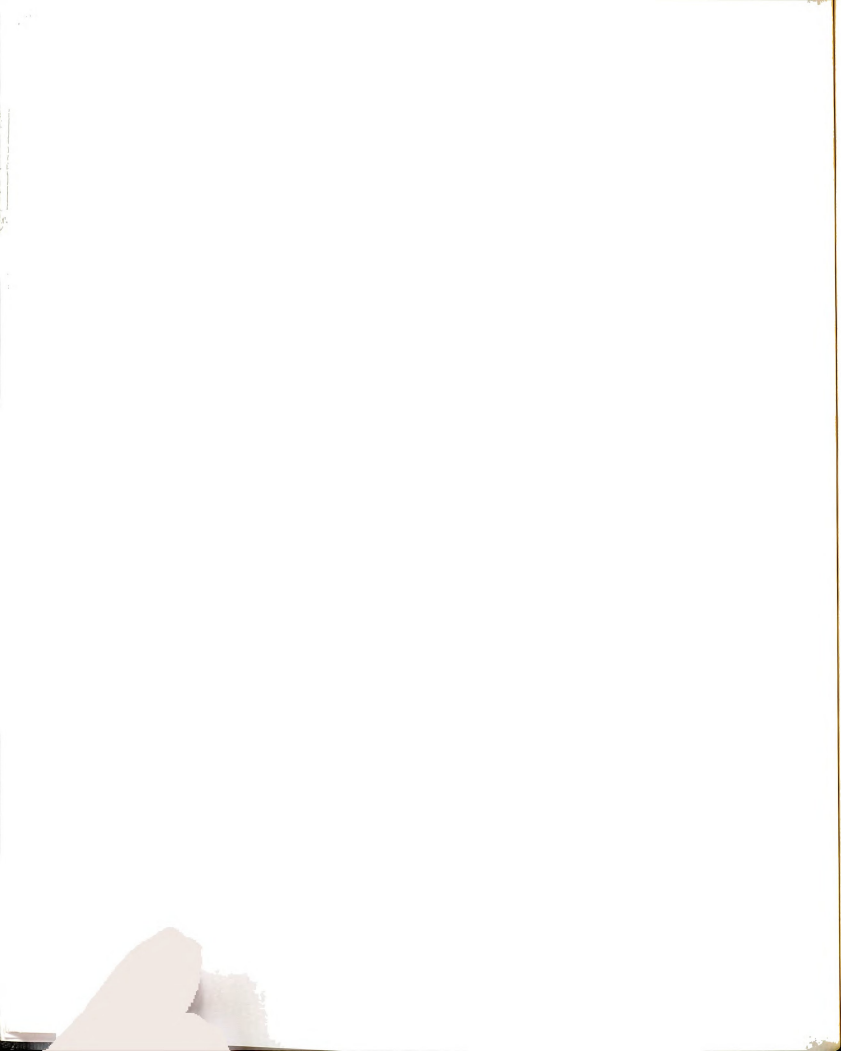
The rate of publication or rate of citation is one of the more important performance measures in the academic world. Its correlation with the rate of patents or the rate of technology transfer is uncertain. Publications are one of the primary tools for the exchange of information in research. Concern has been expressed that increased university interest in development of commercial products will decrease the rate of publication or at least alter its contents. Empirical work studying this question would be appropriate for future research.

4. Exchange of research materials.

The exchange of research materials is another important performance measure in the academic and research world. Again, concern has been expressed that increased university interest in development of commercial products will decrease the exchange of research materials. Empirical work studying this question would be another appropriate area for future research.

5. Interdepartmental and interuniversity research teams.

Interdepartmental and interuniversity research teams can be extremely important in today's complex research world. Increased emphasis on proprietary research has uncertain effects on the composition of research teams. The degree of institutional



cooperation as a performance criterion capturing the impact of university-industry ties might be important for administrators concerned with formulating research policy on a local or national level.

4.1.3 Situation and Structure

Situational characteristics considered by this study are mostly cost related. They include investment costs, transaction costs, information costs, exclusion costs, and production costs. Structure interacts with situation to form an opportunity set for management choice.² A set of structural variables is outlined before interactions with situation and influence on performance are discussed.

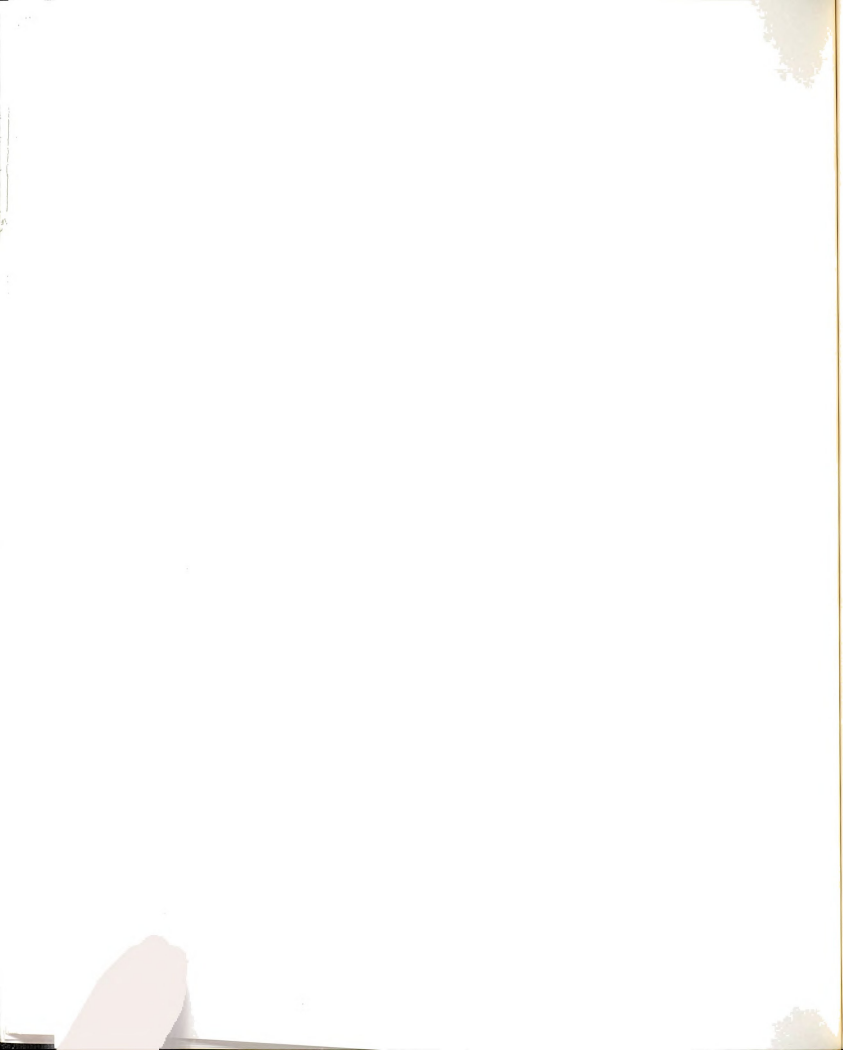
A. Financial resources.

1. Total budget.

The total budget of the transfer firm may vary considerably. While the total budget might influence performance, the percentage of

²Structural variation among transfer mechanisms formed the original questions which led to this study. Sheldon's (1986) characterization of university/industry linkage structures at four Michigan universities established some connections between the type of firm or the age of the firm and its staff components, financial resources, and autonomy from the university. There is little analysis with performance criteria in her work, especially those of a financial nature.

Murray and O'Conner's (1983) report focuses on corporate-sponsored university research in biotechnology. While their work represents a narrow picture of crossover sectors, the chapter on contracts is thorough and suggests the major components of this type of relationship (i.e. contractual relationships). Again, there is little analysis with performance criteria.



the budget concerned with transfer activities might explain more variation in performance.

2. Source of funds.

The source of transfer firm funds and their percentage of the total budget might be an important source of influence on performance. One difference is the dichotomy of private versus public funding. Other differences might be found in the nature of project-related funds. A large percentage of project related funds received by the transfer firm might be directly tied to product sales (fees, royalties or sales) or to various interest groups.

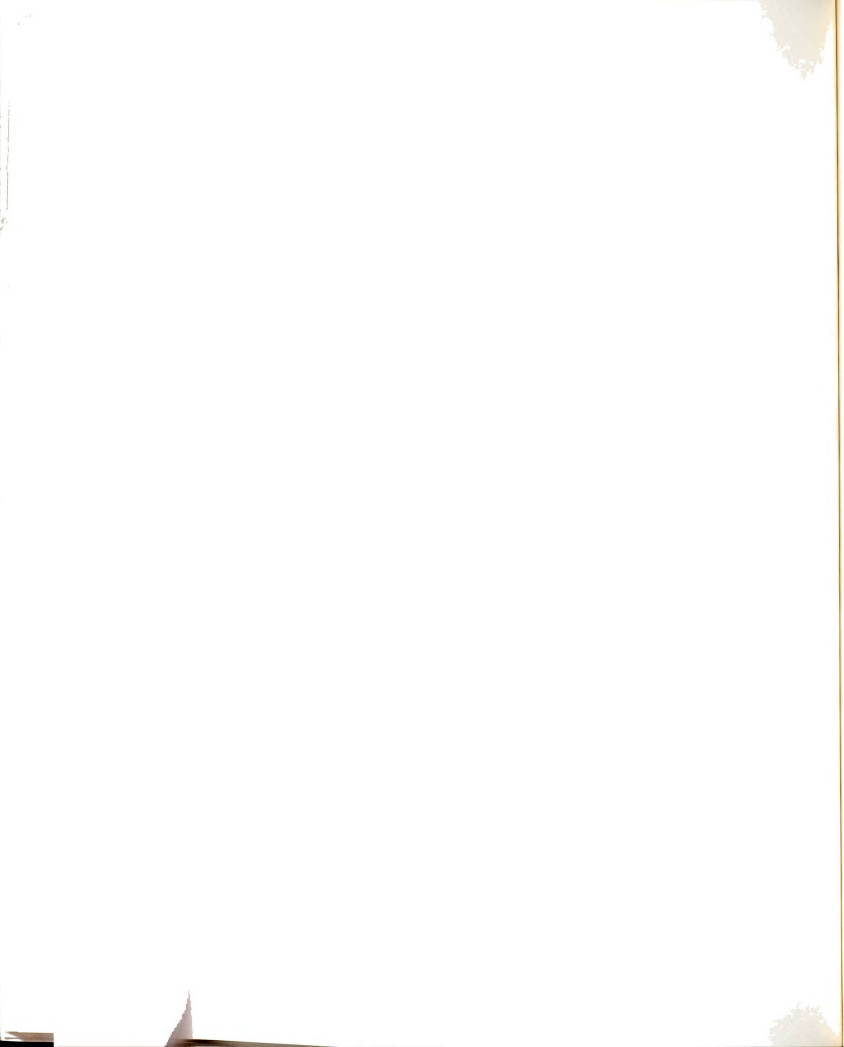
B. Controls

1. Administrative.

Most transfer firms have some kind of administrative oversight in their organization. This might come in the form of a single position of title, a board of directors, an advisory committee, partial ownership, or retention of consulting advisors. The secondary distinction, and perhaps the more important one in this study, is whether some part of the administrative oversight is played by a university employee.

C. Contracts

Contracts are an important part of structure. They have many components, not all of which influence the selected performance measures of this study. In the broadest sense a contract is any agreement between two parties. It is not limited to what is often labeled "contract research" since grants, prizes, gifts, and licenses may have definitive language regarding designation and utilization of



funds. For an initial look at how these various forms can influence the type of research conducted and the rate of innovation see Wright (1983) and some of the extended literature on patents and licensing. For the purposes of this study it is sufficient to recognize that grants, prizes, and gifts are all a form of research contract.³ Contractual components might include, but not be limited to, the following situational and non-situational elements:

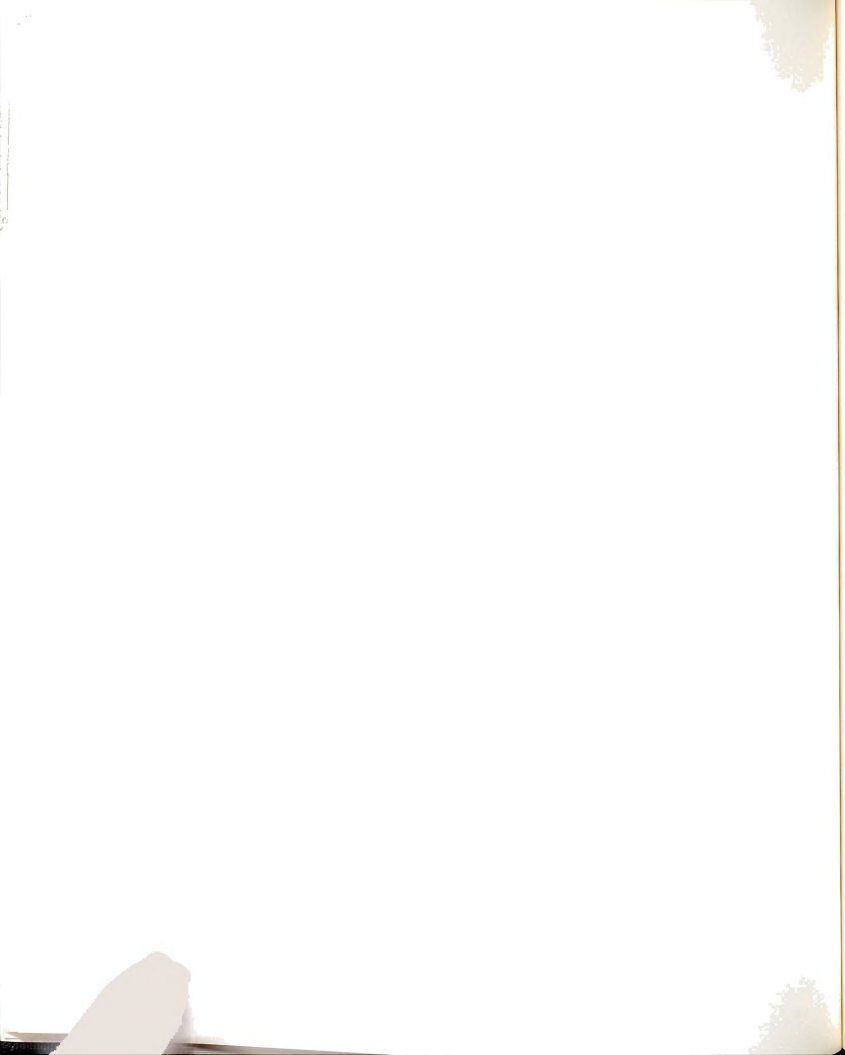
1. Scope of research.

The scope of research can be defined quite specifically or very broadly in a contract. Both content and stage of research development can be included in the scope of research definition. The stage of research is covered by the situational characteristic of investment costs.

2. Investigator.

The identification of a principal investigator might be part of a contract when money is given to the university. In addition, the procedure for his or her replacement or termination may be specified. If an individual or project is not identified by the contract, a department or similar entity may be the specified unit.

³A grant might designate many of the components of a contract such as scope of research, investigator, duration, reporting, etc.. A gift might just designate type of research or investigator but if the designation is there a contract exists. Prizes and awards often have stringent requirements, regarding use of funds, liabilities, property rights, and other contractual components. Licenses often designate policing requirements and royalty payments which become strictly contractual. The term "research contract" has acquired a rather narrow meaning but in reality most monetary receipts of the university lie under the umbrella of contracts and are treated as such in this framework.



3. Length of agreement.

The length of the contract and the policy on renewal are often specified in a research contract.

4. Payments.

The scheduling of payments to the university in a research contract does not influence either measure of performance which this study considers since the payments occur before the fact. However, if multiple payments are tied to the success of the research or product, some effect might then be felt.

5. Publication and review.

A publication and review period specified in a research contract or licensing agreement are common characteristics which allow patenting and avoid excessive information costs.

6. Patents and licenses.

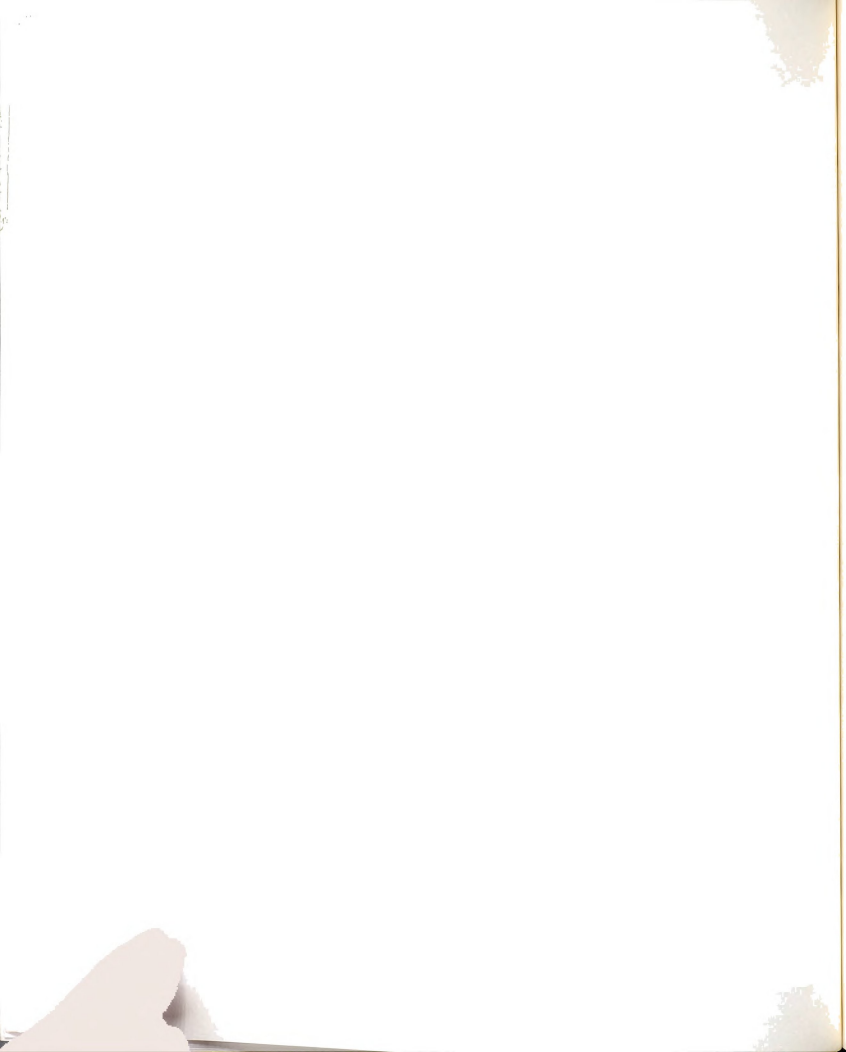
Who pays for the patent, holds the patent, and polices the patent are potential determinants of performance as a situational characteristic of exclusion costs. Who pays for the license and who holds the license are potential determinants of performance as a situational characteristic of transaction costs.

7. Royalties.

While royalty payments may be stipulated in the contract or licensing agreement they are part of one of the selected performance measures of this study and as such act as a dependent component.

8. Termination.

Contract or licensing termination clauses are often used in university-industry contracts.



9. Confidentiality.

Confidentiality, like publication and review specifications, might influence performance by decreasing information costs. It is one of the more questioned aspects of university-industry ties.

10. Reporting.

Reporting may be specified by a contract or it may exist more informally under the structural variable of control. The university may be reporting to the firm or the firm may be reporting to the university through controls which are administrative in nature.

11. Competing research.

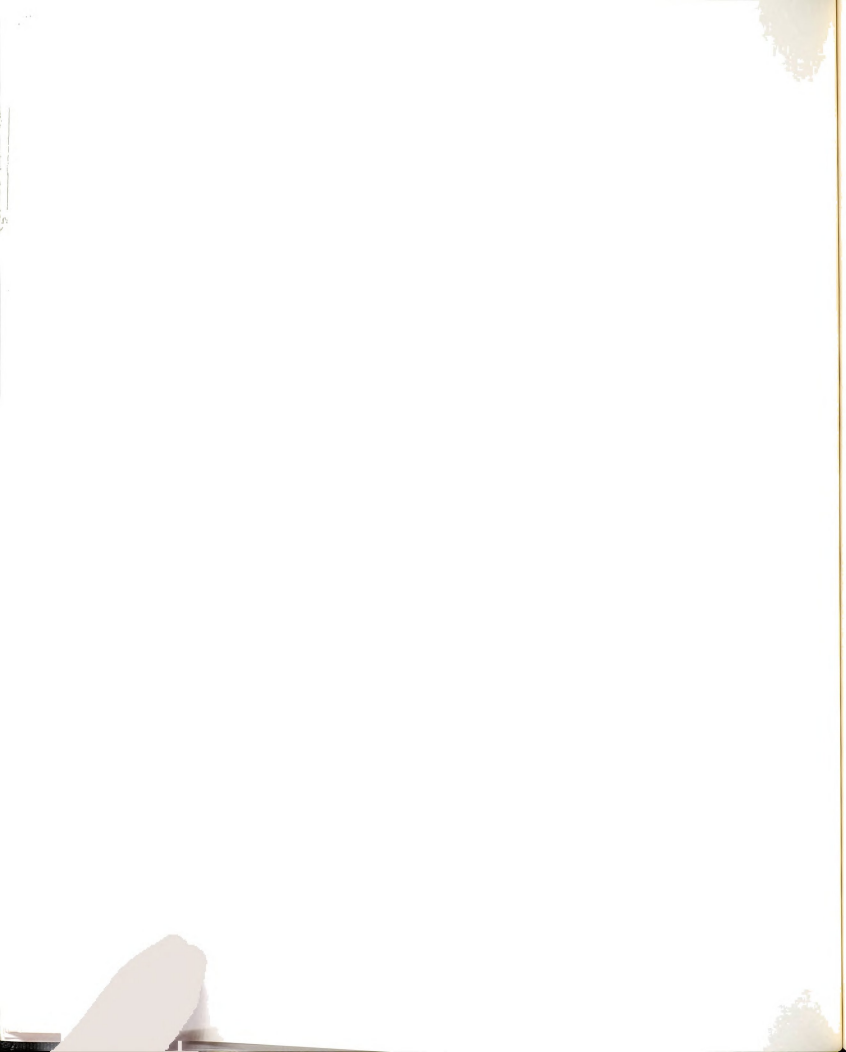
Competing research by the university, the firm, or a third party, might be expected to reduce the portion of rents captured for a particular innovation. Contractual clauses may attempt to minimize this effect but the outcome is complicated by competing markets.

12. Liabilities, insurance, and warranties.

Liabilities, insurance, and warranties can be treated as transaction costs once they are stipulated in the contract. The university, the firm, or a third party may be responsible for these costs.

13. Use of name.

The use of the university name might appear as a minor component of the contract but it has far-reaching implications. It is a source of free advertising for the transfer firm and can be treated as an extension cost to the university. Association of the university with a well respected firm or product might have an



indirect positive effect or indirect negative effect on other performance measures than those considered by this study.

D. Legal status

The alternatives for a firm's legal status might include incorporation, profit or non-profit status, or general or limited partnerships. The firm's legal status still allows any one of several economic objectives to be embraced by the directors.

E. Economic objective.

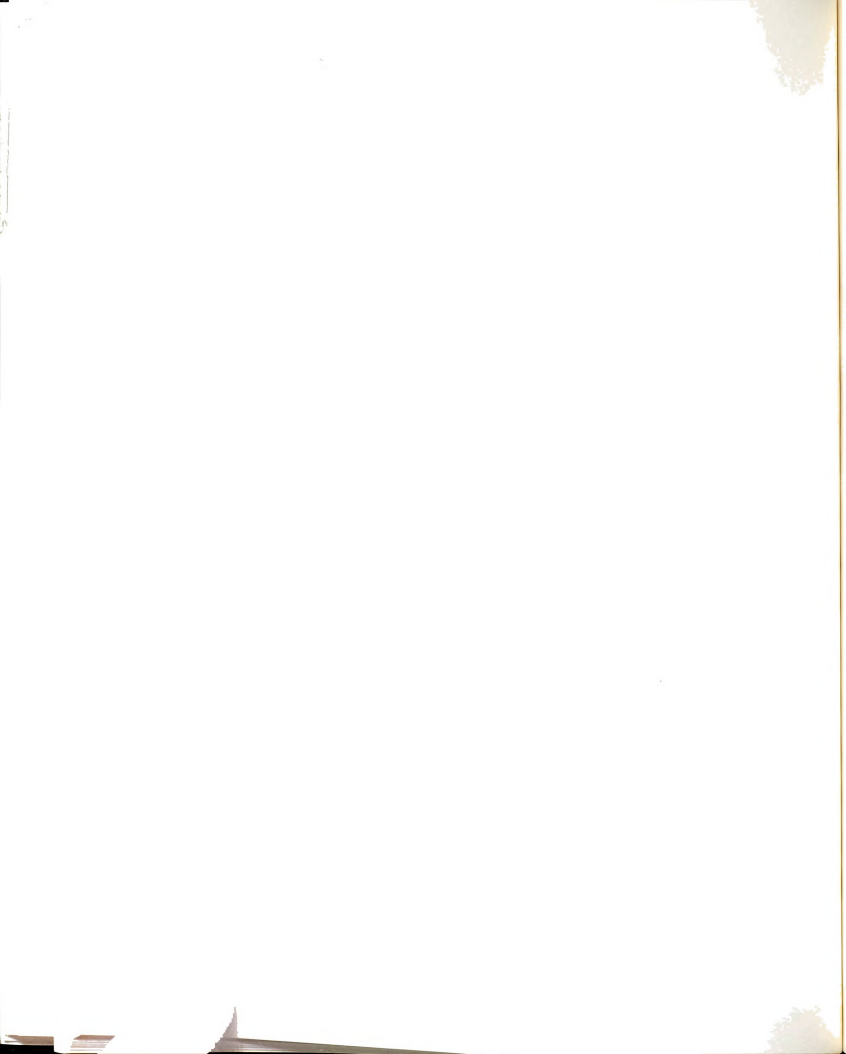
The economic objective of the crossover might have a strong impact on performance but the expected results are not clear. Steinberg (1986) discusses different objective functions of the non-profit firm; profit maximizing, revenue maximizing, and quantity or quality maximizing. Another objective, satisfying the research interests of the executive, is included in this study.

F. Market structure

Market structure is important in any analysis of innovation and technology transfer. Alternative research processes and products, alternative market products, and characterization of competition all affect performance.

G. University rules.

Many university rules influence the performance measures in this study. The allocation and distribution of returns to the university is one example (see footnote #1, Chapter 4). Retention of property rights by the university is the most common rule that will affect performance of the transfer firm. The general rule has been for



universities to retain property rights, although there have been many exceptions to this in recent university-industry developments.

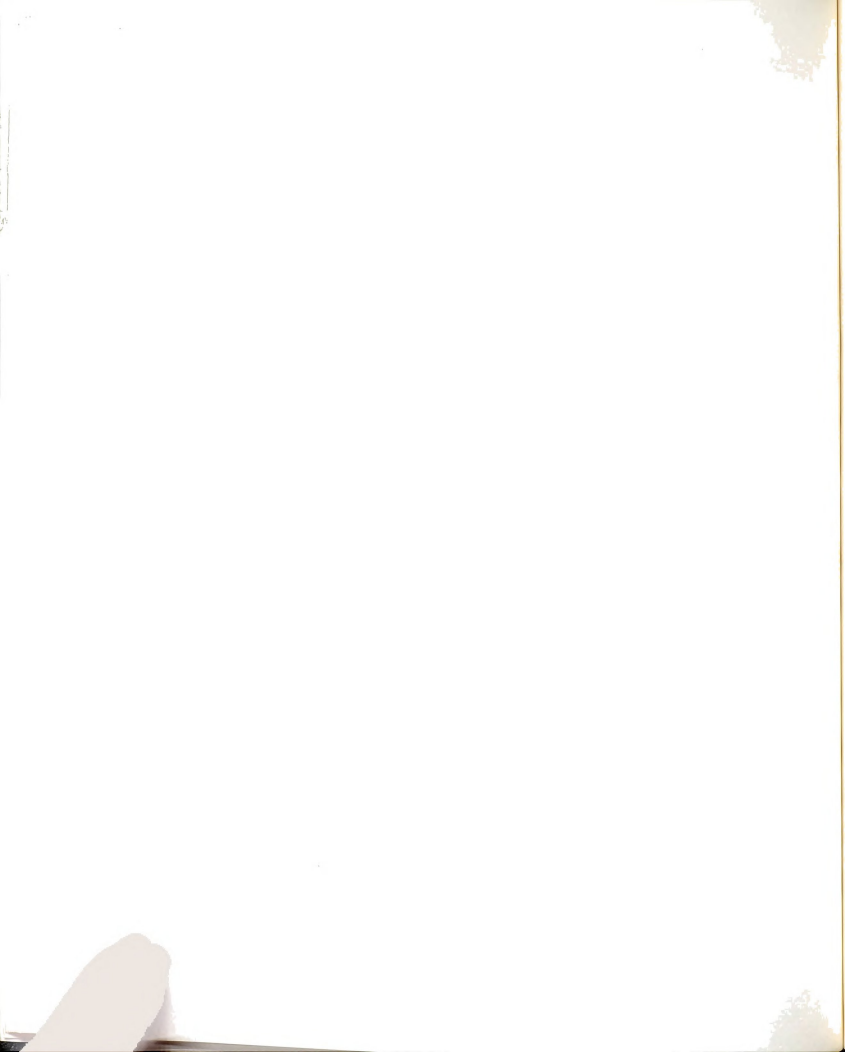
H. Organizational hierarchy.

Much has been written about organizational hierarchies in the economics literature. Sah and Stiglitz (1986) construct a model of economic performance of polyarchies (independent, horizontal decision makers) and hierarchies (dependent, vertical decision makers). Williamson (1979 and 1980) assesses microeconomic outcomes for different organizational hierarchies which are primarily driven by differences in transaction costs. If Williamson is correct, much of the organizational outcome in university-industry relationships is driven by transaction costs which are in the situation and structure, not the other way around. McEowan (1987) expressed efficiency reasons for avoiding the excessive vertical separation evolving in many of the new university-industry relationships.

I. Staff.

The size of the transfer firm staff probably does not influence performance unless it is a limiting factor. Economies of scale for innovative activities exist only to a certain level and that is not a performance measure in this study.

The makeup of the transfer firm staff may be more important. The percentage of non-professional staff, professional staff, and university-associated staff might be one composition factor to look at. The percentage of business, engineering, physical science, social science, or other professionally trained staff might be another.



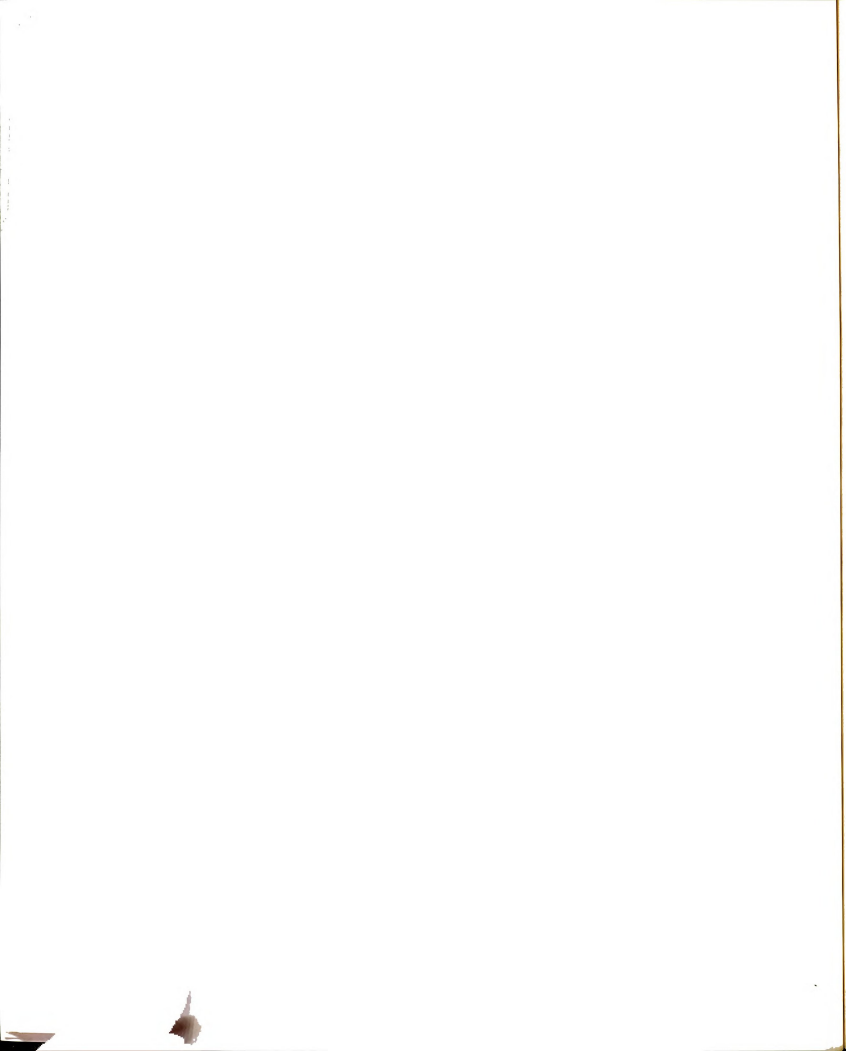
4.2 A Sample Interaction

This section of Chapter 4 breaks down two important variables, information costs and exclusion costs, into the alternatives they might take on, some interactions which might exist, and suggests what their expected influence on performance could be.⁴

Situational characteristics affect many different performance criteria. The two performance criteria the model focuses on are the percentage of rent which the transfer firm captures and the percentage of captured rent returned to the university. A multitude of scenarios are possible when discussing the expected influence of situational and structural alternatives on either measure of performance. The starting point for this framework is where the transfer firm attempts to maximize rents no matter what the share of costs and obligations are between the university, the transfer firm, and a possible third party.

It is reasonable to assume that the rent maximizer will always capture as much rent or more than any other type of imposed transfer condition. The rent maximizer does not necessarily act as a profit maximizer (the rent maximizer may not be a cost minimizer while a profit maximizer is). This is a managerial choice. In addition, a

⁴A dynamic treatment of all variables is an ideal way to analyze a changing environment. However, this would be both unrealistic given the tools and understanding which have developed around university/industry ties, and lacking in clarity given the complexity of the few variables included here. Each variable is treated in this framework as changing while other variables are held constant.



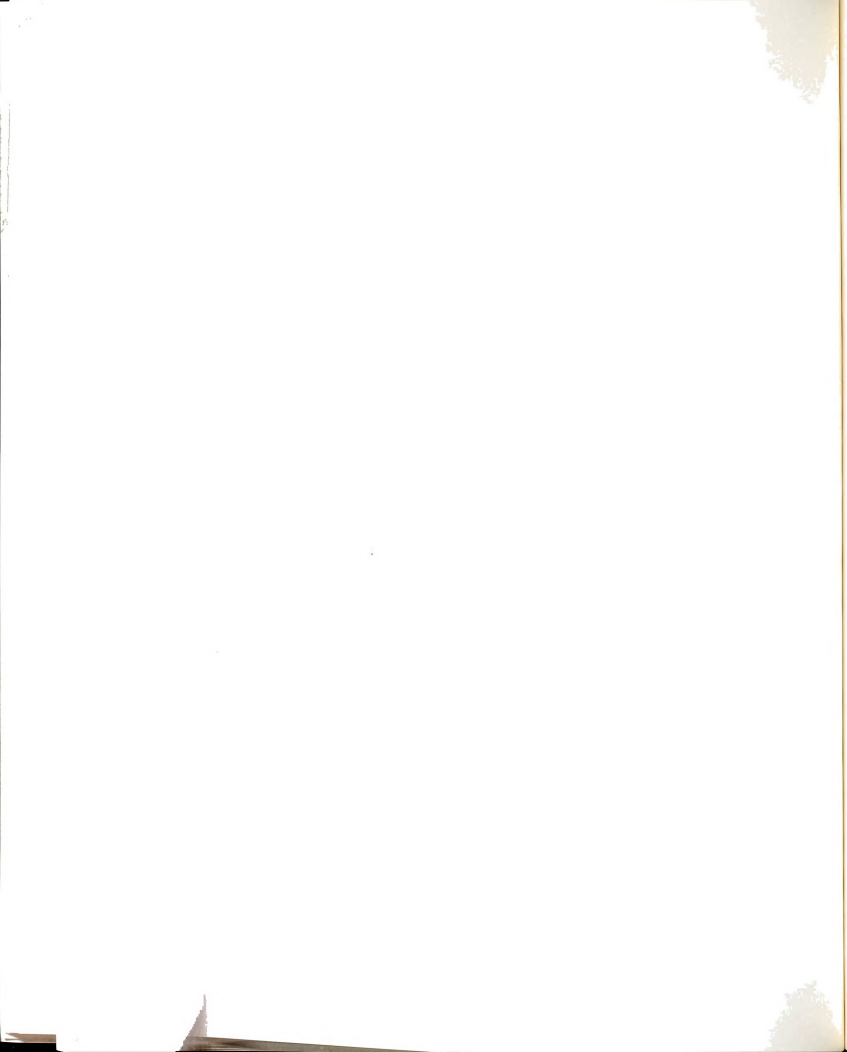
rent maximizer may or may not be a return maximizer. Structural alternatives will influence that outcome.

4.2.1 Information Costs and the Rent Maximizing Firm

Information costs can be divided into two components, market knowledge and commercial knowledge. Market knowledge enables the consumer to learn about, and make decisions, regarding new technologies and their substitutes. Common forms of market knowledge include university extension and outreach programs and private-sector advertising. Commercial knowledge enables competitors to evaluate and imitate new technologies or provide substitutes. Common forms of commercial knowledge include patent disclosures and professional publications. The issue of patent disclosures connects information costs to exclusion costs.

Market knowledge as an information cost is relatively straightforward to include in the framework. University extension or outreach programs convey certain information about new technologies or products to markets. They generally will be endorsed by a rent-maximizing transfer firm as an additional form of free advertising. It is also expected that the rent-maximizing transfer firm will engage in private advertising to further the decision-making capabilities of the consumer.⁵

⁵When there are no substitutes other forms of information than advertising may engage the consumer and create sufficient demand to reduce the need for advertising. The structural alternatives to avoid or prevent substitutes are complicated. They may involve targeting of particular market structures and choice and breadth of patent coverage. While advertising needs can be reduced by such action, and rent maximization more easily engaged, the impact of this

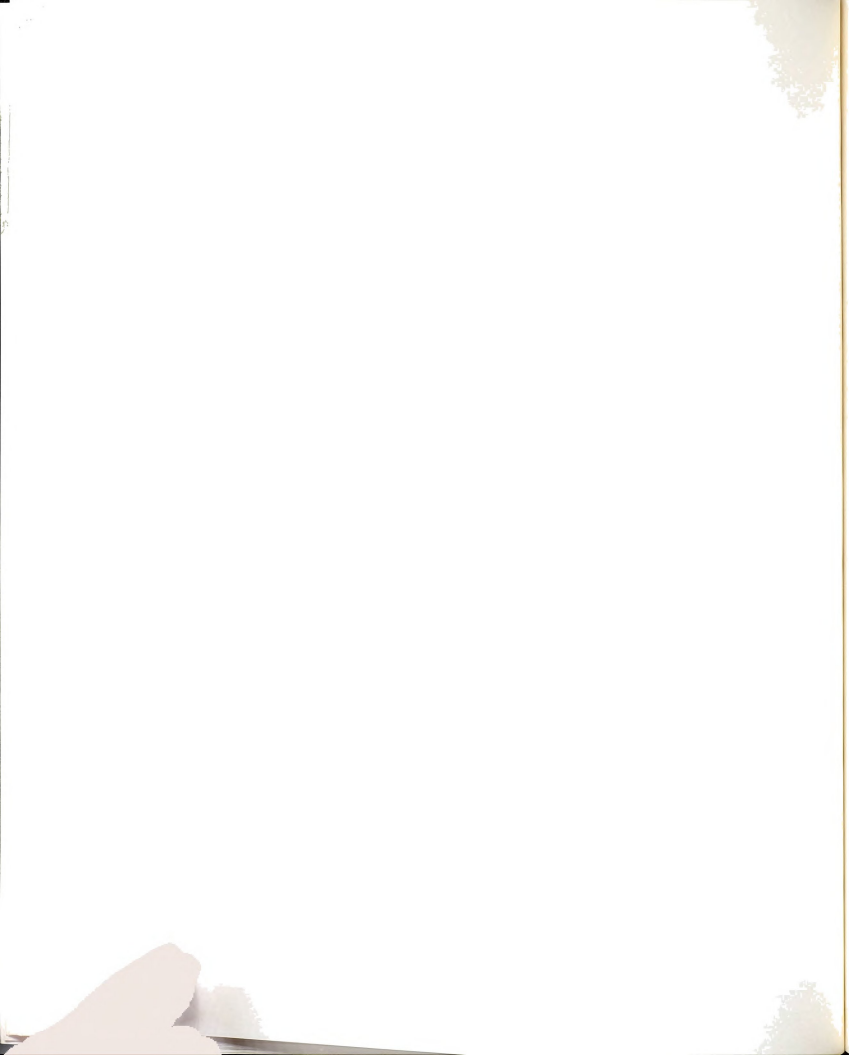


Structural variability can interact with the transfer firm's advertising decision through the contractual component regarding use of the university name. This is a second source of free advertising and the rent maximizing transfer firm can be expected to opt for its use. While this issue might appear to be a minor component of the contract it stood out as a point of strong debate at a recent national workshop on plant patents (Gast, 1987). Association of the university with a well respected firm or successful product might have an indirect positive effect on other performance measures of the transfer firm. Philosophical and real differences suggest that this effect might also be negative.

Commercial knowledge as an information cost is slightly more complicated to include in the framework than market knowledge. Professional publications and patent disclosures convey technical information about new products or technologies to potential competitors. It is expected that the rent-maximizing firm manager will attempt to minimize the transfer of commercial knowledge.

Structural influence on publications comes from the contractual component of transfer firm publication review and editorial control. The rent-maximizing transfer firm will probably attempt to delay publication through specified review periods. This prevents technical information from reaching potential competitors until after a certain developmental period has passed. The negative side of this choice is that publication delay might allow others to establish

decision is felt in other parts of the framework.



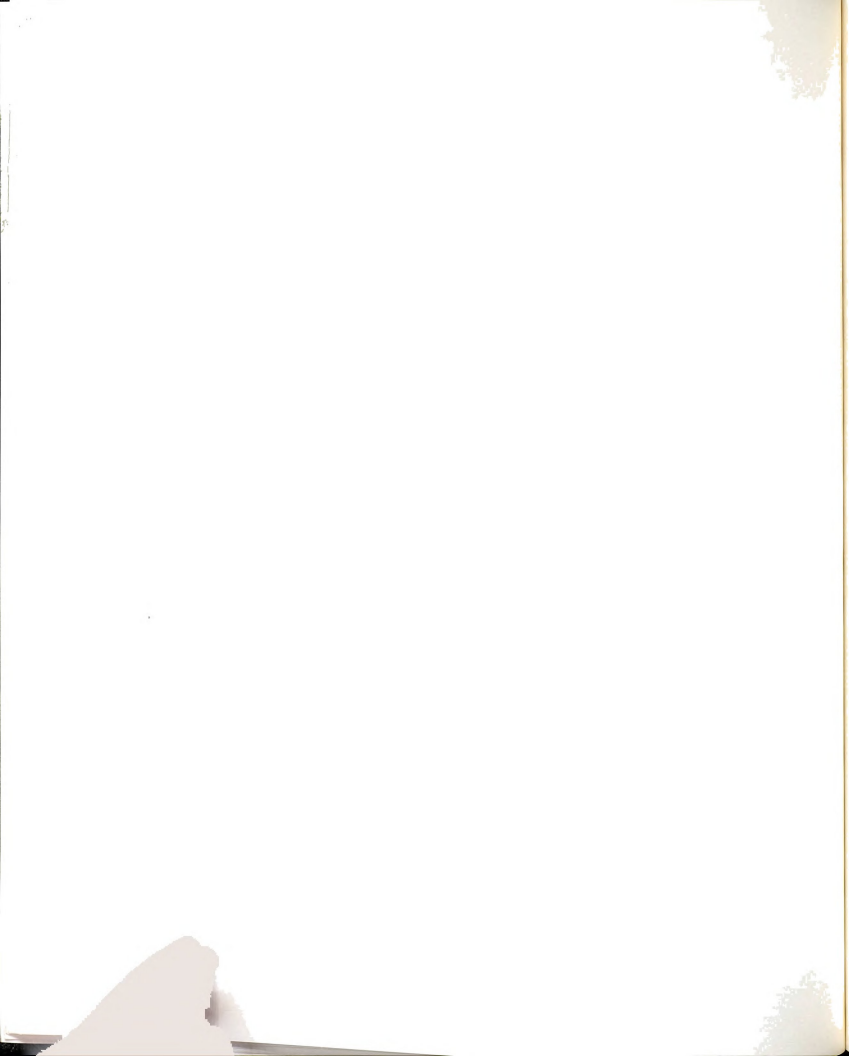
first credit, slow down scientific progress, or reduce academic achievement by traditional standards.

Editorial control, when invoked by a transfer firm, can have similar consequences. The rent-maximizing transfer firm might try to gain editorial control through a contractual clause, although this is probably more difficult for the university to accept than publication delays.

The other form of commercial knowledge is a direct consequence of the decision to patent a new product. One of the negative aspects of a patent is that patent disclosures enable competitors to use technical information to develop similar products or technologies which do not infringe on specific patent rights. An alternative method of retaining proprietary rights on technologies while minimizing the transfer of commercial knowledge is to use the trade secret laws. The rent-maximizing transfer firm may choose to establish trade secret rights for as long as possible before obtaining a patent. Timing of the patent application is a critical choice for the management trying to minimize information costs due to patent disclosures while still maximizing rents.

4.2.2 Exclusion Costs and the Rent Maximizing Firm

The most important decision regarding exclusion costs may be the choice to patent. Patents ensure proprietary rights and ease the recovery of investment costs through the capture of monopoly

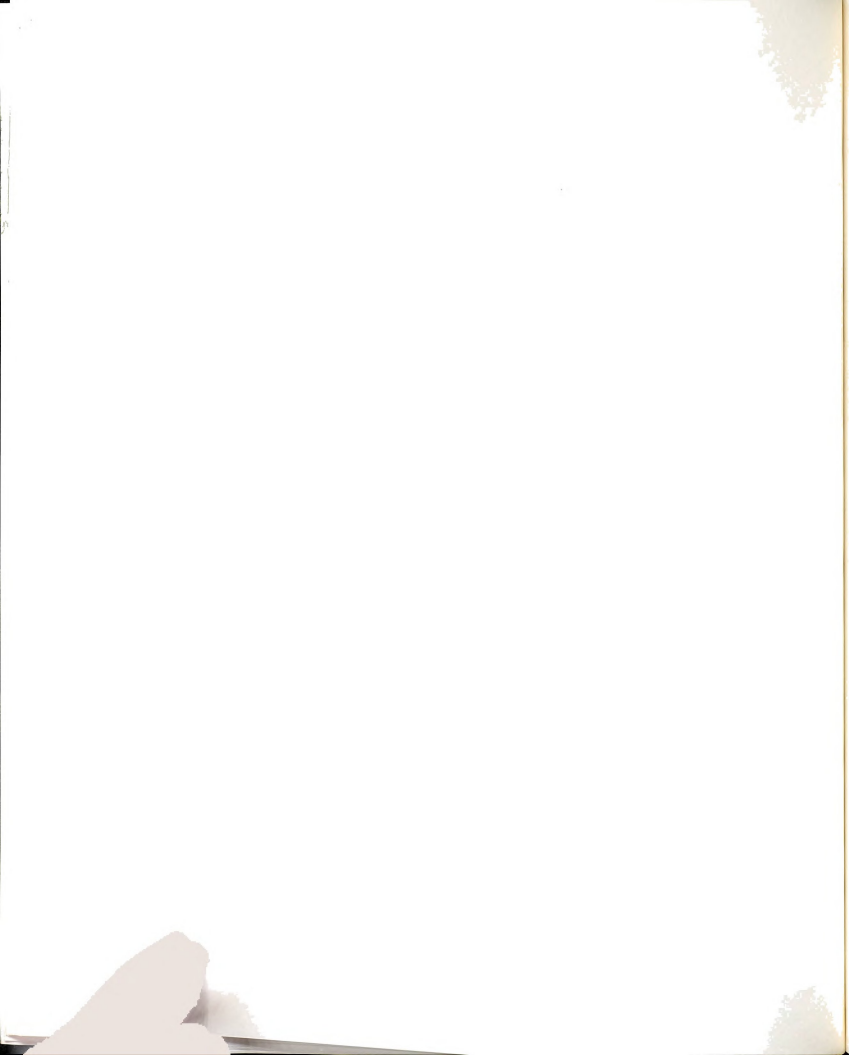


profits.⁶ The rent-maximizing manager will generally seek a patent but the action may be delayed in order to minimize information loss and maintain the full length of the patent during a product's commercially available lifetime.

Who applies for the patent and who holds it are often determined through the structural component of a contractual clause. Many universities involved in traditional commercialization ties insist on holding the patent for a university-based invention but this attitude is not rigid. A rent-maximizing transfer firm may try to negotiate for the right to patent materials developed through a university research relationship. This gives the transfer firm increased control over product development, reduces their potential licensing and royalty costs, and increases their potential administrative and policing costs.

Patents cost money. Administrative time, legal fees, and application fees must be less than the anticipated value of the proprietary protection or the transfer firm will opt to let the university pay for and hold the patent. If the risk of cost recovery

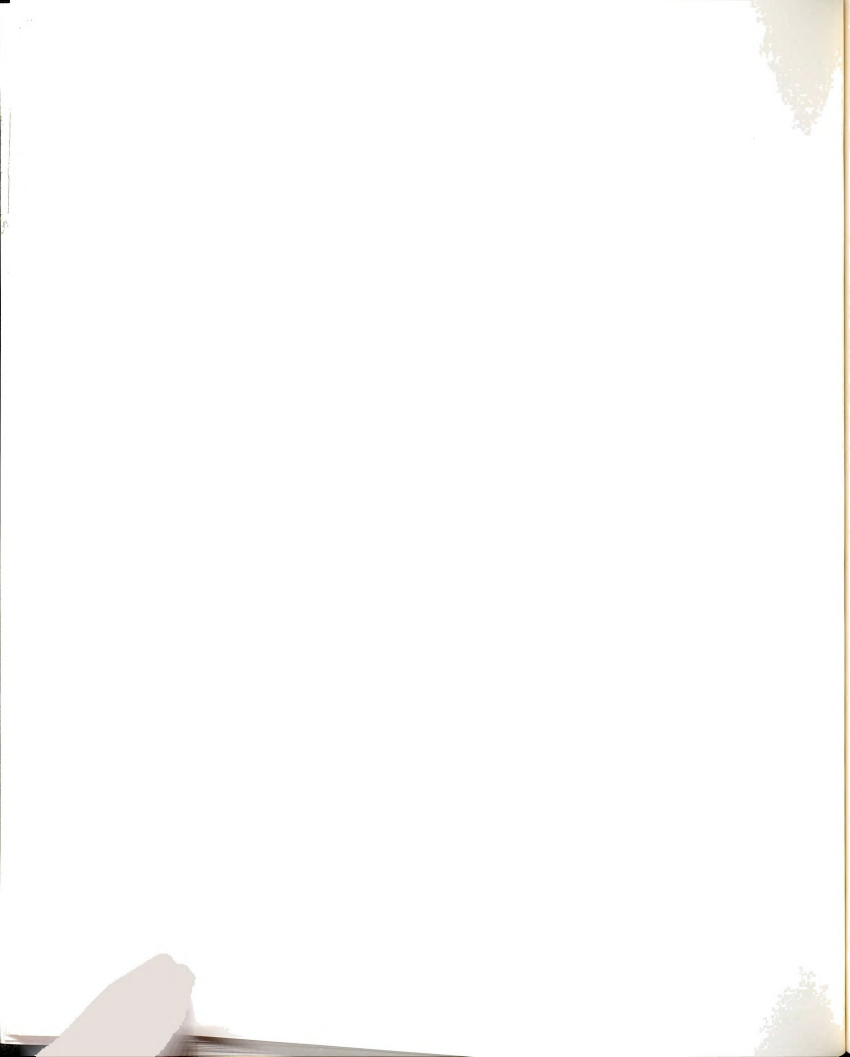
⁶Alternatives to patents exist. One alternative is to maintain technical information as a trade secret as long as possible though this provides little protection for a good with public exposure. The discussion in this Chapter generally omits the possibility that the university will engage in trade secret options. No established university policy mandates an award system or condones non-disclosure with a trade secret practice. Another alternative is to develop mechanical protection which ensures proprietary rights without legal protection. A good example of this is the commercial development of hybrid crop lines while keeping the parent generations secret. Genetic locks, software codes, and key technical compatibilities are all mechanical protective mechanisms which may proliferate in the future and eventually replace patents. These technologies are probably too new to play an important role in this study.



is high because of market conditions or technical considerations, the value of proprietary protection is reduced and the transfer firm might prefer not to hold the patent.

If the transfer firm holds a patent acquired through university relationships it must consider licensing agreements, royalty payments, and policing requirements. A price-quantity tradeoff is involved. When determining licensing arrangements, multiple licenses imply increased competition, lower prices, larger quantities, and decreased licensing costs. The rent-maximizing transfer firm which owns a patent faces a decision regarding the number of licenses issued which will allow maximum rents to be captured. Accepting bids for licenses might help the transfer management in making this decision. Other factors may prevail or a third-party firm may have the strength to negotiate exclusivity (single licensee). A high licensing fee might be imposed to ensure quick recovery of investment costs and a high royalty payment might be imposed to ensure quality markets for certain alterable goods. If the transfer firm holds a patent and is also the production and sales facility, there will be no licensing or royalty issues involved. It is expected that the rent-maximizing transfer firm will engage in some policing activities. The activity might stop at the point of cost recovery or it might continue to ensure rent maximization. In either case the activity will be tempered by the reproducibility of the product as in the decision to patent.

If the university holds a patent and uses an internal transfer firm that is a rent maximizer it will make similar choices as the



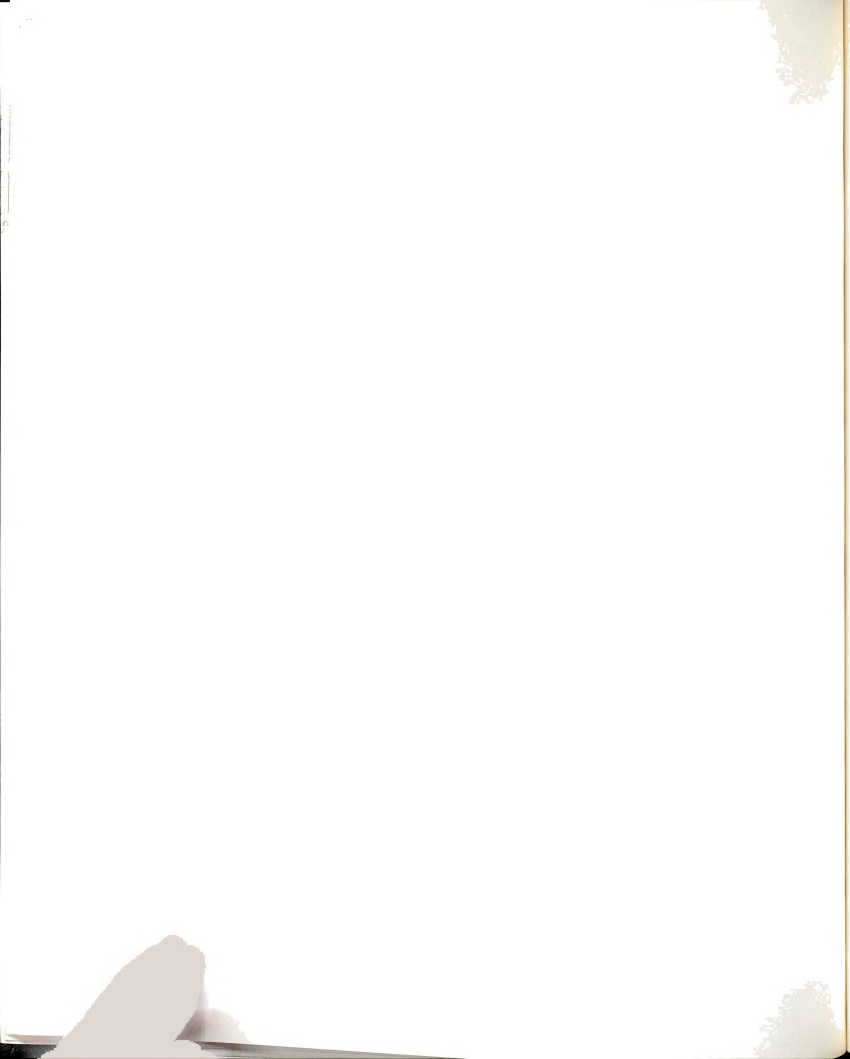
external transfer firm. If the university holds a patent and uses an external transfer firm that is a rent maximizer the expected scenario changes slightly. The transfer firm will probably attempt to obtain an exclusive license from the university. This choice will help to eliminate competition. Licensing fees and royalty payments will probably be high if the license is exclusive. More than one sublicense might be issued by the rent-maximizing transfer licensee. Policing will be open for negotiation between the university and the transfer firm. The rent-maximizing external transfer firm will probably opt to engage in some policing activities in order to ensure rent objectives but the university may remain ultimately responsible for policing and prosecution as the patent holder.

4.3 Selected Variables and Expected Outcome

A set of variables to be examined by this study is selected in this section. Their expected alternatives and potential influence on identified performance criteria are presented in Figure 4.2 and outlined in conjunction with five hypotheses.

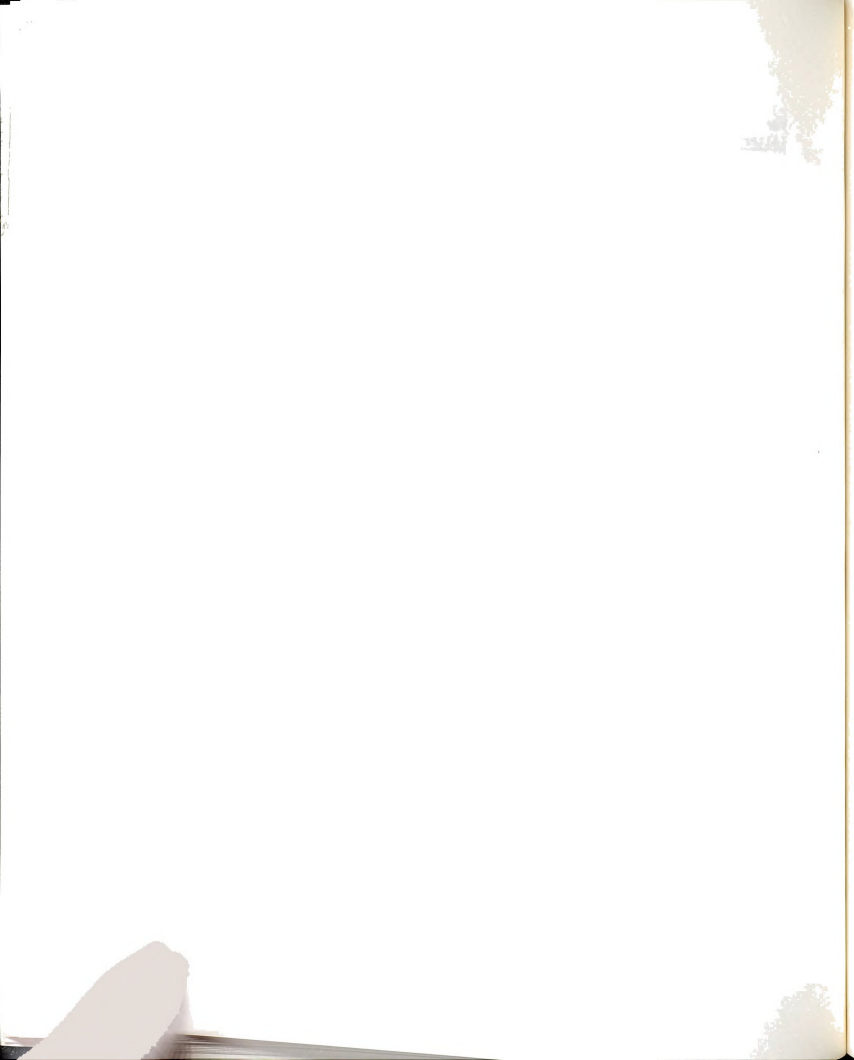
4.3.1 Public Controls

Hypothesis 1: Public or university involvement in a transfer firm leads to inefficiencies capturing rents but enhances direct returns to the university. The null hypothesis would be that there is no relationship between public controls of a transfer firm and the capture or return of rents.



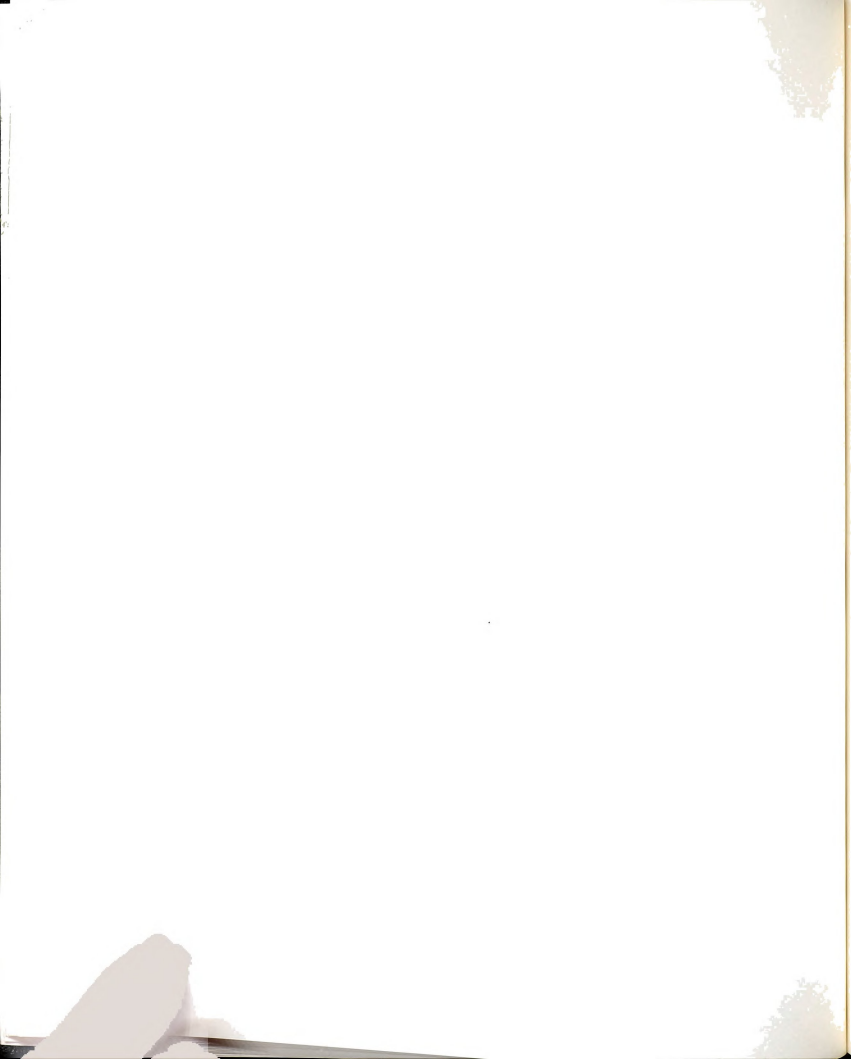
Variables (Alternatives)	Captured rent	Returned rent
<u>Assertion 1: Public Controls</u>		
Source of funds for the transfer firm:		
State or federal	-	+
University	-	+
Partial faculty	-	+
Private	+	-
Full faculty	+	-
Public directorates on the transfer firm:		
Science advisory board	-	+
Executive position	-	+
Board of trustees	-	+
<u>Assertion 2: Economic Objective</u>		
Economic objective of the transfer firm:		
Profit	+	-
Quality	-	+
Self-interest	-	+
Quantity	-	+
<u>Assertion 3: Property Ownership</u>		
Patent ownership:		
University	-	-
Private	+	+
Licensing rights:		
Exclusive	+	+
Non-exclusive	-	-
Public	-	-
Other rights:		
Policing	+	+
Rescission	+	+
Standards	-	-
Development	-	-
<u>Assertion 4: Information Costs</u>		
Publication delays:		
Granted	+	+
Marketing costs paid by the university:		
Extension	+	+
University name	+	+

Figure 4.2 Structural alternatives for selected variables of the framework and their expected impact on performance measures of rent.



<u>Variables</u> <u>(Alternatives)</u>	<u>Captured</u> <u>rent</u>	<u>Returned</u> <u>rent</u>
<u>Assertion 5: Investment Costs</u>		
Investment costs paid by the transfer firm:		
Basic	+	-
Applied	+	-
Development	+	-
Administrative costs paid by the transfer firm:		
University overhead	+	-
Separate administrative budget	+	-
Exclusion costs paid by the transfer firm:		
Patent costs	+	-
Licensing fee	+	-
Policing costs	+	-

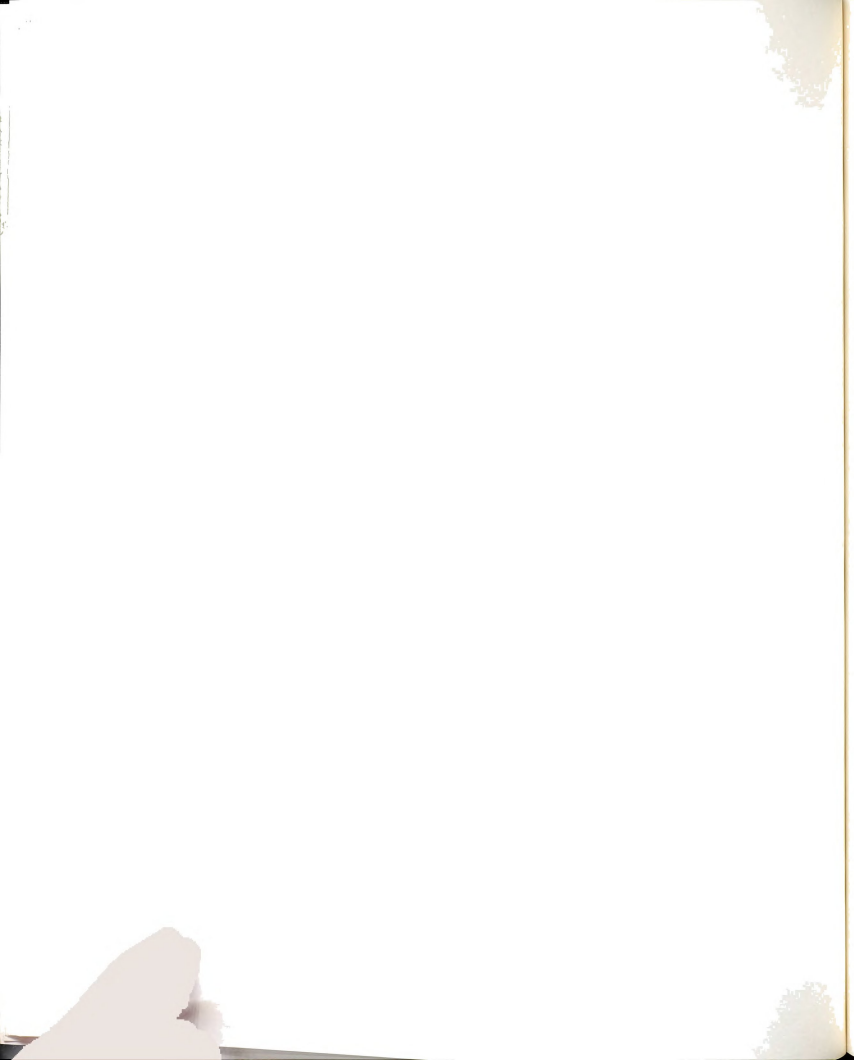
Figure 4.2 (cont'd.).



Public involvement in a transfer firm may be administrative or financial. Administrative controls may come as a board member, scientific director, partial owner, or executive. Financial controls may come as loans, direct payments, bargaining tradeoffs, donations, or equity interests.

There are several reasons which lead to this first hypothesis:

1) Public institutions have experience which lies outside of markets. States, universities, and even faculty members are still learning the rules of the market game. Until they become more attuned to these rules their presence in any form of transfer control could result in less efficient market transactions than the pure private sector. This is also true of any new firm but training and expectations factor in. 2) Public institutions are responsive to public pressures. Public universities respond to budget pressures. While fiscal stress may be one reason universities are increasingly engaging in transfer activities there is an opposite pressure from the tax-based budget to not-double charge for their services. Because of this, any state, university, or faculty presence in transfer firms may result in inefficient pricing. 3) Public institutions and their employees exhibit some self-interest. All university members, as individuals, have an interest in perpetuating their position and maintaining their institution. Universities would not be involved in extensive commercialization efforts if they did not need money. For this reason when there is a public presence in transfer firms they will attempt to maximize returns to the university, be they direct or indirect returns. 4) Personal cultural



expectations may also be a force. The scientist or engineer has a creative nature which dictates different priorities from the financier and leads to market inefficiencies.

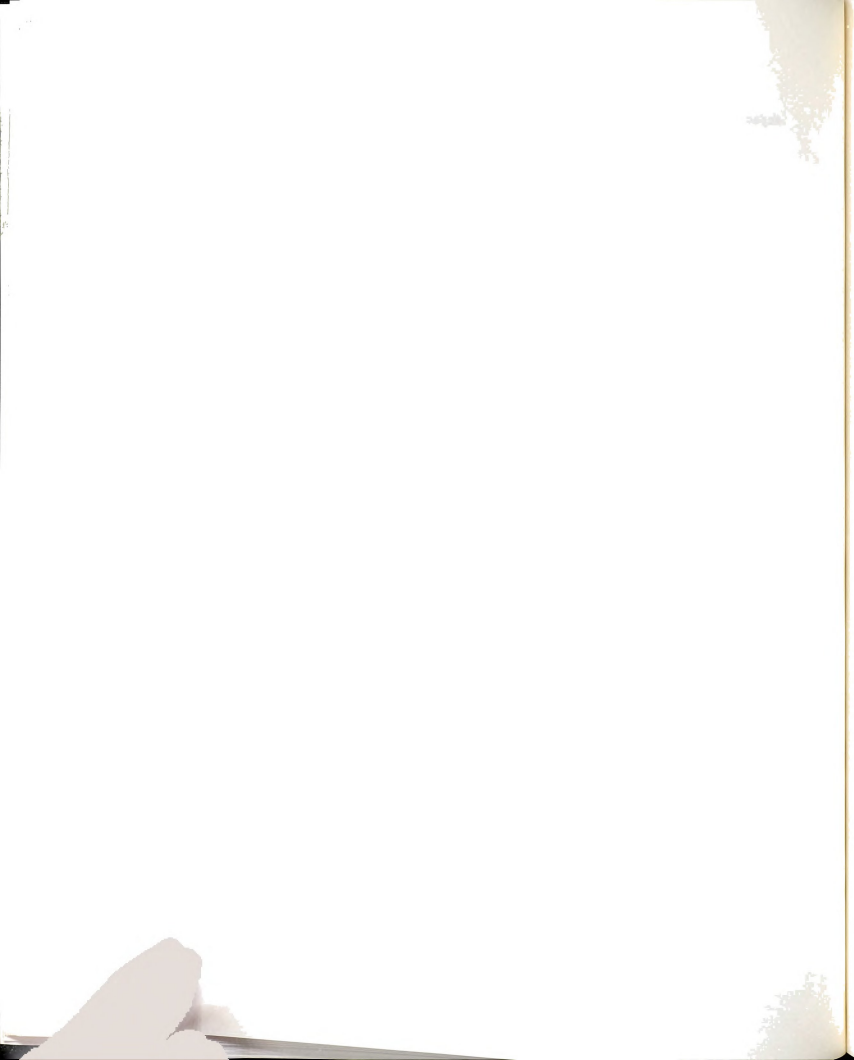
The structural alternatives for state or university interest in the transfer firm can be related to financial control or to directorate control. These alternatives are outlined in Figure 4.2 with their expected influence on performance measures given a positive or negative rating.

4.3.2 Economic Objectives

Hypothesis 2: Profit objectives lead to more efficient capture of rents and detract from direct returns to the university. Firms which are not profit maximizers may have a mix of objectives which lead to inefficiencies capturing rents and could contribute to direct returns to the university. The null hypothesis would be that there is no relationship between the economic objective of the transfer firm and the capture or return of rents.

This hypothesis derives from the arguments about economic objectives of the transfer firm. Profit objectives are the most efficient for capturing rents (to argue otherwise would be to argue with nearly the whole of twentieth century economic theory). And the profit maximizing firm will attempt to minimize returns to the university by seeking the least-cost alternative.

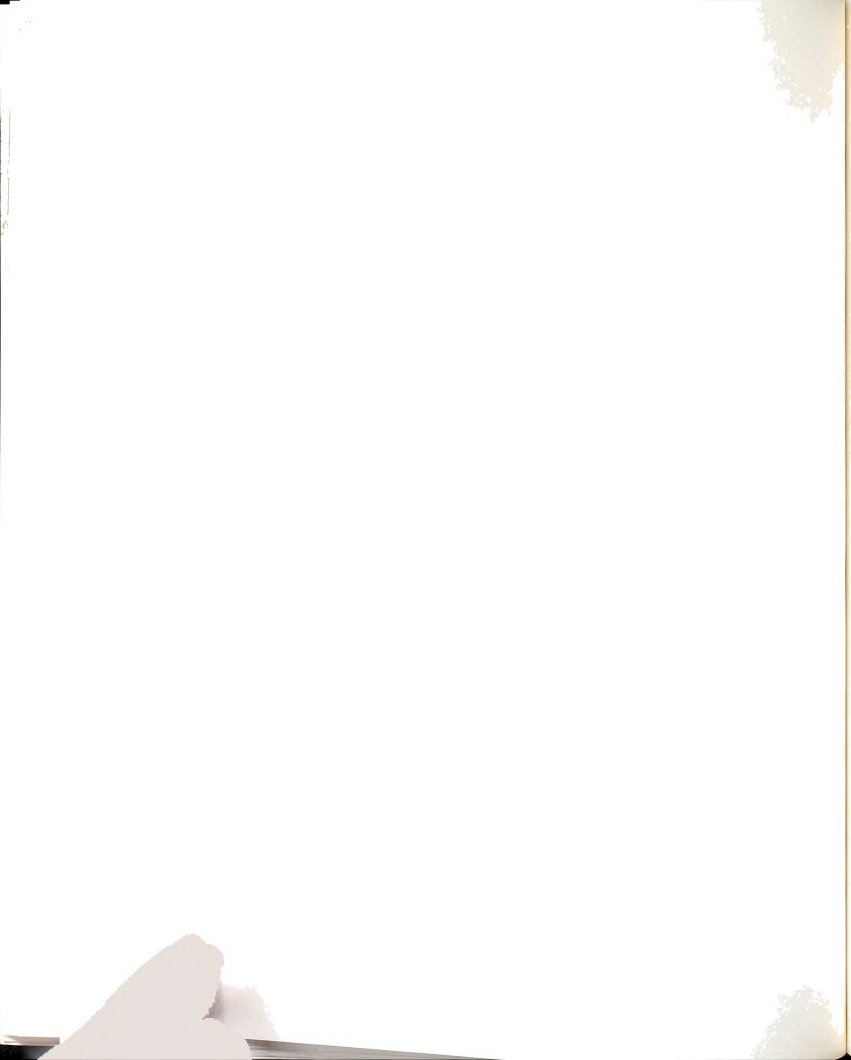
Alternative objectives are more difficult to understand. Those firms which are not profit maximizers have some mix of economic objectives which may be influenced by their structure. What these



firms attempt to maximize and what part of their structure influences these objectives, and thus their performance, is the question of interest. The structural alternatives and their influence on performance may be directly tied to Hypothesis 1. Public influence on the firm leads to behavior other than profit maximization. There may be growth objectives, quality objectives, self-interest or research interest, quantity objectives, or some other mix.

These firms are not as efficient as the profit-maximizing transfer firm in capturing rents. That much should be clear by definition. What is their effect on returns to the university? Returns to the university are negotiated as some portion of the rents captured by the transfer firm. When the transfer firm guarantees fifty-percent return of some defined sales to the university but fails to capture one-hundred percent of appropriable rents because it is a quality objective firm, it returns a smaller portion of the appropriable rents to the university.

The question is whether a quality (or other) objective transfer firm will increase the portion of captured rents returned to the university over its counterpart, the profit-objective transfer firm, to equal or surpass the percentage of appropriable rents returned to the university. In a university technology transfer system the structural alternatives that are likely to be in place which lead to the quality objective include university or faculty ownership and attaching the university name to the commercial product. In conjunction with Hypothesis 1, it is suggested that the quality objective firm will return a greater portion of captured rents to

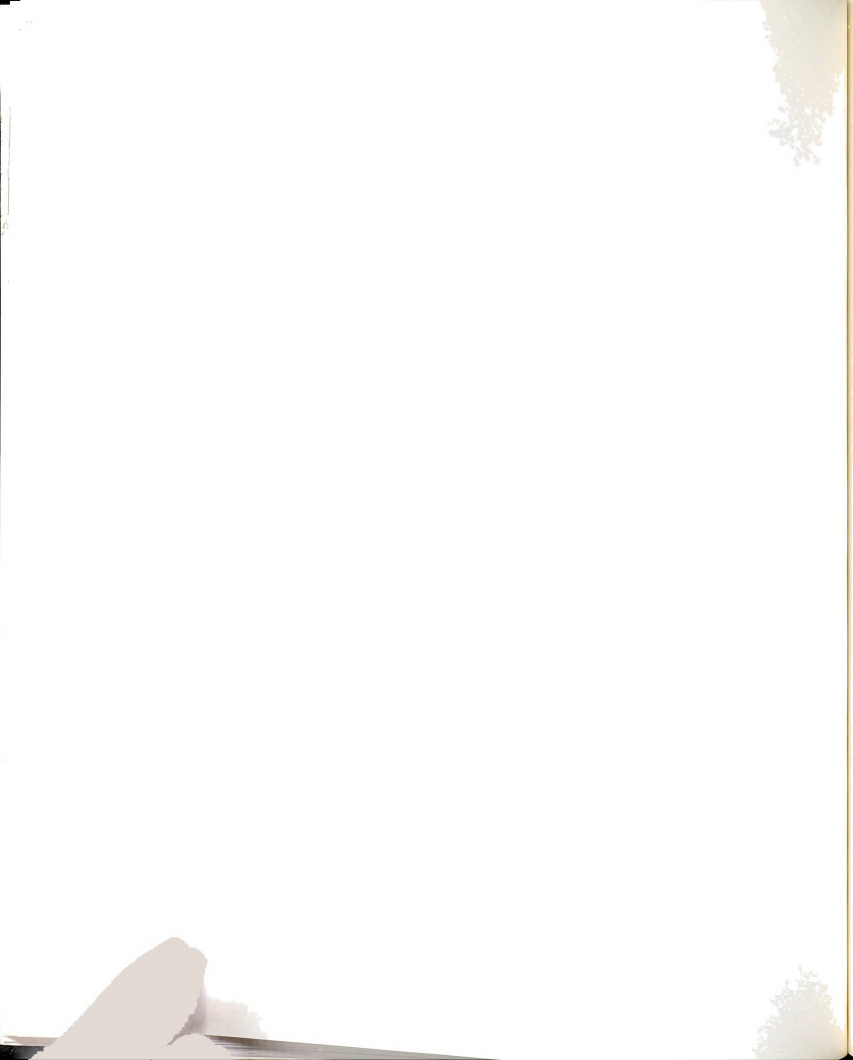


the university but whether it exceeds the portion of appropriable rents returned by the profit objective transfer firm remains unclear.

Similar arguments may be presented for the firm with self-interest or research interest or quantity maximization as part of the objective mix. The structural alternative which may lead to quantity maximization is again suggested as part of the university influence. In the case of agricultural research release mechanisms there may be pressure for quantity maximization in developing a new variety or technology.

It would be remiss not to include the possibility of consumer influence built into the structure of the firm. How their presence changes the mix of economic objectives is difficult to say. Their influence on performance may be similar to that of some other public influence. While the consumer's direct ties to the board may lead to inefficiencies capturing rents it is difficult to assume that they also lead to greater returns to the University. In the case of agriculture this can be done because of the perceived value of university research by farmers.

The structural alternatives for the economic objective of the transfer firm are simple in form but interact with other components of the framework. These alternatives are outlined in Figure 4.2 with their expected influence on performance measures given a positive or negative rating.



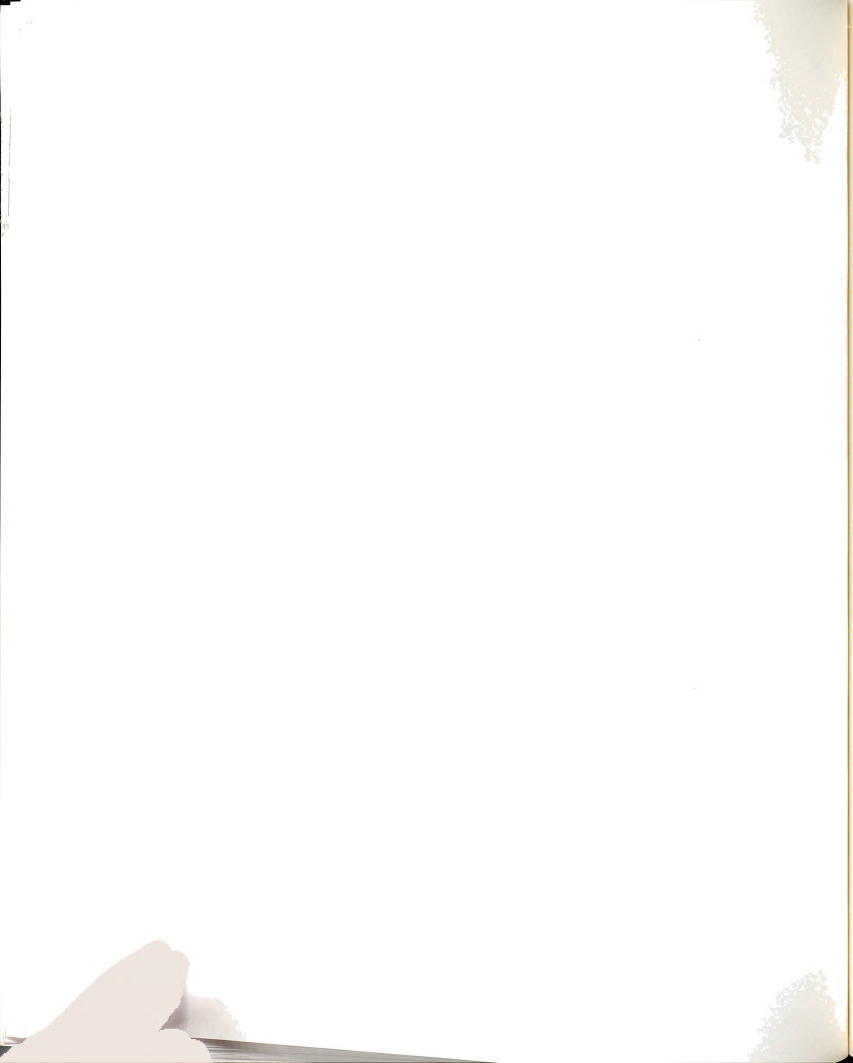
4.3.3 Property Ownership

Hypothesis 3: Public or university property ownership leads to inefficiencies capturing rents and detracts from direct returns to the university. The null hypothesis would be that there is no relationship between property ownership and the capture or return of rents.

This hypothesis is based primarily on principles of property rights. There are only two structural variables but a number of issues are involved. One variable is patent ownership and the other is licensing rights. However, the relevant question is what are the enforceable interests which are retained on a contractual basis. Secondly, when those interests are not contracted, which party retains the unprovided residuals. Patent ownership and licensing rights are discussed below.

Patent ownership may seem irrelevant when exclusive rights can be granted by the patent holder, in this case, the university to the licensee or the transfer firm. This is not necessarily true. Patent ownership gives control over change and exploitation and it has a certain symbolic value. Contractual arrangements can cover many aspects of current and future property rights but there is always an unanswered question regarding further development. In the case of interests which are not contracted, and there may always be some of these, when a new opportunity presents itself for a basic patent it is better to be the patent holder than not.

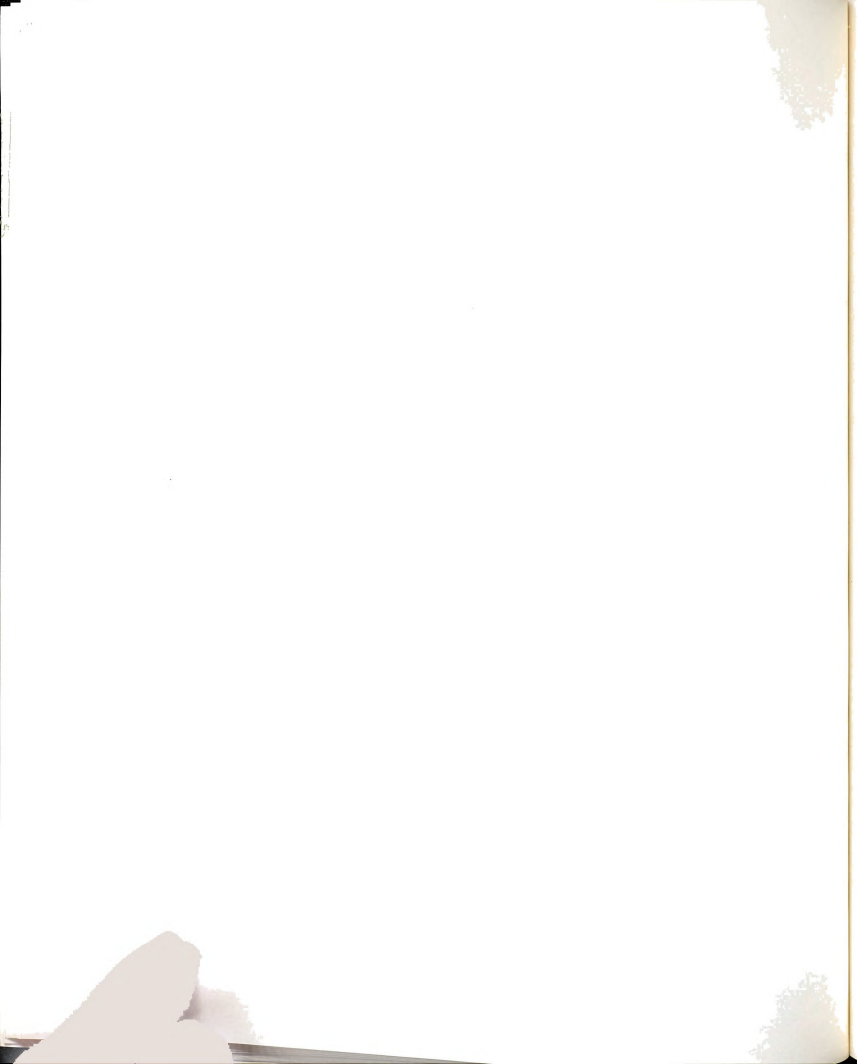
In general, universities have been unwilling to give up patent ownership. This has limited their relationships with some private



sector firms. Patent ownership remains an issue for two reasons; trust and self-interest. Patent ownership would not be a negotiating point if trust were absolute in the relationship between the university and the transfer firm (or if contracts could cover every possible eventuality). One concern of universities is that commercial development of university research remain dynamic. Giving up patent ownership leads to fears that this aspect of a technology transfer might be lost (Bredeck, 1987; Interview I results). Patent ownership would also not be a negotiating point if there were not some self-interest in holding the patent. There is a certain prestige in being a patent owner and in the case of faculty members the indirect benefits may be substantial.

In addition to the points of trust and self-interest, non-university patent ownership may allow rent appropriations and returns for certain types of structural relationships which might not exist without private patent ownership. Some forms of legal structure may require patent ownership for tax treatments in their financing obligations.

University patent ownership can, though not always, lead to inefficiencies in capturing rents by external transfer firms. Because it can lead to inefficiencies in capturing rents and because it remains a negotiating point between universities and firms, university patent ownership can also detract from returns to the university. On the other hand, universities which give up patent ownership, or other contractual incentives to develop, may find that the technology is being bought out by the transfer firm in order to



eliminate competition. In this case it leads to inefficiencies in capturing rents and detracts from returns to the university. These alternatives are complicated by other built-in controls which can act as development incentives.

The alternatives for licensing rights and their influence on performance measures is more straightforward than for patent ownership. These are basically exclusivity issues. The alternatives are based on the assumption of university patent ownership. The university may issue an exclusive license, a non-exclusive license, provide for a public agency license, or some combination of the three. Exclusive rights lead to more efficient capture of rents by the transfer firm and in some cases to the capture of monopoly profits. In accordance with this, the transfer firm that has been granted exclusive licensing rights by the university will have more rents available to bargain with for returns to the university, and other things being equal, will return a greater portion of appropriable rents to the university. Non-exclusive rights and public rights lead to less efficient capture of rents or an inability to capture monopoly profits. This outcome, in turn, tends to detract from returns to the university by a transfer firm unless other structural alternatives override this force.

The structural alternatives for patent ownership and licensing rights are simple in and of themselves but their effect on captured and returned rents is not always clear. This is because there is a whole package of enforceable rights which may be built into a contract that affect product development and firm performance. Some



of these other enforceable rights include the primary or secondary rights to police the patent and the right to rescind the license. These may be designed to influence performance of the transfer firm and put efficiencies into the capture and return of rents. Other rights which may be retained by the university are quality standards and the right to any future developments based on the technology represented in the original patent. While these may increase rents in the long run, their influence on the current case may be to introduce inefficiencies in the capture and return of rents.

The alternatives for patent ownership and licensing rights are outlined in Figure 4.2 with their expected influence on performance measures given a positive or negative rating. These effects are given barring alternative issues which may override the performance outcome.

4.3.4 Information Costs

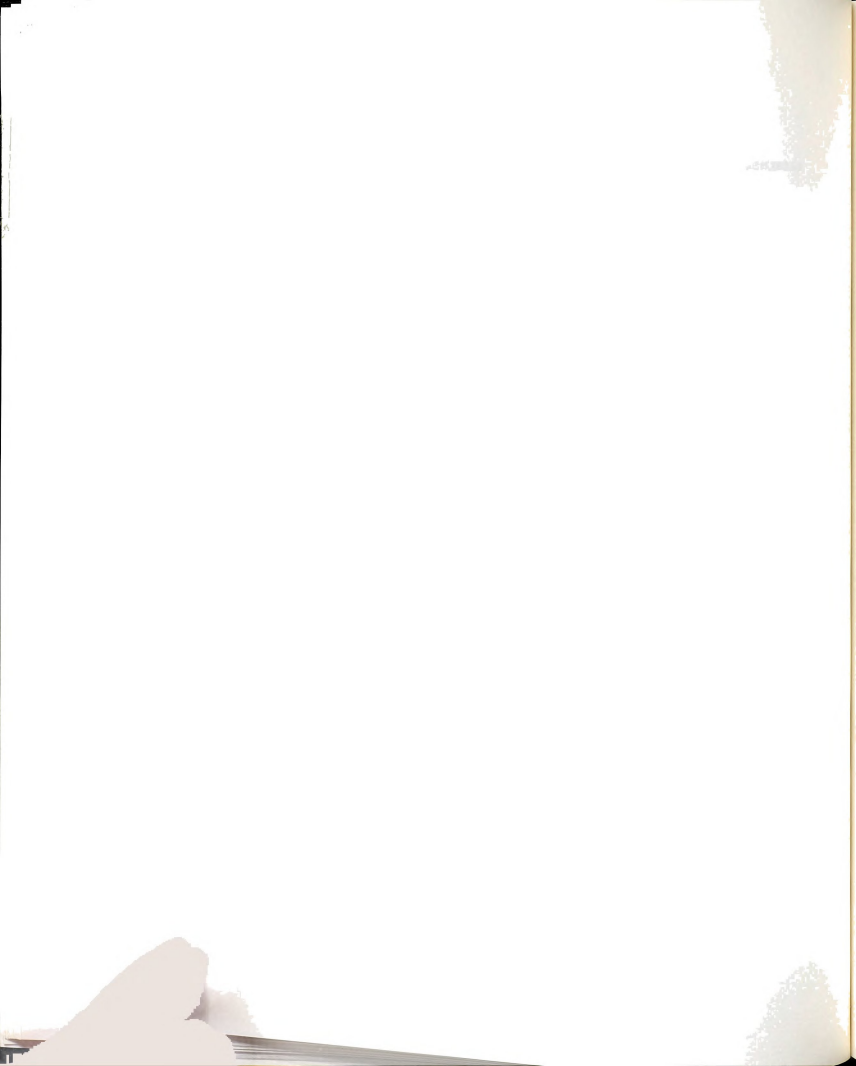
Hypothesis 4: Information costs borne by the university lead to more efficient capture of rents and enhance direct returns to the university. The null hypothesis would be that there is no relationship between information costs borne by the university and the capture or return of rents.

Two variables are selected from the framework to address the issue of information costs. One is the negotiated point of publication reviews and delays in a research contract between the university and a transfer firm. The other is the portion and type of marketing costs borne by the university in a product-development mechanism.



Publication delays negotiated by the university (internal or external) reduce exclusion costs by reducing the indirect information costs of the transfer firm and thereby lead to more efficient capture of rents. Indeed, publication delays are needed in order to insure patent protection and licensing through some transfer firms. With this outcome there is greater bargaining power by the university and more rent to bargain for from the transfer firm. This should lead to increased returns to the university. Publication delays appear to be so prevalent, either in contracts or by choice, that there may be no variation across transfer firms.

Marketing costs can be absorbed by the university in two ways that are easily accounted for. Extension support and use of the university name are primary alternatives for the university to bear some portion of marketing costs, and in most cases, enhance marketing potential. These alternatives generally lend credence to a product which allows rents to be captured more easily. They also reduce information costs of the transfer firm and stand as a bargaining point which should lead to a greater portion of rents being returned to the university. In part, this may be a function of the difference in the length of the testing program. Public testing may be longer, reflecting a less risk-prone, quality-asserting administration, while private testing may be shorter, reflecting a more risk-prone, profit-seeking administration (Stallman, 1986). This difference may also reflect time allocation differences between the public and private researchers. While use of the university name has certain liabilities attached to it in



research commercialization there may be no comparison to the potential benefits derived by both the institution and the faculty.

One caution suggested by Schmid is that if the use of the university name becomes too common, or revenue-maximization behavior by the university becomes part of public perception, the value of the name in development activities may subsequently be discounted. The counter argument to this simply presents the case of the Massachusetts Institute of Technology (MIT) where a large part of its academic structure is based on research commercialization and the reputation and name is only enhanced.

The structural alternatives for these two information cost variables are extremely important in policy decisions. Publication delays and use of the university name in markets are anathema to some academics. However, they afford greater opportunity to enhance the university-industry relationship and, in the latter case, to increase indirect rewards to the university. These alternatives are outlined in Figure 4.2 with their expected influence on performance measures given a positive or negative rating.

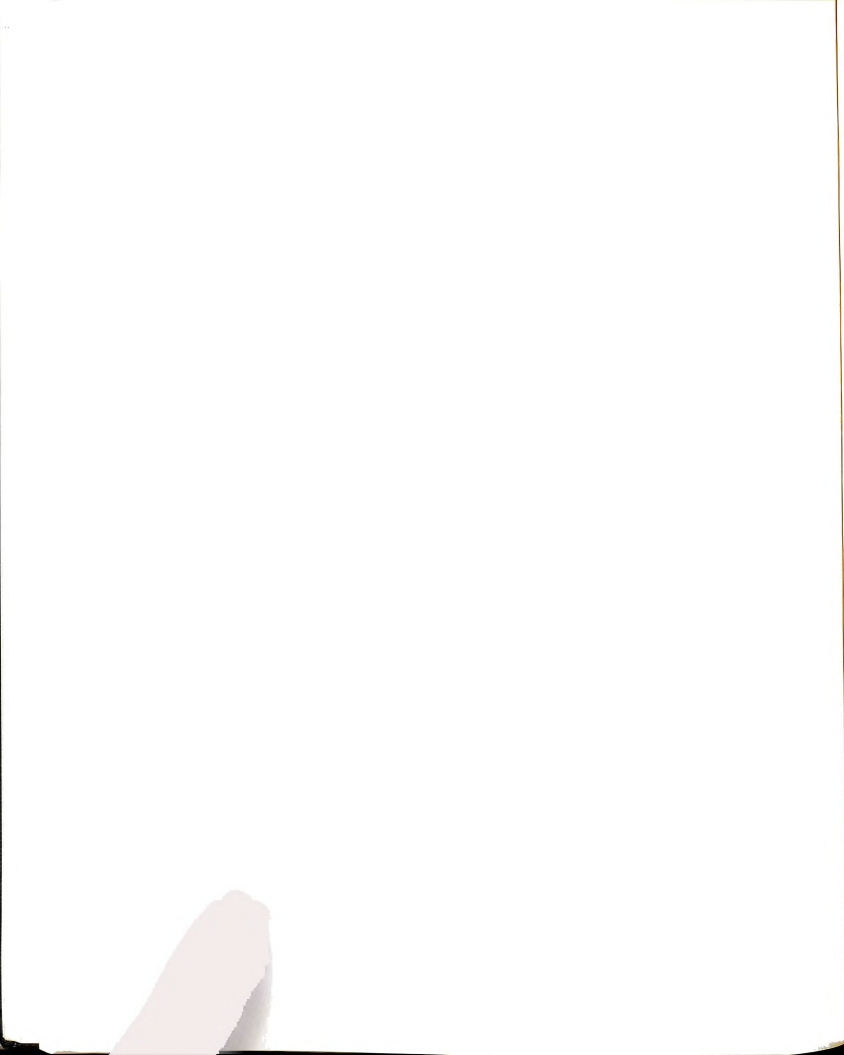
4.3.5 Investment Costs

Hypothesis 5: Investment costs, administrative costs, and exclusion costs borne by the transfer firm can lead to more efficient capture of rents and detract from direct returns to the university. The null hypothesis would be that there is no relationship between the costs borne by the transfer firm and the capture or return of rents.



Investment costs, administrative costs, and exclusion costs differ from the treatment of information costs. Any increase in firm costs may be borne out in one of two ways. It may be borne out in pricing and hence in increased captured rents or it may be borne out in bargaining and hence in decreased returns to the university. Who pays what portion of costs and how this division is treated by the firm in its pricing decision is a question which is beyond the scope of this study.

Several questions may be considered. As universities attempt to recover a greater portion of development costs through licensing will firms begin to look at university costs as part of total product development costs and price accordingly? Do firms treat royalties as a cost or as a share of profits? If a profit-maximizing firm treats them as a cost then it will attempt to minimize them. On the other hand if a profit-maximizing firm cannot treat them as a cost (say through tax structures) then there may be some alternative approach to profit-sharing. A third consideration is the aspect of cost sharing within the institution. In a university, the ability to develop one research project across disciplines may be curtailed when there are dollars or patents at stake. Researchers may be less likely to engage in interdisciplinary research spending their time and resources on a project which may result in a patent and monetary gain for their counterpart in a different department. As stated above, the complexity of cost sharing and the incentives they evoke, only three of which have been suggested, are beyond the scope of this study.



Investment costs of the firm may be any research or development costs the firm incurs once the invention leaves the university. Administrative costs may be any costs for the support of an infrastructure used in the commercialization process. Overhead payments on returns to the university may be required for pre- or post-commercialization contracts. They may also be required for lump-sum payments to the university for commercialization. Patent fees, policing costs, and licensing fees may also be costs borne by the firm during the development process.

It is important to recognize that all of the alternatives presented here for these three variables may not be variable costs of production to the transfer firm. One example alternative that is not a variable cost issue is basic research costs borne by the transfer firm. For the purposes of this study it is assumed that the profit-maximizing transfer firm does attempt to recover at least some portion of sunk costs in its pricing and capture of rents during commercialization.

The actual structural alternatives for investment costs, administrative costs, and exclusion costs are fairly straightforward. These alternatives are listed in Figure 4.2 with their expected influence on performance measures given a positive or negative rating.

4.4 Expected Outcome for Selected Institutions

The alternatives selected in Section 4.3 were compiled and listed in Figure 4.2. The expected outcome for each alternative may

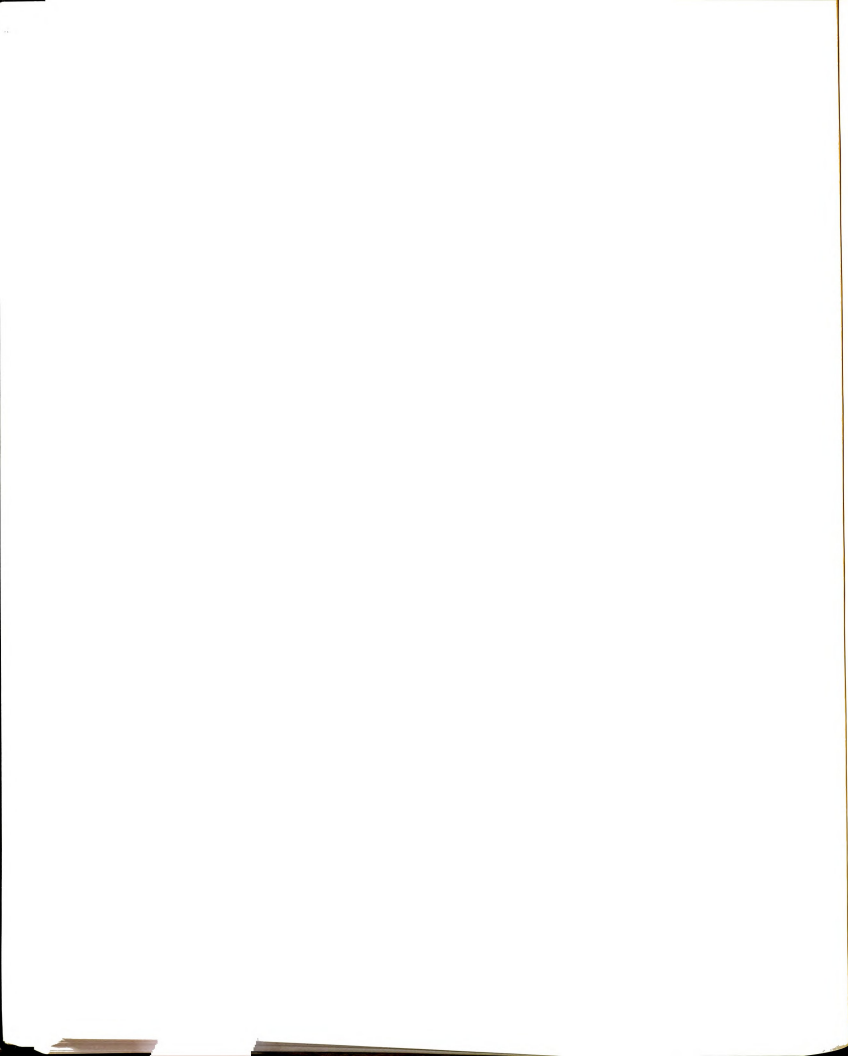
be carried over to facilitate comparison of institutions. This is useful for anticipating differences in performance by firms which have different structural characteristics.

Ten mechanisms that were identified at Michigan State University are discussed in this section. Relevant alternatives can be considered and the expected outcome with respect to performance measures can be suggested.

4.4.1 University Facilities

University facilities are primarily teaching and research facilities of University departments. Their products can be considered as both University research going to commercial products and University production from research going to private markets. In either case they may be treated the same; sold to the highest bidder in normal markets with receipts returned to the facility through a department revolving account.

Public funds and directorates would imply inefficient capture of rents. Quality objectives might also lead to inefficient capture of rents. However, several factors might override these negative trends. Because the University operations are an integral part of market user groups, in part through extension and association with the University name, and in part because of the close association between University personnel and user groups, there may be a natural capture of market price plus a premium for use of the University name.



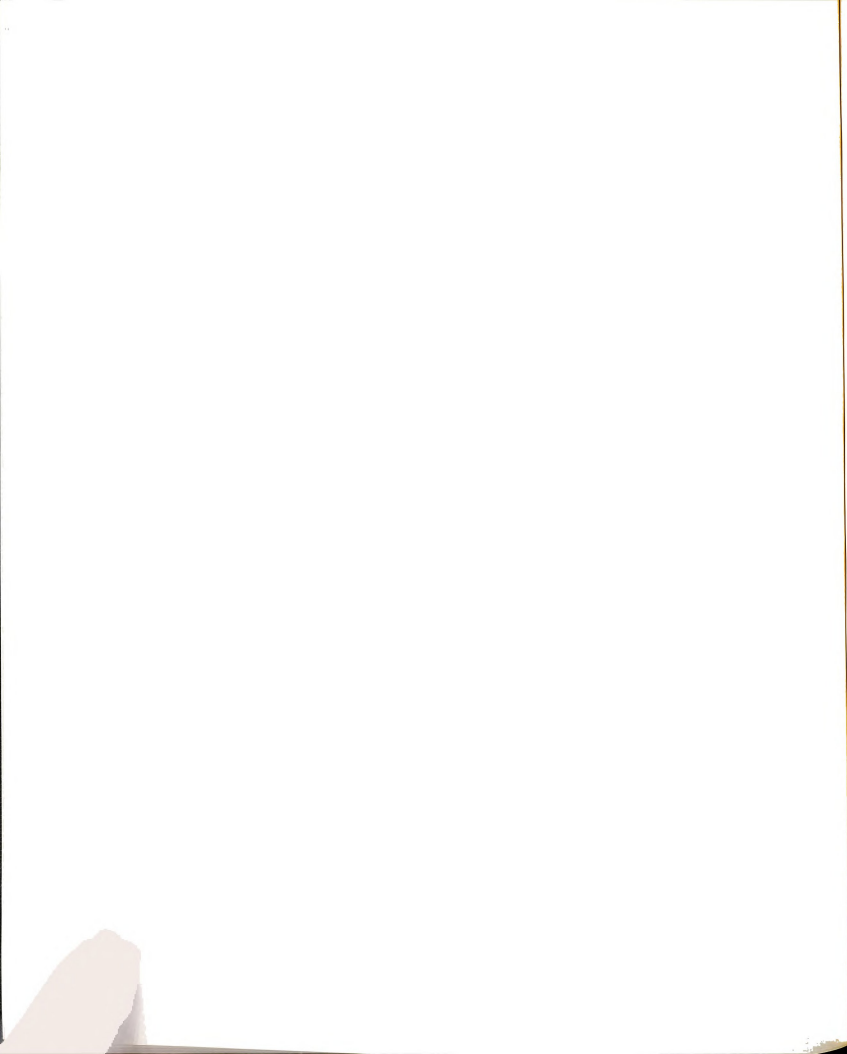
The facilities are internal operations to the University and there is a correction to the expected influence of investment costs on returned rents. In this case there may be a positive effect due to the source of products and the direct flow of funds. The structural alternative of revolving accounts presents no blockage for the return of rents and may be (I think) unusual for this scale of operation. Why other productive activities by University personnel are not given this favor is unknown.

It appears that the unique structural advantages of certain University facilities may make them remarkably efficient in capturing and returning rents to the University on a percentage basis. If true, can their structure be applied to other areas of University research commercialization?

4.4.2 Faculty Owned Companies

Faculty owned companies that are related to faculty member's scientific interests are often established in order to assure quality objectives in transferring technology. Their products can be considered a direct continuation of university work or an associated concept of University work. The faculty member is limited to five percent ownership only if the company does business with the University and even this policy can be bypassed when appropriate arrangements are established.

It is expected that the effect on performance of complete private financing will conflict with the nature of the public directorate and the probable quality and self-interest objectives.



Since patent ownership, licensing rights, and publication delays are now a choice of the faculty member-owner and not a bargaining issue with the University, they will remain as efficiency points in capturing rents but will not be effective in enhancing the return of captured rents to the University. The remainder of the costs as paid by the faculty-owned firm are incentives to capture rent but disincentives to return rents to the University.

There are two questions which stand out. One is whether the quality objective and public interest effect on the capture of rents outweighs the positive effects of the other alternatives and there is inefficient pricing. The other is whether the quality and self-interest objectives effect on the return of rents outweighs the negative effects of the other alternatives and there is greater than expected returns to the University. This latter point is in part enhanced by the faculty member's intertwined interest in supporting both his or her business and his research at the University which, in turn, supports his or her business.

4.4.3 University-financed Centers for Commercialization

The University-financed center for commercialization at Michigan State University is financed in part by the MSU Foundation. In addition there is potential equity ownership by contracting faculty. There is also public involvement by University faculty on the scientific advisory board. However, the dominant force is private financing through limited partnerships and other financial instruments. This fits in with the profit objective of the firm. It

is expected that these alternatives direct the firm to be efficient in capturing rents and inefficient in returning them to the University.

Patent ownership by the transfer firm for research funded at the University is unusual. The University apparently justifies this breach of policy by claiming that University equity in the firm through the Foundation gives it similar status as University ownership of the patent. Loss of control over development and future improvements might indicate otherwise. The transfer firm apparently justifies this demand by using limited partnerships which require patent ownership for investor tax purposes. The effect on performance may increase the capture of rents through control and self-interest and increase returns of rent through the bargaining position of the University.

Licensing rights are generally exclusive as is to be expected with the profit-making firm that controls technology transfer. Publication delays are granted through contracts and this should enhance both the capture of rents and the return of rents to the University.

Investment costs, administrative costs, and exclusion costs are paid in part by the transfer firm and while these may increase the capture of rents they may decrease the return of rents to the University.

The question that stands out about this mechanism is whether the University can use its investment and patent bargaining chips to overcome the effects of the profit objective and costs absorbed by

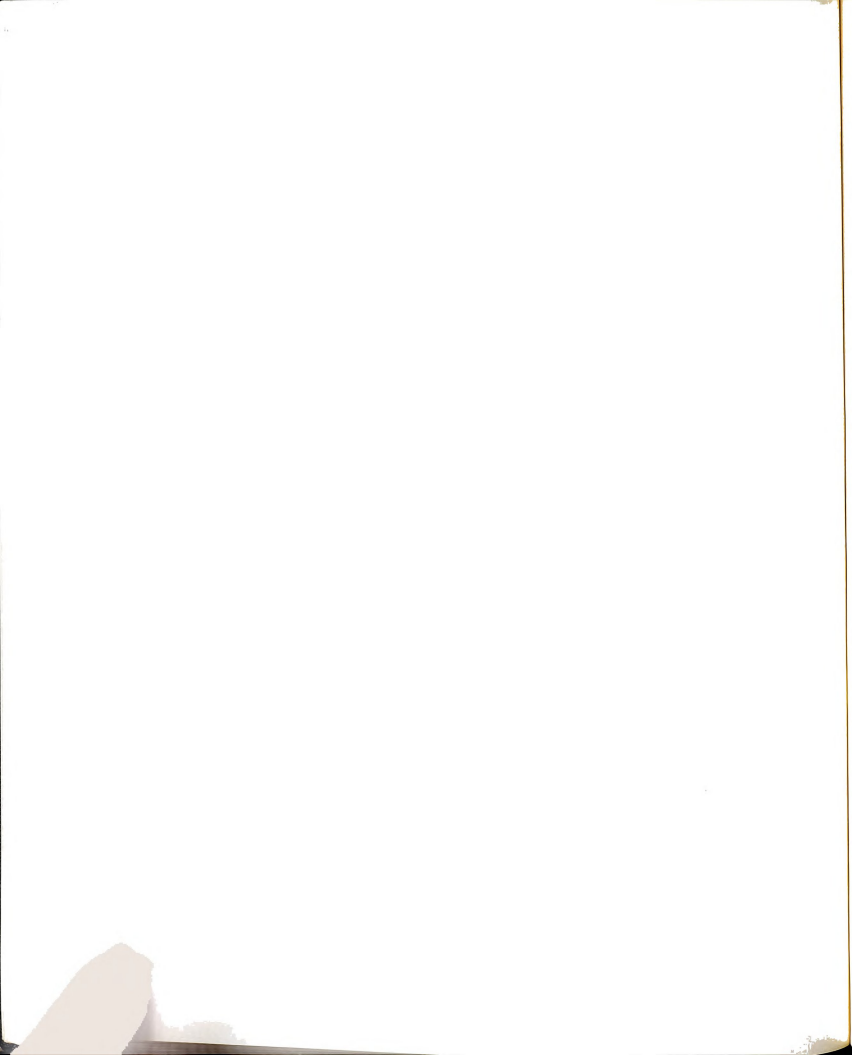
the transfer firm on returns to the University. Another question is whether the added administrative layers detracts from potential research resources for the University.

4.4.4 State-financed Centers for Commercialization

It is clear that there are many more public influences at the State-financed center for commercialization than there are at the University financed center. In Michigan, substantial State start-up funds, University donation of land, and federal research grants make such a firm indebted to the public interest. In addition, the University president is on the board, the chief executive officer is a professor at Michigan State University and has a background in academia, and there are university faculty members on the science advisory board and in key positions at the firm. A large portion of its employees are currently employed by, or enrolled at, a university. Private foundation funds also aided in the start-up costs but this is not the same as a private investment.

While the economic objectives of the firm are less than clear, it is safe to consider the State-financed commercialization center as a non-profit group with a profit objective. Two reasons support this choice. It is determined to be self-supporting by a target date, and its mission is to aid economic development in the State.

Depending on investment costs absorbed by the firm, patent ownership may be retained by the University or retained by the firm. Licensing follows from either path. For the University to gain by returns of captured rent it must commit to project resources. Most



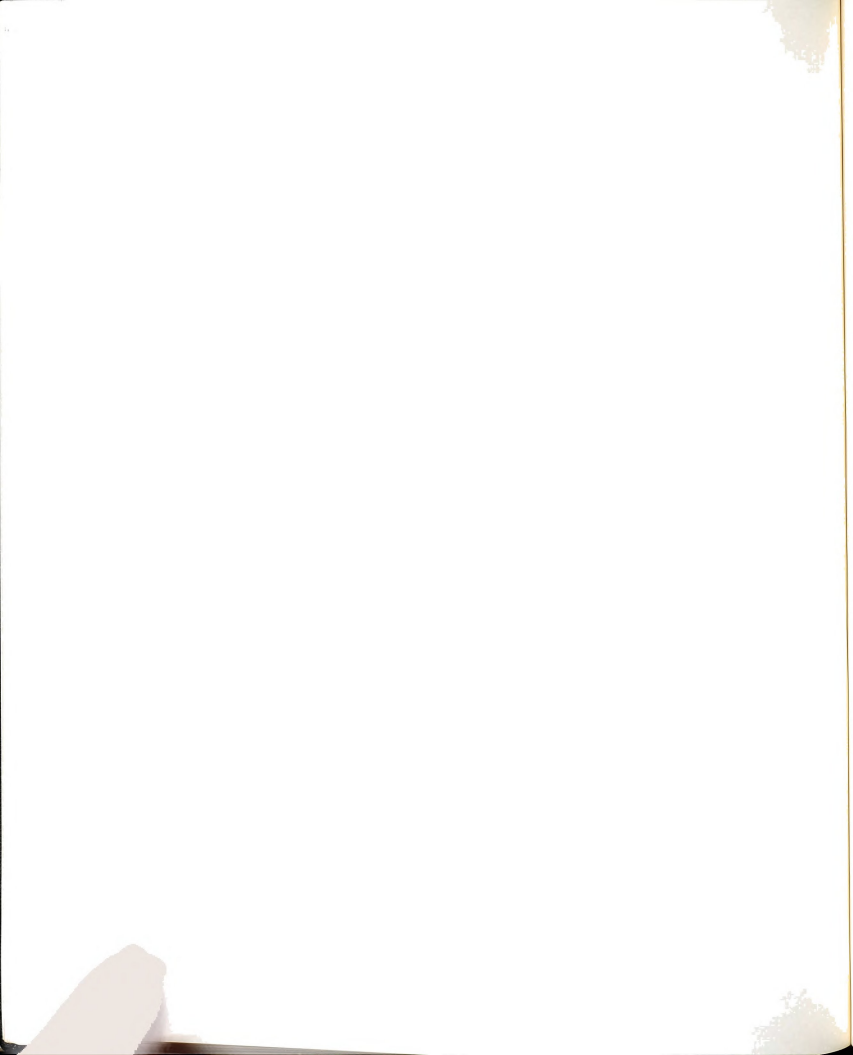
investment costs, administrative costs, and exclusion costs are paid by the firm.

Two questions surface given this set of structural alternatives. One is whether the profit objectives and firm mission, along with the choice to pay most costs, overrides the strong public interest in the firm in capturing rents more efficiently and returning less of those rents to the University. The other is whether the tradeoff between University participation in a project and the return of rents to the University is clear, and is there some point in the future where arbitration will be necessary?

The suggested performance is that the State-financed commercialization center is less efficient at capturing rents but may return more rents to the University than the University-financed commercialization center primarily because of its stronger public interests in both financing and controls.

4.4.5 Privately Financed Centers for Commercialization

A privately financed center for commercialization has contracts with Michigan State University for research and development in specified areas. No public funds and no source of public controls (identified at this time) would imply that capture of rents is efficient and that return of rents to the University is limited. Coverage of some portion of investment costs, administrative costs, and exclusion costs by the transfer firm further supports this position.



Exclusive rights and publication delays also promote capture of rents by the firm but serve to temper the negative trend on returns. Patent ownership is retained by the University. This may not be a strong downward force on the capture of rents but it adds to the negative trend on returns.

What might be expected is that a privately financed center is more efficient at capturing rents and less likely to return rents to the University than a University-financed center which is, in turn, more efficient at capturing rents and less likely to return rents to the University than a state-financed center.

4.4.6 Internal Third-party Brokerage Units

The internal third-party brokerage unit at Michigan State University is The Industrial Development Institute. It is a sister organization to the Technology Transfer Center. These institutes have targeted clientele in Michigan and only a small part of the Industrial Development Institute mission is to act as a brokerage unit or aid in start-ups.

Any technology transfer the Institute engages in goes through the University. In that sense the structural alternatives of University licensing apply. Does the brokerage unit introduce any inefficiencies to the system through its structural alternatives or otherwise? Not really. While it serves as an additional vertical step in the University it may be a step that has been missing. The Institutes begin to approach the external communication needs of the University. They may increase the number of university-industry

interactions but their structure does not seem to change the performance of University licensing or start-up firms.

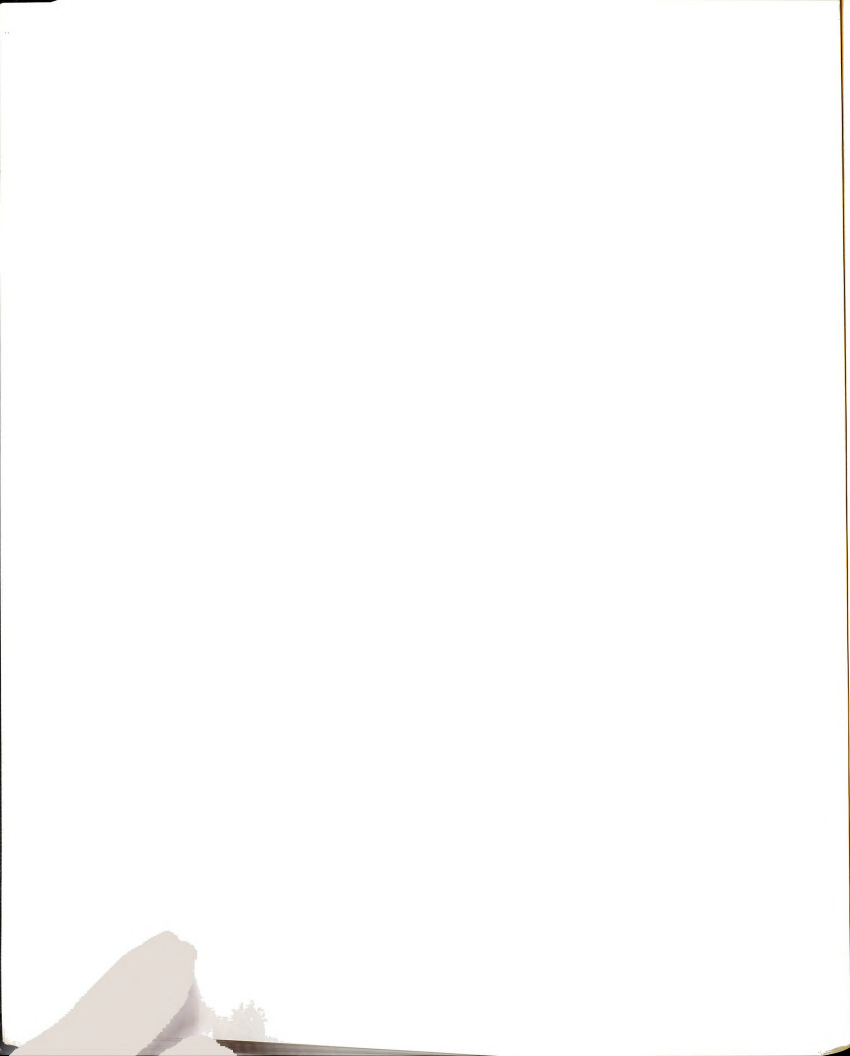
4.4.7 External Third-party Brokerage Units

Two external third-party brokerage units demonstrate the variability that can exist with this type of transfer mechanism. One is a national generalized brokerage unit and the other is a local sector-specific brokerage unit.

The general type of external brokerage unit will have many similarities to direct university licensing with two important exceptions. They are driven by private funding and they must support an administrative budget through revenues generated by successful licenses. These alternatives would imply that technology transfer through this mechanism may result in less rent being returned to the University. Because they are not the transfer firm doing the actual pricing it is not clear that they have an influence on the capture of rents.

General university brokerage units offer the University private sector commercialization expertise in a broad array of fields which a fledgling internal brokerage unit could not have. At what point does it pay for the University to internalize this process?

The specialized brokerage unit is closely tied to the University through start-up finances, administrative controls, quality objectives, and close association with the University. The first three points lead to inefficient capture of rents while the marketing



issue may allow them to capture a costless premium as in the University facilities.

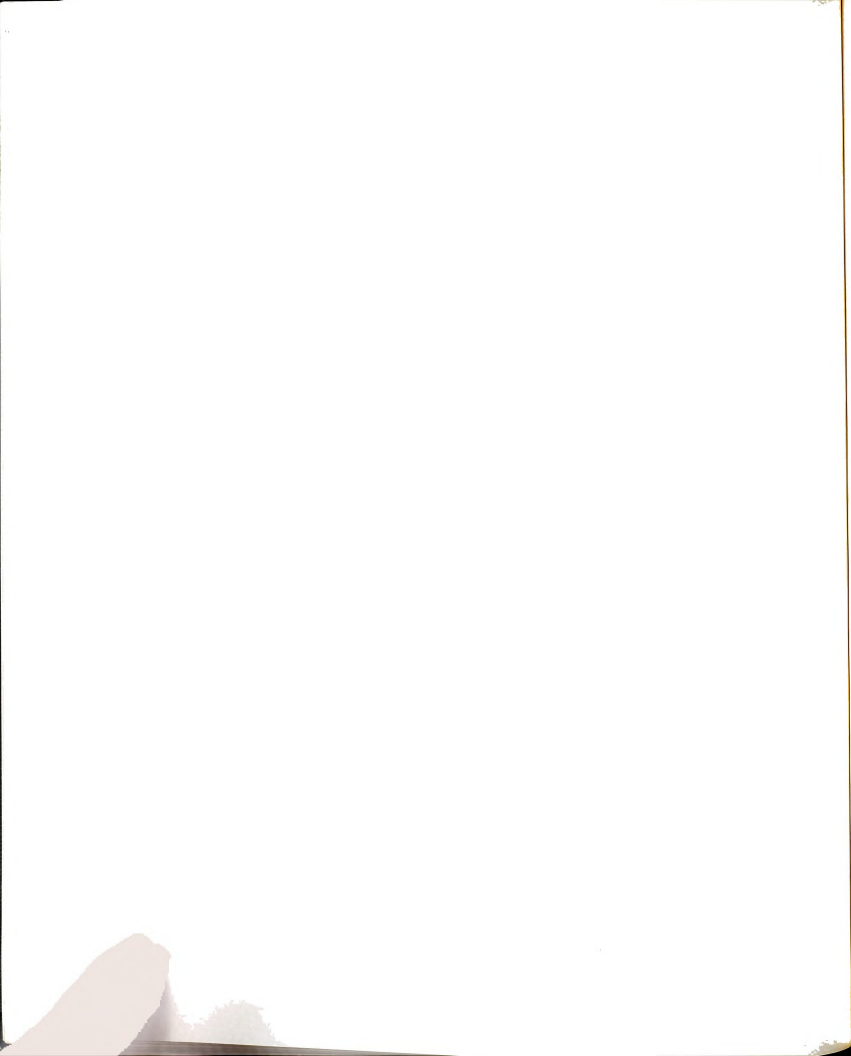
Patents may be controlled by the University when dealing with brokerage units and a variety of distribution patterns with respect to property rights are found. No effect can be stated without dissecting these alternatives thoroughly. The effects of these alternatives are internal and selected with input from the researchers.

A separate administrative budget, current private financing, and the responsibility for high exclusion costs in certain cases would imply that the firm may capture rent more efficiently and return less of it to the University.

Two questions stand out. One is whether the quality objective and public controls overcome the private nature and marketing advantage of a local brokerage unit and result in a negative impact on captured rents. The other is whether the public influence, the marketing advantage, and the application of direct gifts to the University, not unlike that of University facilities, overcomes the private nature and strong quality objectives of the firm and leads to greater returns to the University.

4.4.8 Faculty Initiated Companies

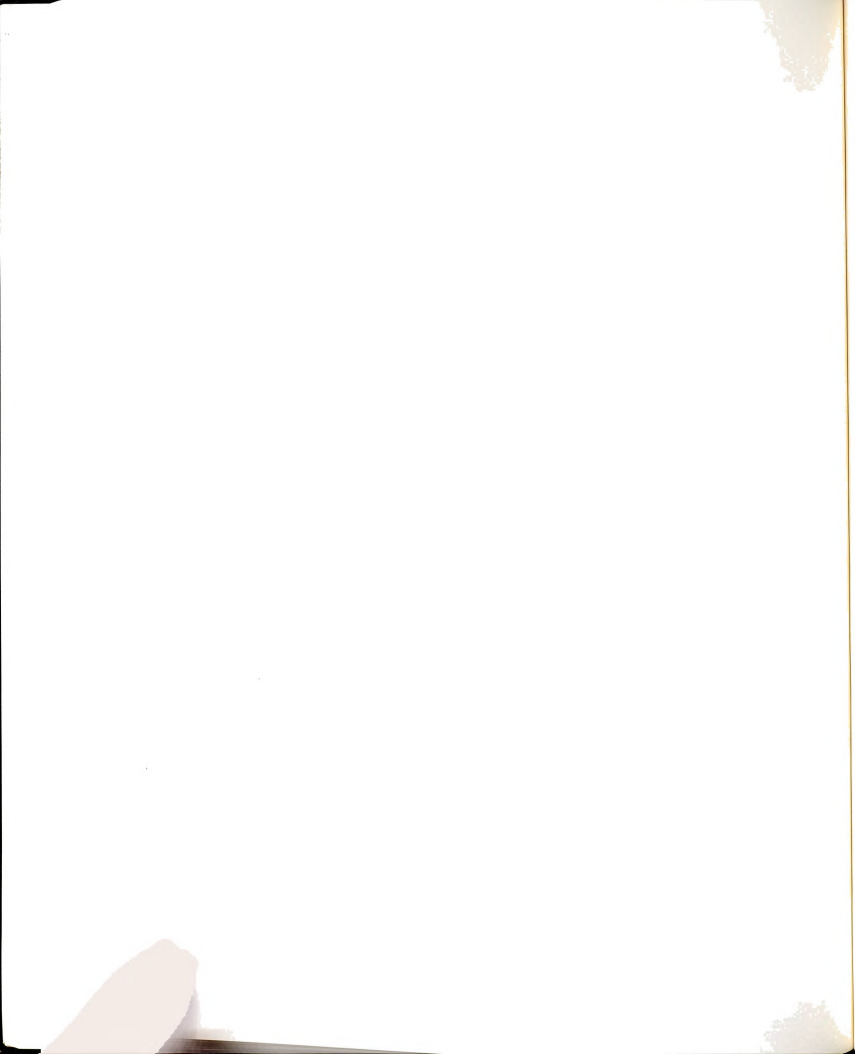
Faculty initiated companies, as differentiated from faculty owned companies in this study, are located both in a research park complex and isolated from the University. They have little structural difference and are treated similarly here.



Even though faculty funding may help initiate a firm, the primary funding of this type of mechanism is from private sources. The economic objective of the faculty initiated firm is profit, but there are, no doubt, some quality issues involved. In addition, the science advisory board or board of trustees may have University representation but this probably stops short of executive positions. The outcome with respect to performance for these alternatives is expected to favor the capture of rents and detract from the return of rents to the University. In other words, it is expected that the funding and profit objective will dominate in their effect on performance.

The remainder of the variables demonstrate too much flexibility to work with at this time. Faculty that initiate firms may maintain research programs both at the firm and on campus. The campus research may be, in part, funded by the firm. Where the research is done and who funds it determines patent ownership, licensing outcomes, and exclusion cost responsibility. Such firms may have inventions which are initially licensed through the University but it is probably safe to say the day will soon come when they patent inventions completed in their own labs. This presents a similar question as with the State-financed commercialization center: At what point does the tradeoff between firm sponsorship and university ownership get broken in these "duality" mechanisms and is there some point in the future where arbitration will be applied.

It is expected that the faculty initiated firms will be nearly as efficient as unattached private firms in capturing rents but will



tend to return a greater portion of rents because of university controls and economic objectives. Final questions relevant to this type of mechanism is how much effect does faculty control have on the performance of the firm and is there an adequate structural alternative to circumvent the five percent University policy level of ownership when appropriate.

4.4.9 University-based Centers for Industrial Interaction

As in the case with internal brokerage units, any technology transfer from a University-based center for industrial interaction will go through the University and thus have similar structural characteristics as general University licensing. Examples include the Center for Materials Research and the Food Industry Institute. In some ways these might be considered specific internal brokerage units. Are there any structural qualities which could further affect performance? There is one but it is not part of the current framework.

Hypothesis 1 implies that a public directorate would detract from captured rents but enhance the return of rents to the University. How does the existence of a center for research and its director differ from the negotiating faculty member or the internal brokerage unit in having an effect on performance. It is suggested that the director of such a center, while fulfilling an important communication function may be adding a layer to the public controls but retaining a private influence. He is responsible for maintaining a limited multi-client relationship, and unlike the faculty member or

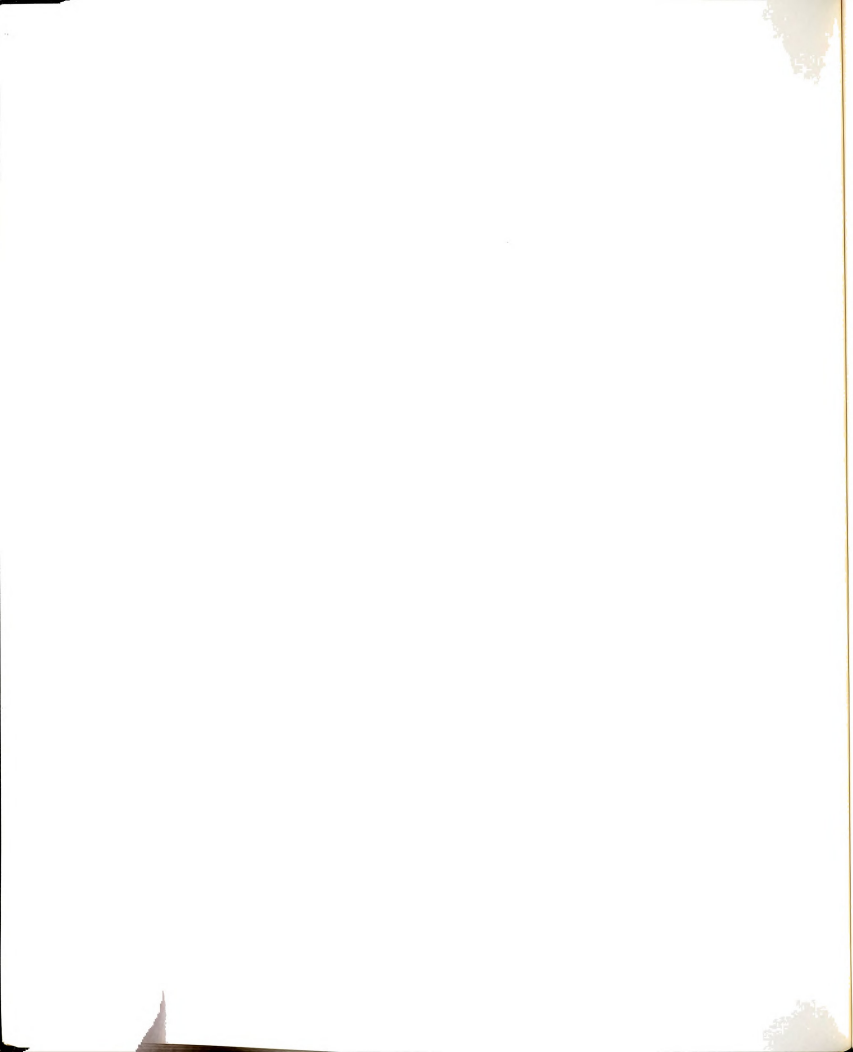
the brokerage unit, he must maintain a base of political and financial support from these clients. These factors detract from his bargaining powers when negotiating licensing arrangements. This consideration lies outside the study but may prove important to consider for future ties.

The above issue suggests that while centers for research may attract more dollars in total, when there is an actual technology transfer the limited scope of the clientele may restrict the pricing and capture of rents, or restrict the portion of captured rents that are returned to the University, more than a general internal brokerage unit. In thinking about this it is important to remember that these suggestions are made on a percentage basis. If this concept is accurate, what is the point of tradeoff between greater total returns and greater returns on a smaller sum, and should those institutions engaging in the relatively new consortium research activities consider this problem?

4.4.10 University Licensing

The licensing of University inventions is primarily through exclusive licenses to private firms. The effect on performance by private/public licenses and public agency rights is not discussed here.

For the most part, University licensing to private firms is expected to result in efficient capture of rents by the transfer firm but unattractive returns to the University. It is expected that these firms will capture a greater portion of rents than those with

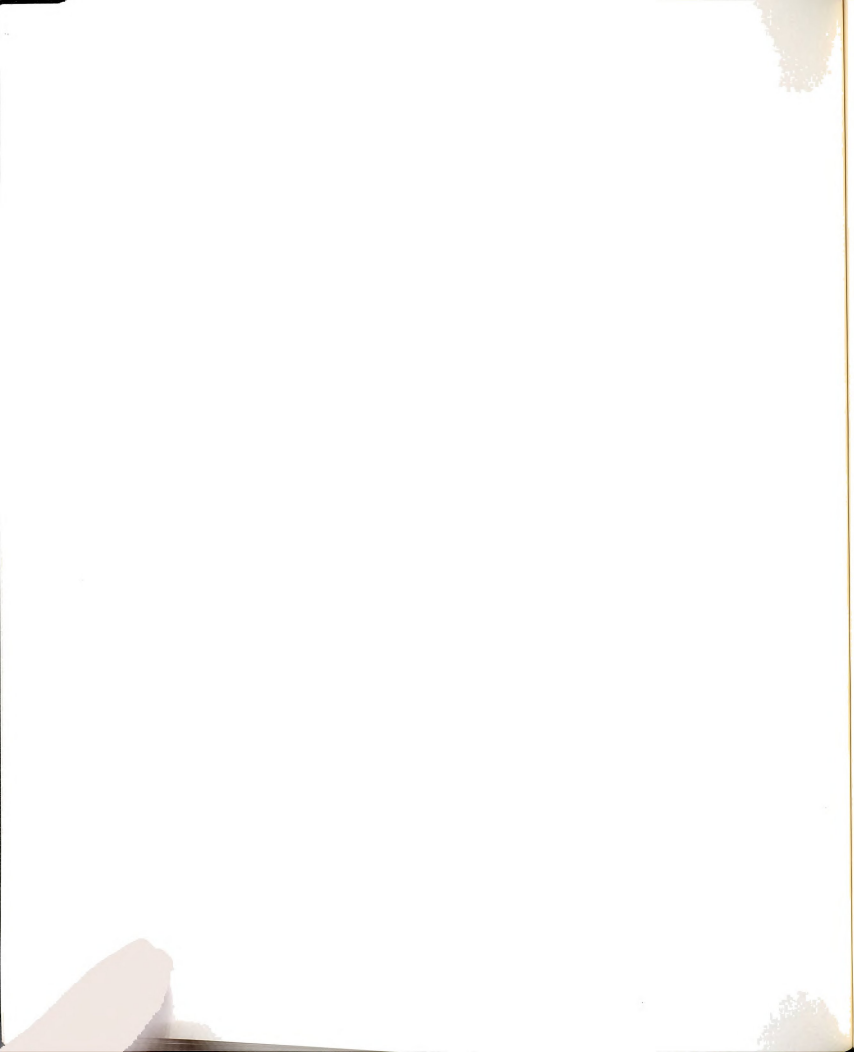


public controls (firms or centers of commercialization) but return a smaller portion of those rents to the University. This outcome may be due to, or dependent upon, three factors. One is the lack of public controls on the transfer firm which are present in so many of the other transfer firms. Another is based on the number of costs absorbed by the University which then serve as bargaining chips in any negotiations. A third is that patent ownership may be more of an issue than we understand when university researchers are not involved with the transfer firm.

Given that the University will not get public controls into private firms and that this will remain an important institution for research commercialization, are there some suggested alternatives that can be put in place to enhance either the capture of rents by the transfer firm or the return of rents to the University? The framework suggests three: Patent ownership, administrative costs, and marketing costs.

4.4.11 Summary of Expected Outcomes for Selected Institutions

The expected outcomes for the ten institutions discussed above are not numerically ranked. If the structural alternatives could be given numerical values with respect to their influence on performance then the institutions could be ranked with respect to their performance. Since there are no rankings for structural alternatives, only suggested orderings can be made.



It was reasoned earlier that the three centers for commercialization had the following decreasing order of capturing rents and increasing order of returning rents to the university:

- Privately financed center for commercialization
- University-financed center for commercialization
- State-financed center for commercialization

It was reasoned earlier that four University-based licensing units had the following equal or decreasing order of capturing rents and equal or decreasing order of returning rents to the University:

- University licensing
- Internal third-party brokerage unit
- External third-party brokerage unit
- University-based centers for industrial interaction

It was reasoned earlier that faculty involved companies had the following decreasing order of capturing rents and equal or increasing order of returning rents to the University:

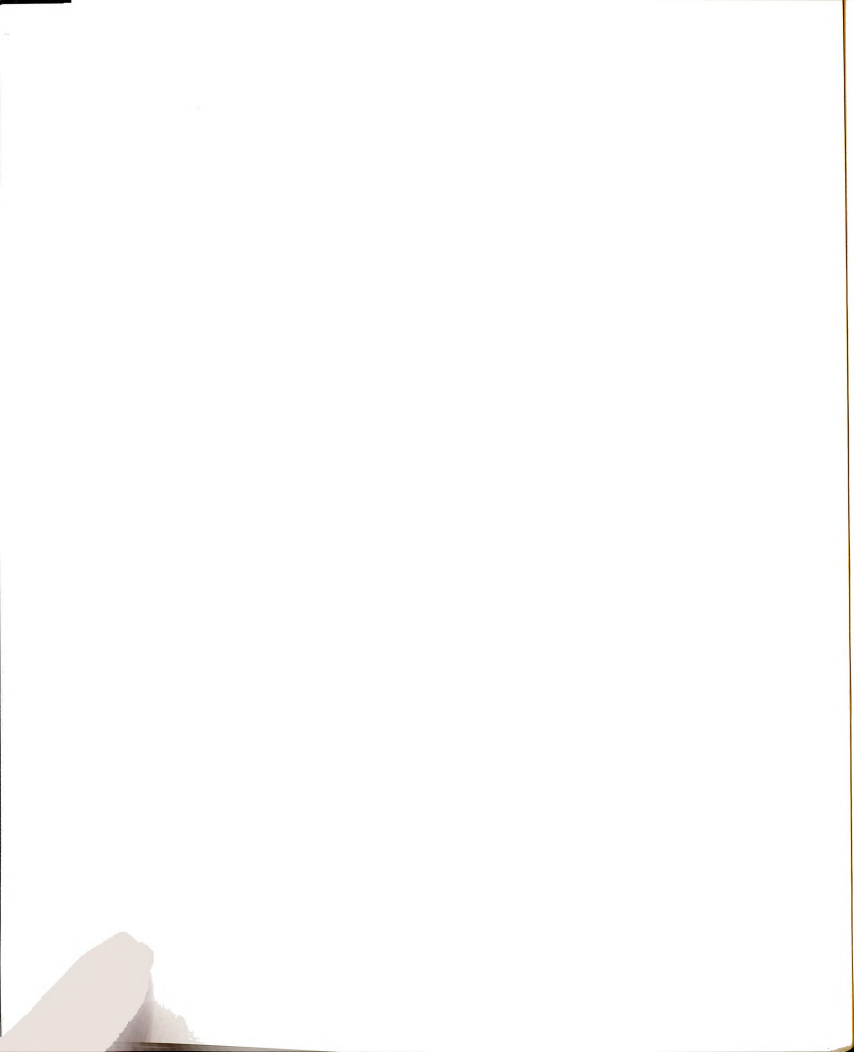
- Faculty initiated companies
- Faculty owned companies

It was reasoned earlier that two closely associated institutions, University facilities and local brokerage units, would have the following equal or decreasing capture of rents and decreasing return of rents to the University:

- University facilities
- Local brokerage unit

These four groups of institutions have structural characteristics which lead to expected performance differences within the groups but do they also lead to expected differences between the groups? Some suggestions can be made.

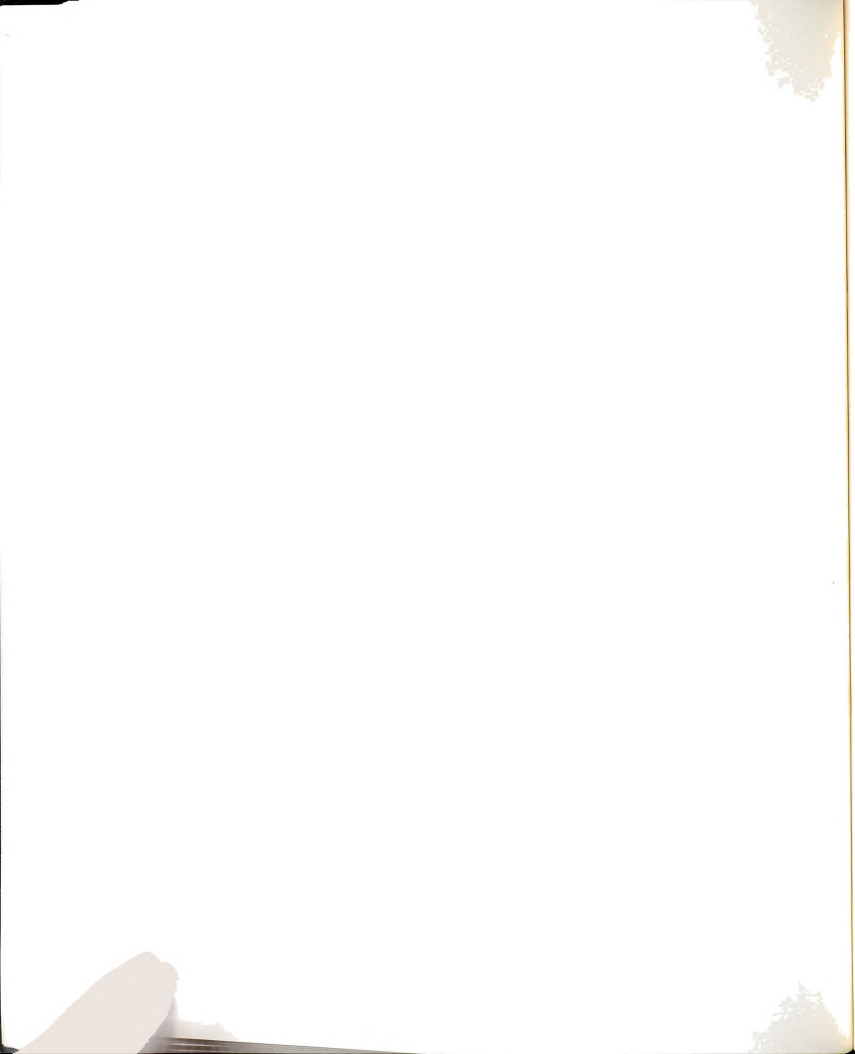
It can be reasoned that the three groups which are not centers for commercialization would have the following decreasing or equal



capture of rents and increasing return of rents to the University:

- University licensing group
- Faculty involved group
- Closely associated group

The one exception may be the premium afforded to University facilities and the local brokerage unit through use of the University name which might result in capturing more rent than expected.



CHAPTER 5

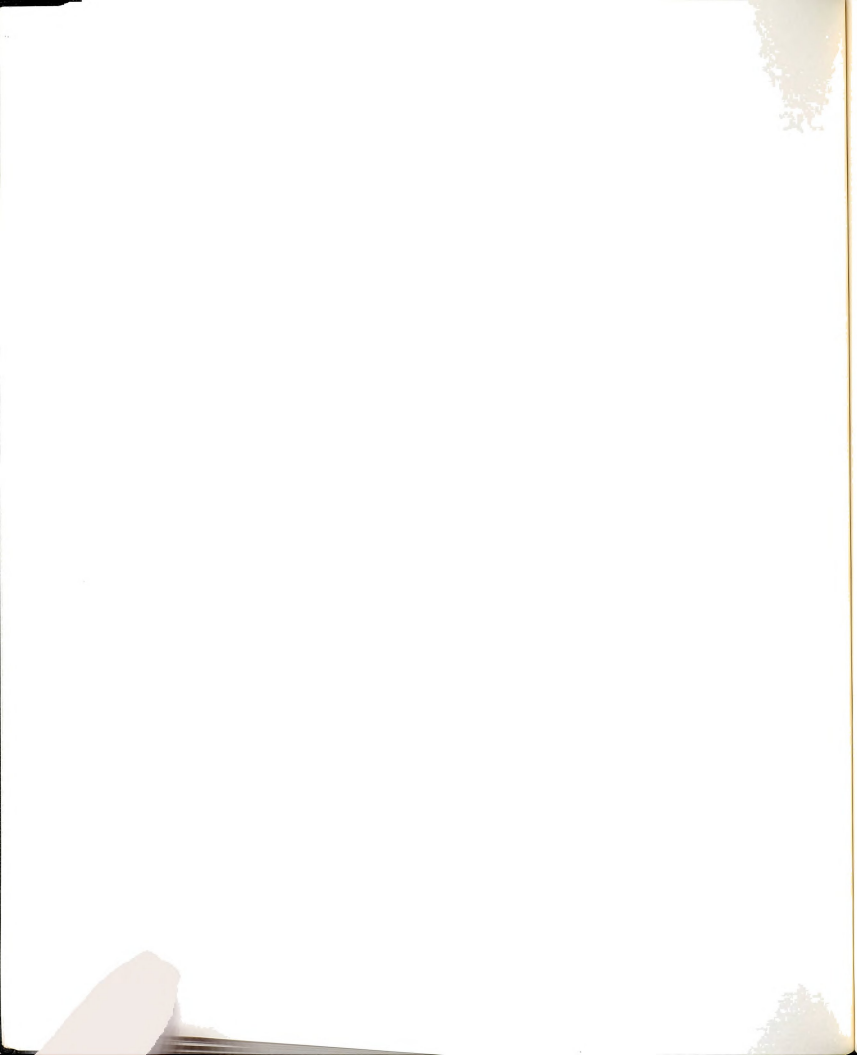
METHODS: DATA AND PROCEDURES

5.1 Data

Data suitable for a study of this nature are difficult to obtain for three reasons: 1) Many universities maintain centralized records for patents and licensing arrangements but not for those alternative mechanisms which transfer research products to the private sector; 2) Some of the contractual and financial information which does exist is maintained as proprietary and non-public; and 3) Estimates of the cost savings of an invention are neither standardized, nor in many cases, obvious to the inventor or producer.

Utilization of national data has certain advantages. These include a wide range of variability, broadly applicable results, and a larger audience. They also have certain disadvantages. These include aggregation problems, introduction of regional variation in legal and cultural variables, and possibly, results which lead to generalized conclusions that are inappropriate for institutional policy decisions. With these points in mind the decision was made to focus on Michigan institutions and use Michigan State University as a case study.

Michigan State University is a Land Grant University of the highest caliber. It maintains an active research profile and is concerned with industry relationships. This is highlighted by the recent formation of a variety of institutions dedicated to private sector ties. In addition, many transfer firms have been in place at



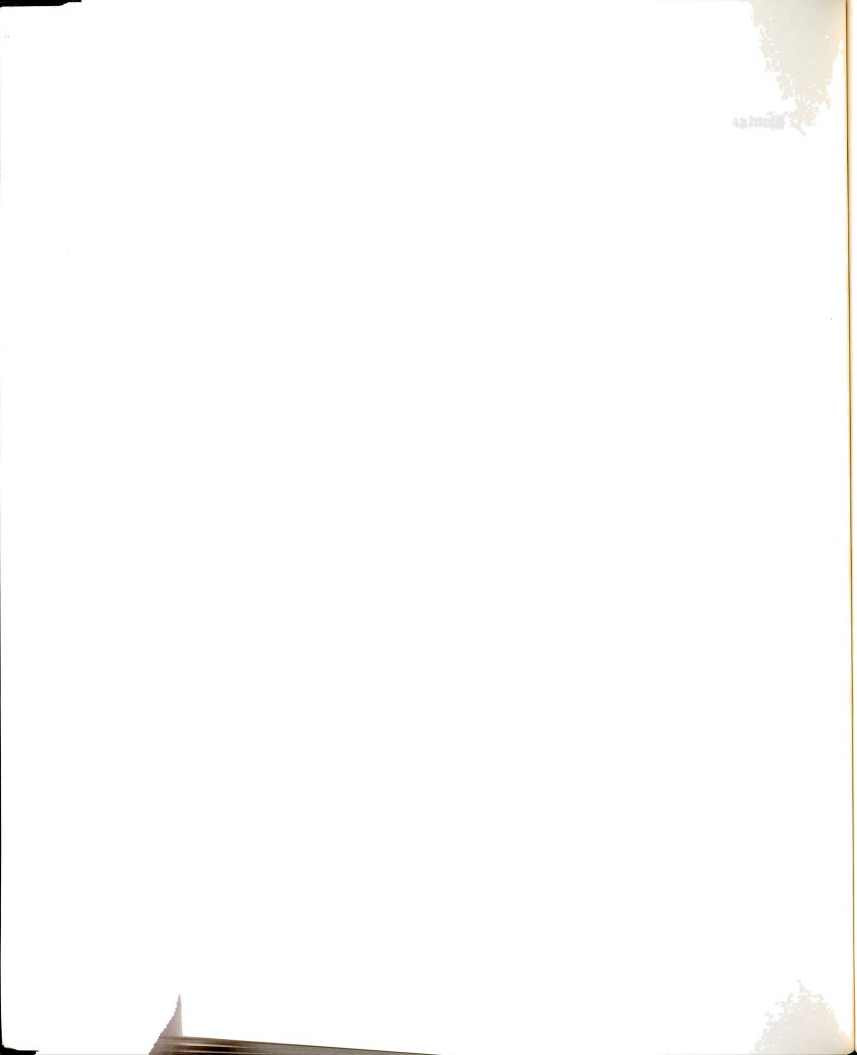
Michigan State University for years. University administrators and various background material indicated that there was structural variation between firms at Michigan State University. What information was readily obtainable about this variation?

A centralized data set with a group of common variables is often the most cost-effective information base to use in initiating an economic study. If such a data base exists two issues must be resolved: 1) The appropriate variables between the data set and the economic model or framework of the study must be matched; and 2) The cost and accessibility of the data must be assessed.

5.2 Special Problems

Initial contacts with Michigan State University administrators revealed that a centralized data set exists for highly structured institutions and a peripheral data set exists for weakly structured institutions. At first, open access was granted by administrators to a set of identified records. Administrators then indicated that access would be difficult, limited in numbers to about six specific items, and restricted to non-identifying or non-proprietary information (Cantlon, 1987; Bredeck, 1987). Examination of the Michigan Freedom of Information Act indicated that such limits would probably not be upheld (Freedom of Information Act, 1967).

Communications with the University attorney through Dr. Bredeck indicated that the University desired to maintain these limits if possible (Kurtz, 1987). All names, firms, product identities, and financial information were then excluded from the dissertation.



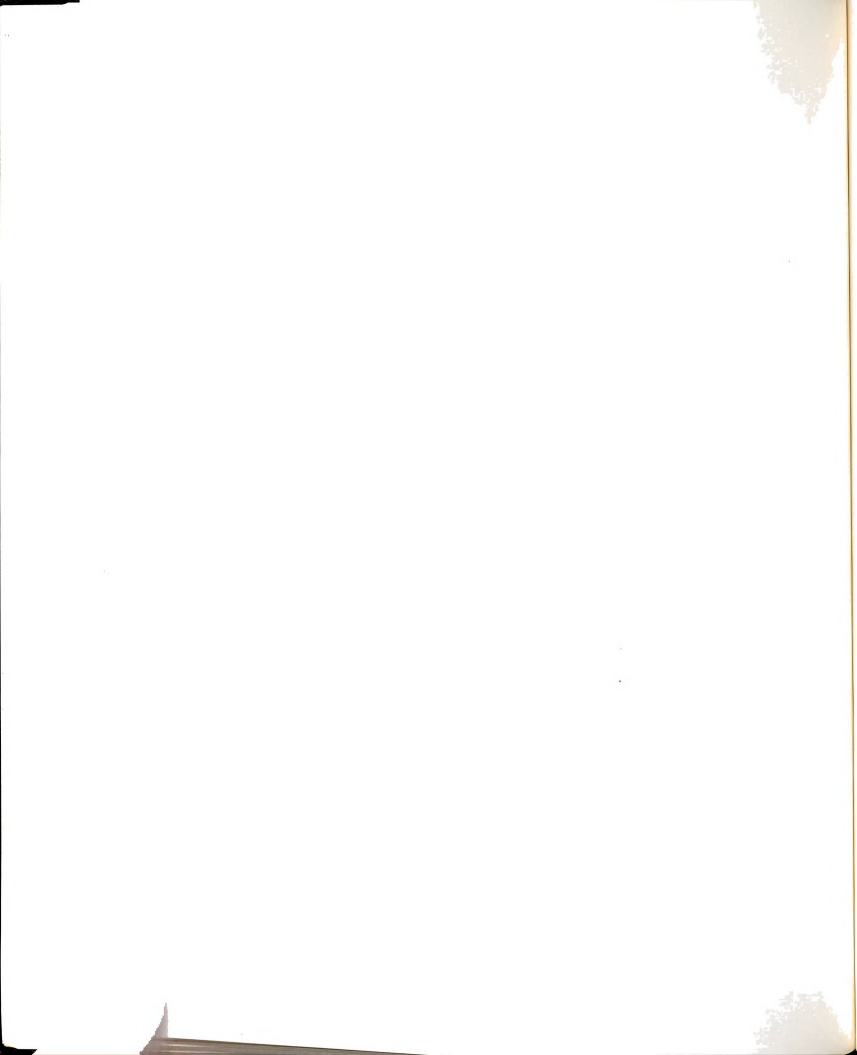
The increasingly closed stance of the University is due to two factors: 1) They want to maintain secrecy for the purposes of maintaining commercialization relationships; and 2) They are uncertain where they stand on the public nature of documents pertaining to university research commercialization. Firms may be engaging in a risk (exposure of their business practices) of which they are unaware.

Because access to most of the above University documents was promised to be limited in numbers and information, and because additional information might be gained through personal interviews, an interview/survey was implemented in order to characterize Michigan State University commercialization institutions.

5.3 University Forms

Since this study was interested in identifying the range of variability which exists in Michigan State University transfer firms it was felt that an initial survey of departments would be more productive than the self-selected and restricted data set that was available from the Administration. However, it is educational to outline selected University forms and their point of access which may be involved in the transfer of university research for possible future inquiries (Bredeck, 1987).

Transmittal Form - This one-page form lists the source of funds, the amount, the type of research, the objective, and the investigator for all contracts, grants, or gifts. They are kept by the Michigan State

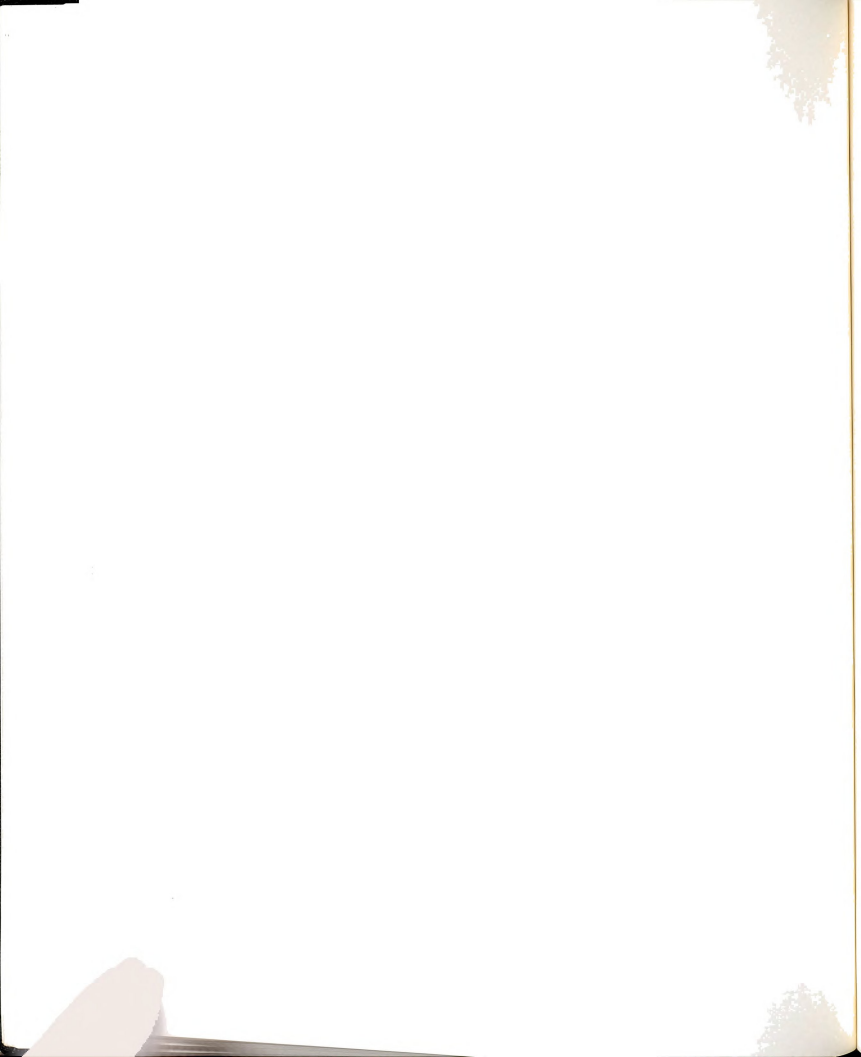


University Development Fund and The Office for Finance and Operations.

The University Board Agenda - The Board Agenda, Attachment D more recently, contains a record of all formal transmittals to the University. The Board Minutes are archived with University Archives in the Main Library but Attachment D is unavailable. The Board Office suggested the Office for Research and Graduate Studies or University Archives and vice versa. Similar records back to 1972 are obtainable at a cost from the Office for Research and Graduate Studies.

Research Proposals - These generally contain little information that is of use to a study of this nature. Proposals are kept by the Office for Research and Graduate Studies, once they are awarded monies, for the duration of the funding period plus five years. After that they are archived.

Research Agreements - A research agreement often postdates award of a contract or grant. This document may identify the funding source, the objective, the personnel, the assignment of rights within the university, the duration of the project, the payment periods, designation of indirect cost payments, assignment of rights outside the university, royalties, publication review, confidentiality, and liability. The amount of detail varies widely. These documents are kept by the Office of Contracts and Grants. If the agreement involves a private party it is not considered a public document by the Administration. Their annual numbers total about 600 from



industry, associations and foundations, 400 from federal agencies, and 200 from Michigan and local agencies.

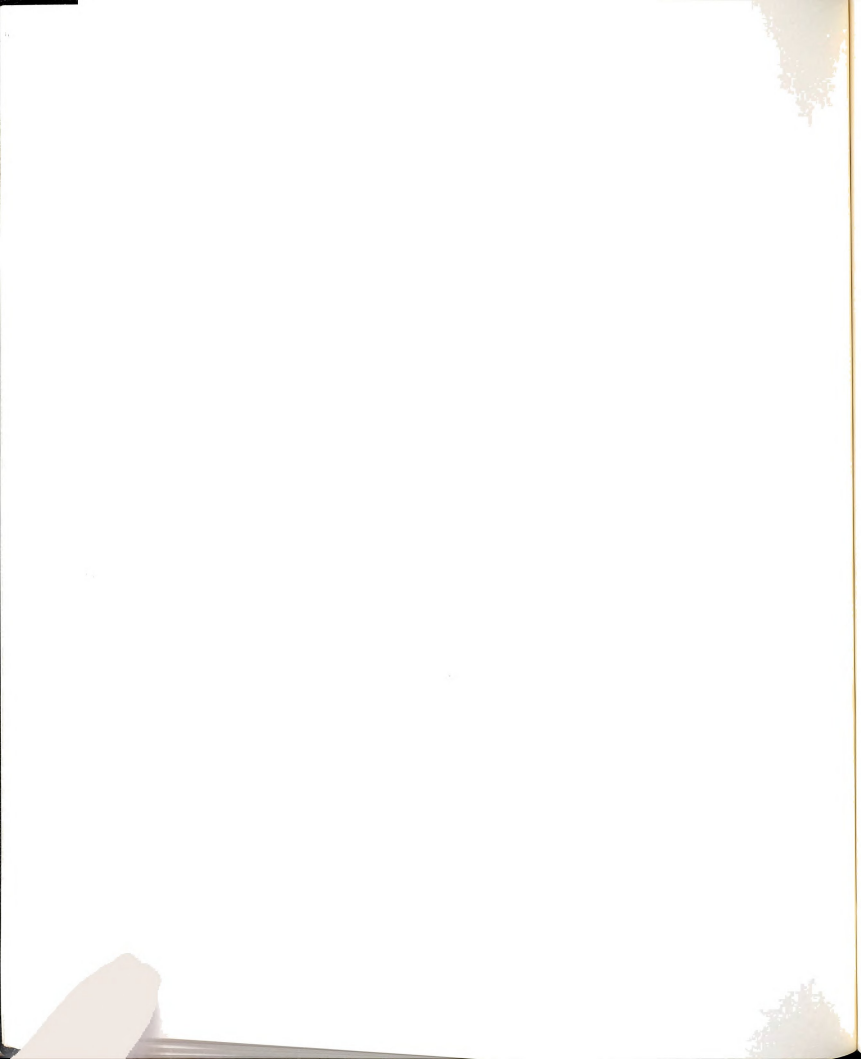
Licensing Agreement - Licensing agreements are for transferred products. They may identify the definition of sales, exclusivity, royalties, sublicensing structures, minimum performance, designation of sales reports, performance and termination clauses, patent litigation rights, warranties and liabilities, and advertising specifications. These documents are kept by the Office of Contracts and Grants. They are not considered public documents by the Administration. Their numbers total about six per year.

Records of Invention - These documents include the invention, the investigators name, royalty payments and records of sales. They are kept by the Office of Research and Graduate Studies and quarterly reports are submitted to the Michigan State University Development Fund. Only the investigators name can tie a Record of Invention to a Research Agreement. These are not considered public documents by the Administration.

Statement of Account - Statements of account listing account expenditures and balances. These documents are maintained by the Office of the Controller.

Designated Gifts - Any gift to the University which may have attached stipulations is processed by the Office of Research and Graduate Studies. Records are maintained by this Office but open access is not provided.

Memorandum of Agreement - Research products are often given away through organizations which have a long-standing relationship with



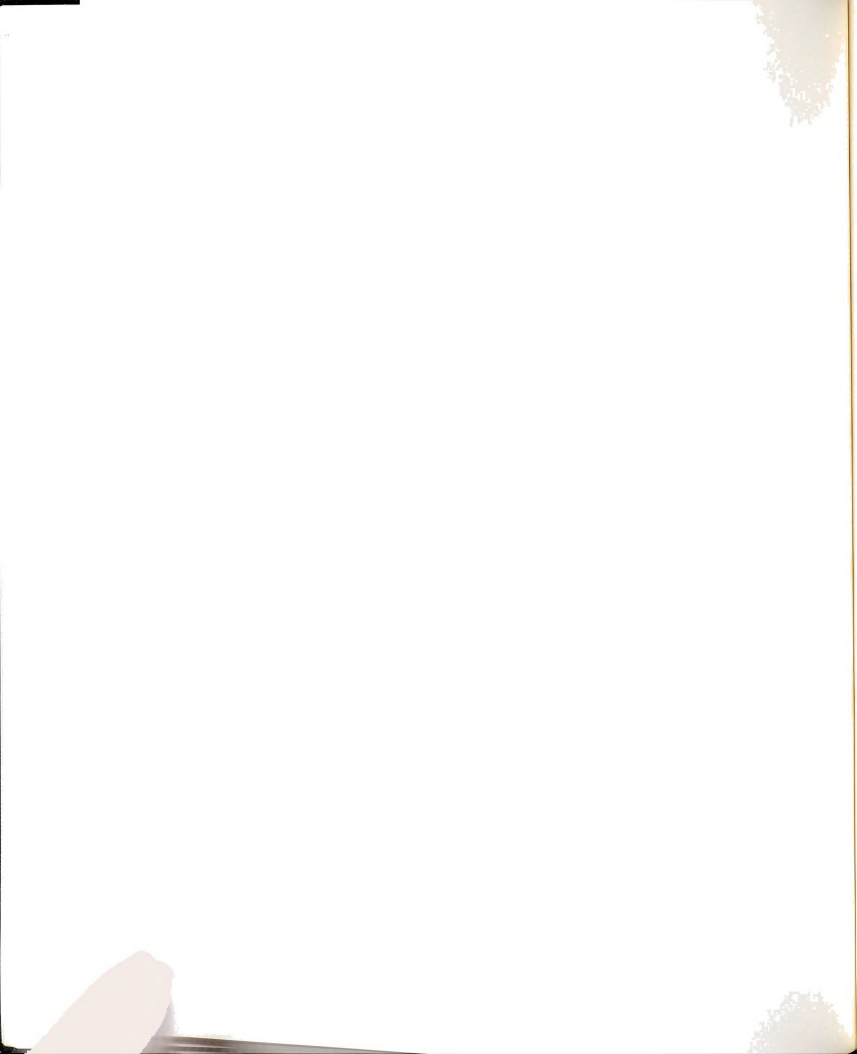
some department or unit. There may be a memorandum of agreement which outlines certain aspects of the relationship. There is no centralized location for such documents and unit administrators may be the most viable collective source.

5.4 Interview I

The purpose of the first round of the interview/survey (Interview I) was to find the range of variability in the firms which exist at Michigan State University for the transfer of research with commercial potential to the private sector. Secondly, it tried to obtain detailed information on those firms and obtain general information on trends, attitudes, and institutional policy.

Department chairpersons were selected as the initial sample unit because they would have the broadest and most in-depth knowledge of activities by faculty members in their departments. College-level research administrators would not be familiar with the details of transfer activities in their separate departments. Faculty members would not be familiar with the details of other transfer activities in their own departments.

A sampling strategy for department units was based on pre-selection of departments that had faculty members with disclosed inventions through the University Office of Research and Graduate Studies. This method of sampling was chosen as an alternative to random sampling of departments or a two-stage sampling of departments with and without disclosures for several reasons: 1) Random sampling would probably include many departments without transfer activities;



2) Random sampling would probably miss many departments with transfer activities; 3) Pre-selected departments included most known departments of interest; and 4) The purpose was to inventory institutions, not inventions, and a complete treatment of all known departments with transfer activities should yield an accurate assessment of institutions even though some inventions might be missed.

The University Invention Disclosure List was obtained from the Administration. It was labeled as confidential and I was required to sign a disclosure agreement with the University. All reporting inventors since 1980 were identified by department through annual faculty directories. A department list was compiled and the sample units identified. A one-hundred percent sample was attempted.

The interview instrument was developed with the help of the research committee (including one current department chairperson, one past department chairperson, one faculty member with transfer activities, and one faculty member with a strong interest in agriculture transfers). It was reviewed by two outsiders and pretested with four former or current department chairpersons not included in the sample. This should be sufficient pretesting according to suggested standards of 25% of the sample size for small samples (Warwick and Lininger, 1975; Converse and Presser, 1986). It was also submitted and accepted by the University Committee for Research Involving Human Subjects.

Department chairpersons were telephoned, given an explanation of the study, and were requested to spend one hour of time in the



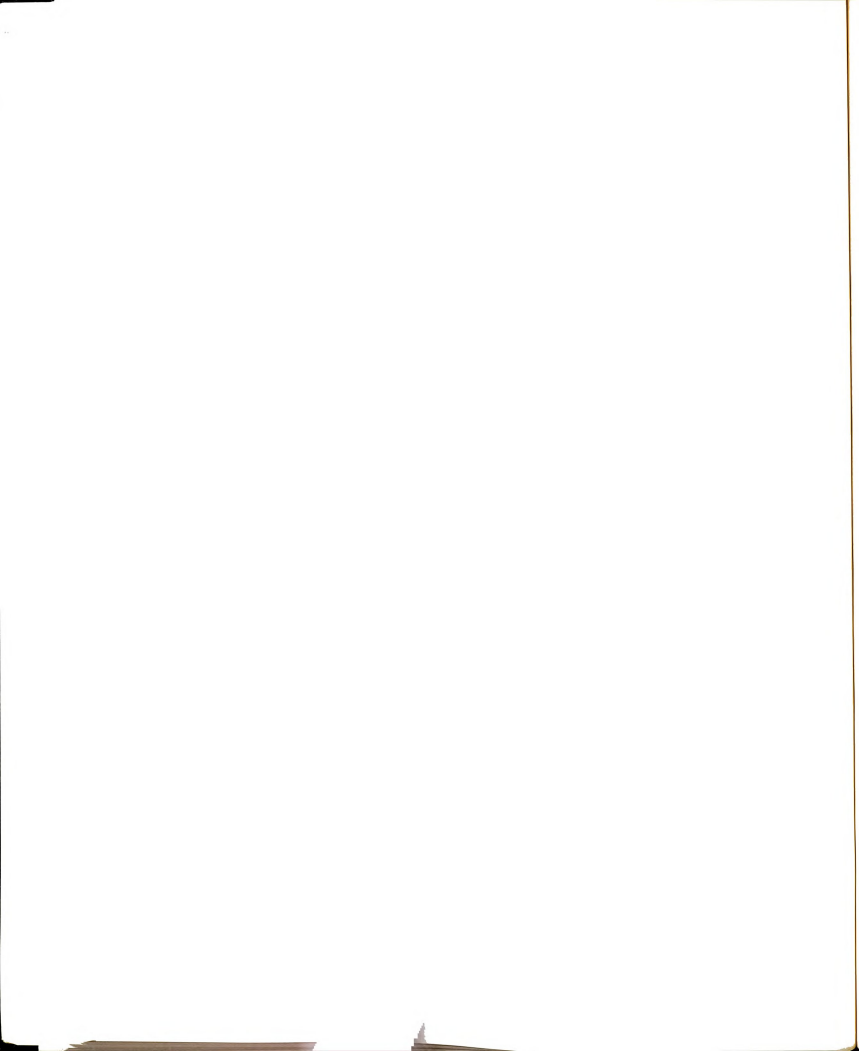
interview. Twenty-one of 24 chairpersons granted the time (88% sample). A cover letter, consent form, and inventory list (Appendix A) were hand-delivered to the department offices. I conducted all of the interviews (Appendix B).

Departments were split into two groups. Those with fewer than four reported inventions were contacted and generally interviewed first. Those with four or more reported inventions were contacted and generally interviewed last. This allowed a second period of instrument testing and interview preparation before the more active departments were sampled.

The only real change in format came about when several chairpersons asked for a list of reporting inventors to facilitate their pre-interview preparation. For this reason the inventory list was supplied to the chairpersons with only the reporting inventors listed for the second group of chairpersons (which had more reported inventions than the first group). This did not stop chairpersons from adding to the list when possible or appropriate.

The University Invention Disclosure List and the inventory from Interview I were cross-checked and compiled. The general character of this compilation and a suggested set of transfer firms used at Michigan State University are reported in Chapter 6. Transfer firms were separated by class (Section 4.4) and specific firms were identified for the second set of interviews (Interview II).

Responses to the open-ended questions regarding commercialization policy from Interview I were edited, sorted, and



tabulated prior to Interview II. These data are also reported in the Chapter 6.

5.5 Interview II

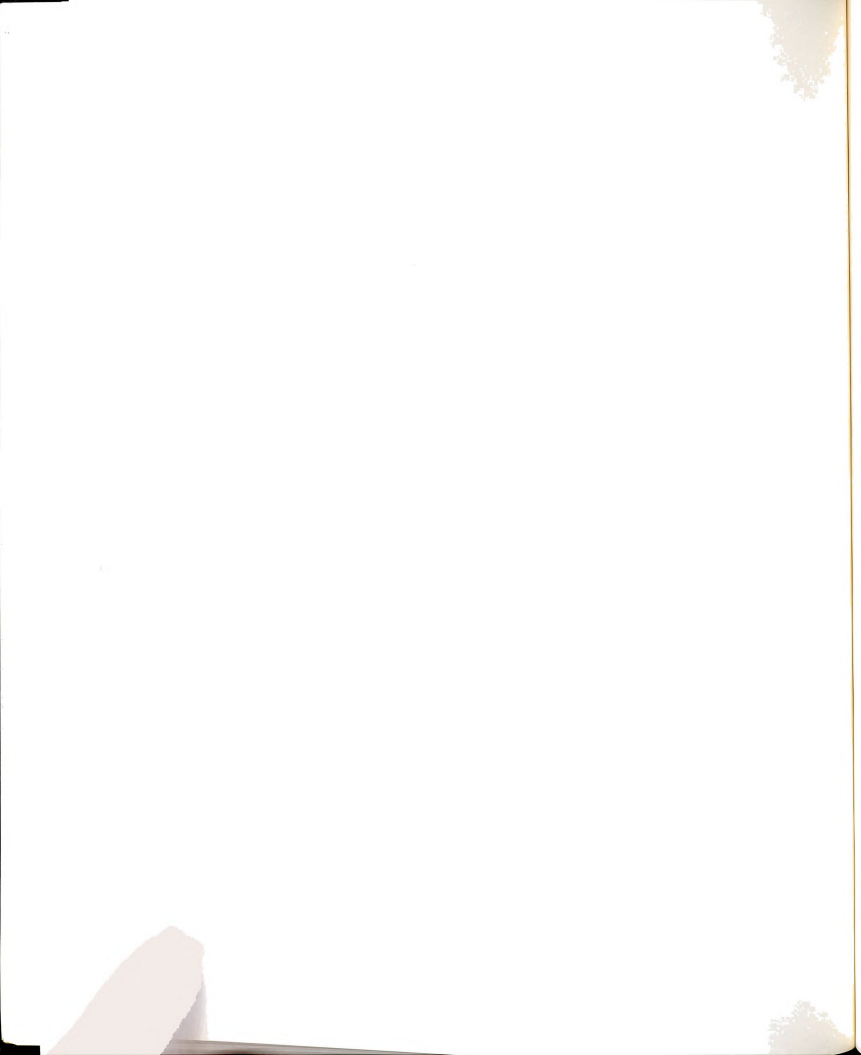
What are the options for putting firms in the context of the framework and measuring captured and returned rents? Two alternatives exist. The first is based on measuring real prices and returns. The second is based on valuing perceived rents. Both are valid measures and both have advantages and disadvantages. At this stage of problem solving it should be more useful to examine actual prices and returns.

Once the decision was made to work with products, prices, and productivity changes or cost savings through selected firms that have commercialized university research, this limited the study to five of ten institutions identified at Michigan State University because the others have not actually sold a product yet. It still covers the range of structural variation which exists from direct sales to University licensing to centers for commercialization.

Interview II included the following types of firms:

- University facilities
- University-financed center for commercialization
- External third-party brokerage unit (specialized)
- Faculty initiated company
- Direct University licensing
 - Exclusive
 - Non-exclusive

All firms were verified with, and contacted by, Dr. Bredeck before contact was established for the study. Of the University licensees, several were selected with the help of Dr. Bredeck.



Important criteria included actual product sales, anticipated level of cooperation, and location. Interview II was pretested and approved by the University Committee for Research Involving Human Subjects, and phone contacts with firms were followed by letters (Appendix C) and interviews (Appendix D). I conducted all of the interviews.

The first step of Interview II confirmed the structure of the transfer firm and the University relationship. A checklist of variables and alternatives outlined in Figure 4.1 was confirmed with firm representatives in order to identify which alternatives apply to the firm and its contract with the University. This information was checked with licensing agreements obtained from the University.

The relative ranking of each of these variables in influencing pricing and returns to the University is important in assessing alternative structures but time limitations did not permit exploration of this issue during Interview II. Also, questions determining whether there is a pattern between the structure of the firm and the terms of their contracts with the University or whether the contract terms are more a function of sector characteristics, asset mobility, economics of the firm, or historical relationships are important but beyond the limitations of Interview II.

The second step of Interview II estimated rents and returns. Procedures used for estimating rents are described in Section 5.5.

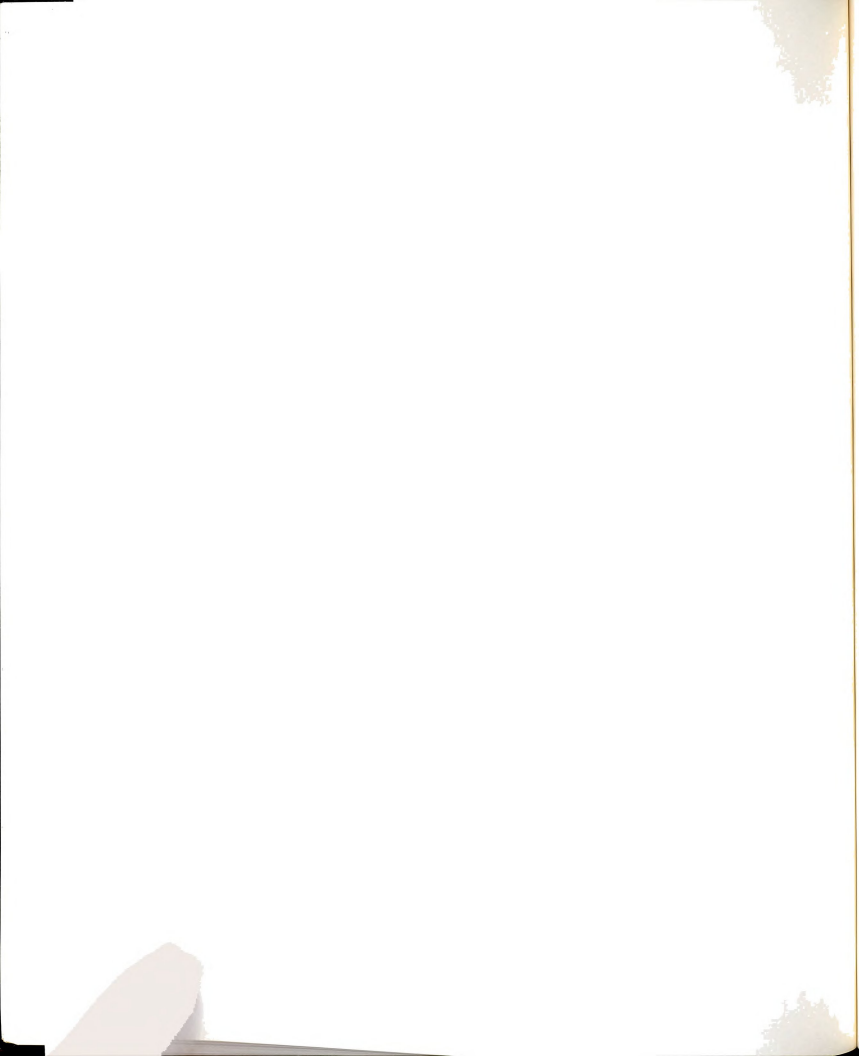
The third step of Interview II tried to understand some policy issues and pricing rules of the firm. Many important factors can effect the pricing decision of the firm. These include demand

elasticities, market share, firm efficiencies, and others. This study tries to understand what portion of a potential appropriable rent gets captured by a given firm and what portion of that rent is returned to the University. It does not account for price elastic goods or market share acquisition attempts or differences in firm production efficiencies. However, several ideas were explored during the interviews in order to increase the understanding of how rents are appropriated and returned by firms in university-industry relationships. These ideas included the following points:

1. Is there an incentive for the firm to understand the potential appropriable rent and capture some portion of it? Alternatively, is there some pricing decision rule mixture which precludes this understanding (elasticities, market share, cost plus, etc.)?
2. Is there an incentive to minimize costs of the transfer firm and have some cooperative joint product maximization? How does this affect licensing and royalty structures or other fee assessment (if the university charges too much it puts the product/firm out of business)? How does this affect selection of a transfer firm by the University?
3. How are profits viewed and shared? How can transfer relationships be structured so that there is an incentive to share profits rather than keep returns to the university as a cost to the firm?

5.6 Estimating Rent

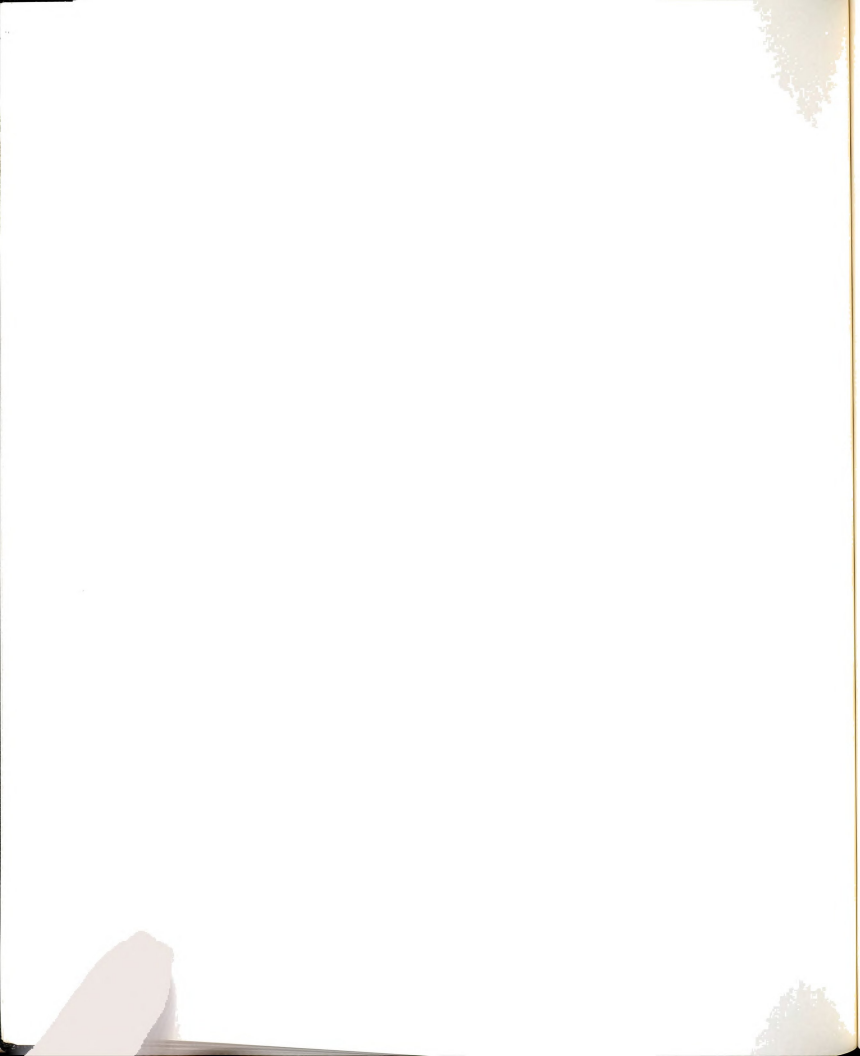
The second step of Interview II measured captured and returned rent. The main problem was understanding the technology differences



and pricing factors between the new product or technology and its substitute. Given real product cases it was possible to identify substitutes, cost savings, productivity changes, and prices.

A reiteration of some of the alternative choices for economic performance measures is helpful at this point: 1) This study does not use classical economic rent or Ricardian rent as a measure of producer surplus. That is the amount earned by any factor of production in excess of the minimal amount required to retain its current use. It reflects producer characteristics and would be more appropriate when comparing several firms that use a single innovation in their production processes; 2) It does not use consumer surplus as a measure of available rents which may be used as a proxy for potential profits and reflect market clearing functions with discriminatory pricing; and 3) It does not use willingness to pay at some constant price which may reflect a contingency value. It does attempt to capture a measure of the product value by estimating user cost savings.

An outline of information obtained from Interview II and steps that were followed in the analysis is covered in the remainder of this section. Some examples of measurement problems for different scenarios of productivity and pricing are included. Actual data can not be used due to the confidentiality restrictions.

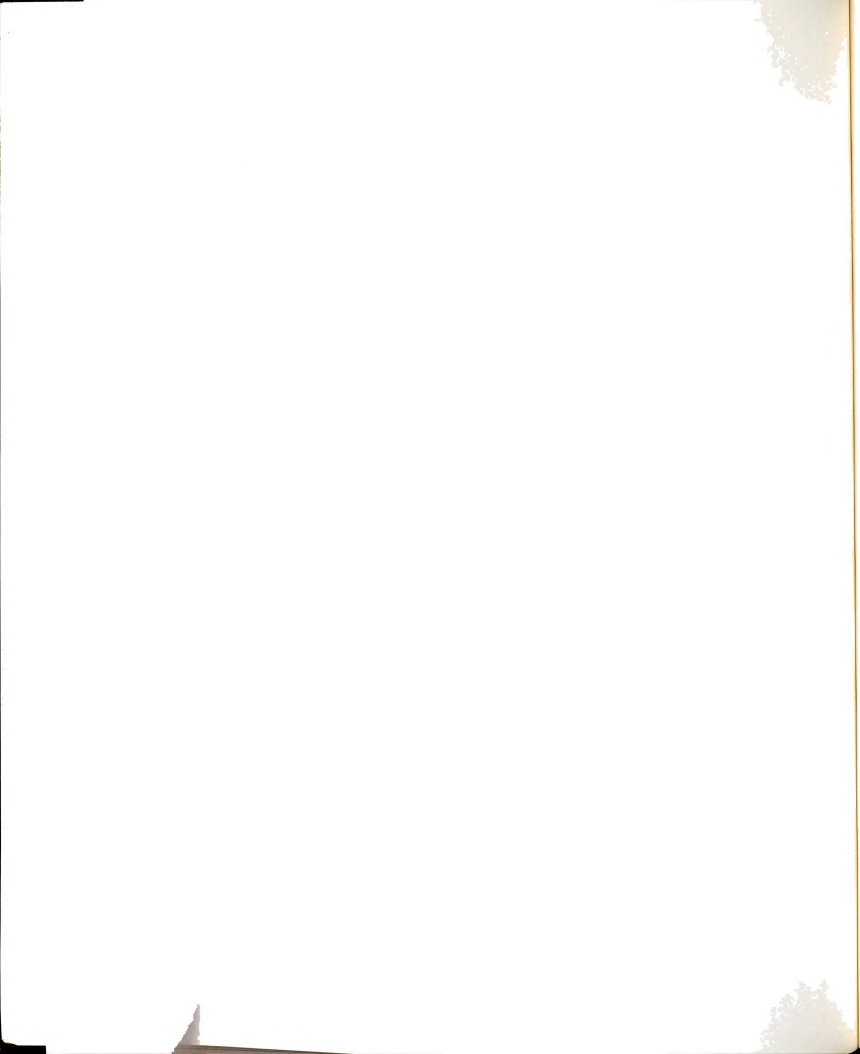


Steps in estimating rent

1. Quantify any change in productivity or cost savings represented by the new product or technology over its closest substitute or old product or technology on a per unit basis.
 - What is the technology?
 - What is the substitute that it has been documented against?
 - What are the productivity changes?
 - What are the labor savings?
 - What are the differences in test efficiencies?
2. Price the old product or technology and new product or technology.
 - The price may be a market price for an actual substitute.
 - The price may be an approximation for labor substitutes.
 - The price may be a cost savings if the technology is a cost saver in a production process.
 - The price may be zero if there really is no substitute product or technology but in this case it may not be a good candidate for inclusion in the study.
3. Calculate the maximum appropriable rent.
 - The maximum appropriable rent for a new product with increased productivity that sells at a premium is calculated on a per unit basis ($\#1 \times \#2$).¹

¹Example 1: Genetic stock

1. Productivity increase of 10% over standard or documented variety.
2. P1 = \$1.00 per unit. Price of standard or documented variety to farmer.
3. RA = \$0.10.
4. P2 = \$1.05 per unit. Firm price of new technology to farmer.
5. RC = \$0.05.
6. PC = 50%.



- The maximum appropriable rent may be the old price for a product that does the same thing but sells for more than the price of the new product (#2).²
- The maximum appropriable rent may be a labor or factor cost that is replaced by the new product or technology which is provided at a discount (#2).³⁴

²Example 2: Test technology

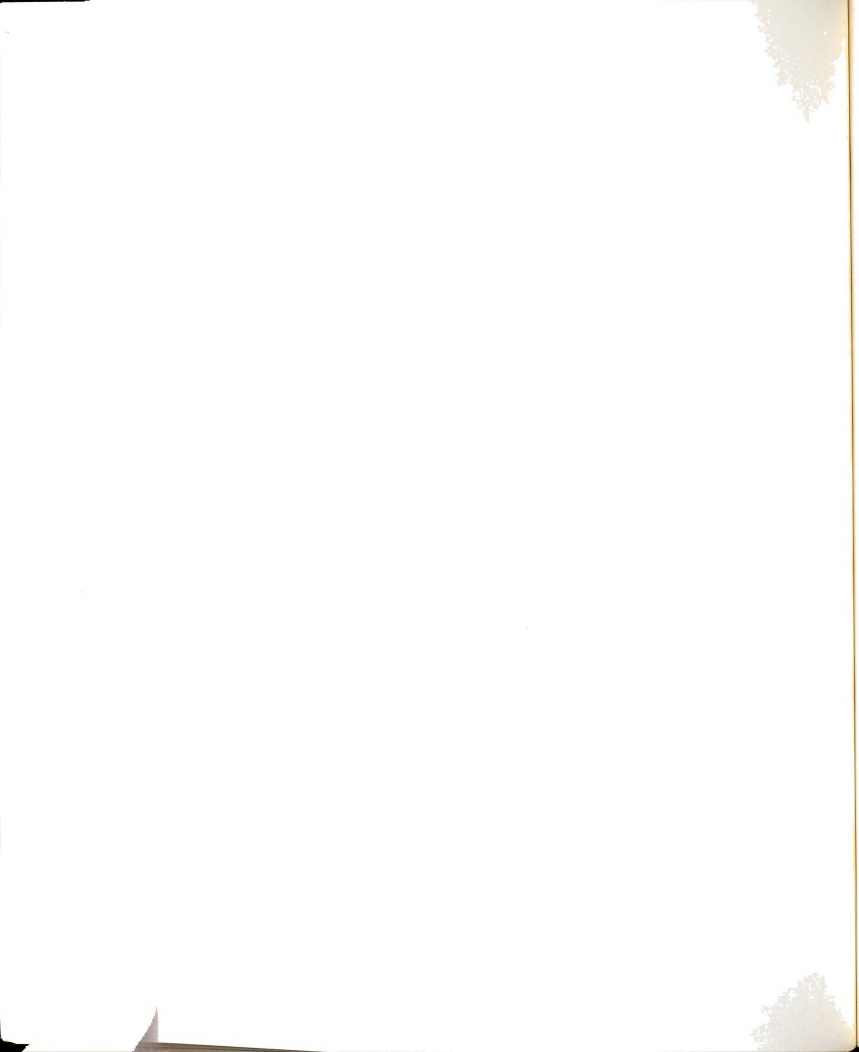
1. Assume same test results and price decrease.
2. P_1 = cost of old test = \$10.00.
3. RA = \$10.00.
4. P_2 = Firm price = \$5.00.
5. RC = \$5.00.
6. PC = 50%

³Example 3: Test technology

1. Assume productivity increase and price decrease.
Test is fifty percent more effective than old test. It saves farmers 25% of their crop or stock (rate of loss incidence) 50% of the time. Saves them 12.5% of their crop overall or 12.5% of the applicable test volume value on average. Assume this figure is \$5.00.
2. P_1 = cost of old test = \$10.00.
3. RA = \$5.00 + \$10.00 = \$15.00.
4. P_2 = Firm price = \$5.00.
5. RC = \$5.00.
6. PC = 33%.

⁴Example 4: Labor saving technology

1. Assume productivity increase, labor cost saving, and price increase.
Takes 30 man hours to run old test at \$10.00/hr.
Takes 3 man hours to run new test at \$10.00/hr.
Labor cost savings of 90% or \$270.00/test.
New machine twice as accurate. Takes two of old test to match accuracy of new test. Labor cost savings of one test or \$300.00/test.
2. P_1 = \$100,000.00 depreciated over five years with a limit of 50 tests per year or \$400.00/test.
3. RA = \$270.00 + \$300.00 = \$570.00/test.
4. P_2 = \$1,250,000.00 depreciated over five years with a limit of 500 tests per year or \$500.00/test.



4. Price the new product or technology.
5. Calculate the captured rent.
 - When the new product sells at a price in excess of the old product it is the difference in price ($\#4 - \#2$).
 - When the new product sells below the price of the old product it is the sum of the discount plus an appropriable rent due to productivity changes $(\#2 - \#4) + (\#3)$.
6. Calculate the percentage of appropriable rent that is captured ($\#5 / \#3$). Note that this figure may be over 100% when the new product provides a productivity increase and a discount.
7. Identify the number of units of the new product or technology that are sold.
8. Identify the dollar amount returned to the university by the transfer firm for that product. Also identify what form the return is made in.
9. Calculate the returned rent per unit ($\#8 / \#7$).
10. Calculate the percentage of appropriable rents returned ($\#9 / \#3$).
11. Calculate the percentage of captured rents returned ($\#9 / \#5$).

5. $RC = \$500.00 - \$400.00 = \$100.00/\text{test}.$
 6. $PC = \$100.00/\$570.00 = 18\%.$

CHAPTER 6

RESULTS AND DISCUSSION

6.1 Interview I: University Inventions

Since 1980, 118 inventions have been reported to the University Office of Research and Graduate Studies. These invention reports come from 22 departments. Seven reports of software and two reports of educational materials bring the department total to 24. Books and non-academic University units are not included in this count.

Twenty-one of the 24 department chairpersons who had scientists in their departments that reported inventions to the University agreed to be interviewed for this study. Four additional reports of educational materials and nine additional reports of software were obtained during the interviews. Some software reports pertained to more than one item. Isolated instances of undisclosed and unspecified product development were also claimed to pertain to more than one item. While some of these additional inventions do not appear on the University invention disclosure list the administration is often aware of them through alternative contractual arrangements or pending action by the principal investigator.

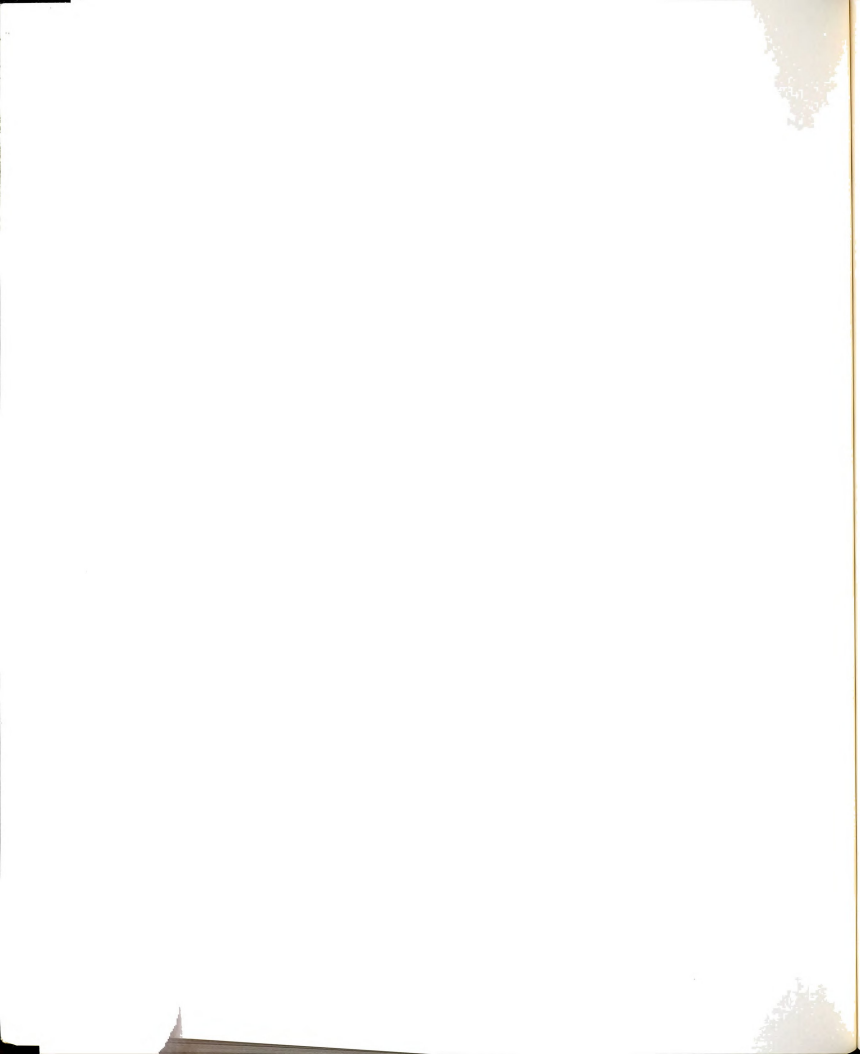
The total invention list is for 127 items with several of them being revisions of earlier reported inventions. In addition, the number of effective inventors is much smaller than this but can't really be defined due to intermixing on invention "teams". The average number of inventors on an invention team for all inventions

is 2.12. The average number of departments represented by an invention team for all inventions is 1.22.

Most of these 127 inventions are not commercial products. Forty-two of 56 inventions submitted for brokerage since 1980 have been declined by Research Corporation, the national licensing intermediary used by Michigan State University. Of those declined by Research Corporation only six have seen subsequent development or licensing through the University. Reasons for declining include prior publications and federal research support. Records indicate that four more inventions are pending with Research Corporation and six have been accepted. No licenses were indicated for the six inventions accepted.

Of the 127 inventions there have been 62 patent applications. Forty of these were prepared by Michigan State University, six by Research Corporation, and 15 by private firms. Of the 62 patent applications, 28 have been allowed, four have been disallowed and 30 are pending. Other patents have been developed outside the University as indicated by department chairpersons.

Of the 127 inventions there have been 32 University licenses or rights options exercised according to records. The breakdown of license types is as follows: 21 exclusive licenses, four public/private licenses, four public rights declared, and three non-exclusive licenses. Of these 32 licenses 16 have allowed patents, 12



have pending applications, one has a disallowed application, and three are uncommitted or unknown. Many are inactive.¹

6.2 Interview I: Institutions

Institutions used by faculty to get educational materials and software from the University to the private sector are not the subject of this study but were covered briefly during Interview I. The identified institutions are listed here to demonstrate that variation exists in transferring these types of technology from Michigan State University.

Educational materials:

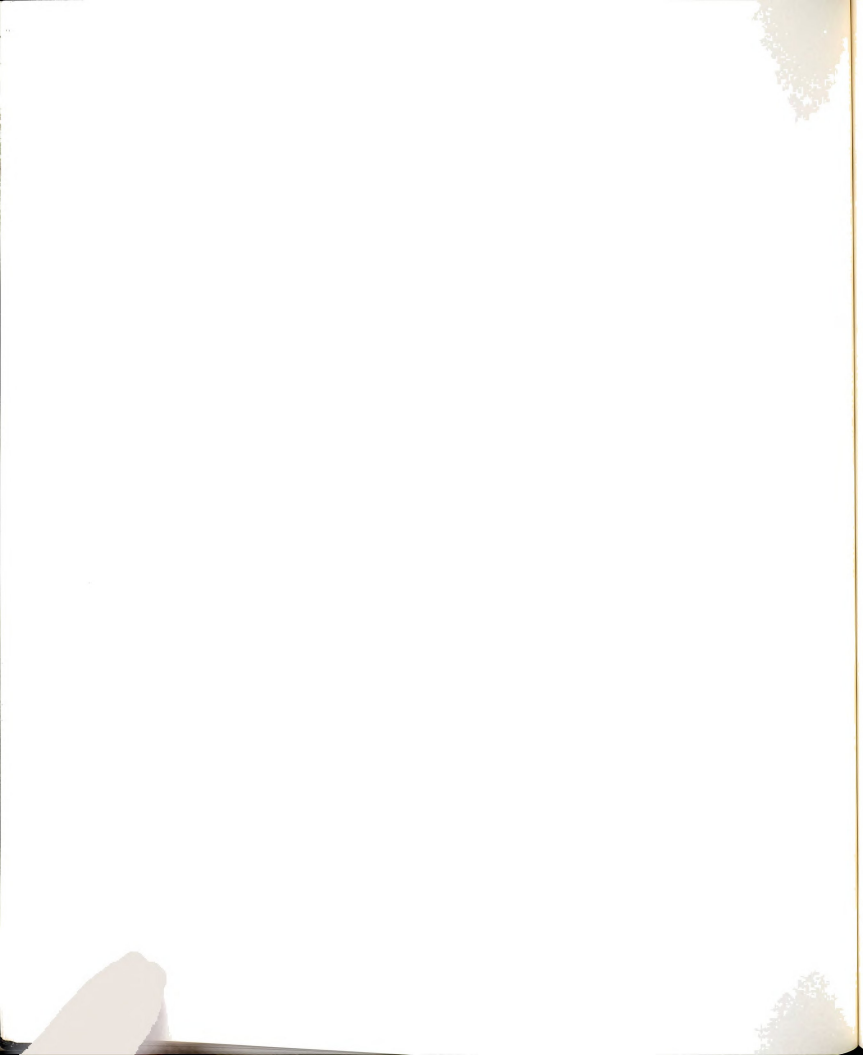
- Sold at cost
- Sold through the University IMC
- Sold through the University Press
- Licensed to non-profit associations

It should be noted that three of these four identified institutions for transferring educational materials involve receipts to the department or center of research.

Software:

- Unknown
- No cost exchange
- Exchange at cost
- Michigan Ag. Exp. Stat.
- Department licensing and sales
- Trade on contract for hardware with private firms
- License to private firm through MSU
- License to faculty owned firm through MSU
- Developed by faculty outside of the University

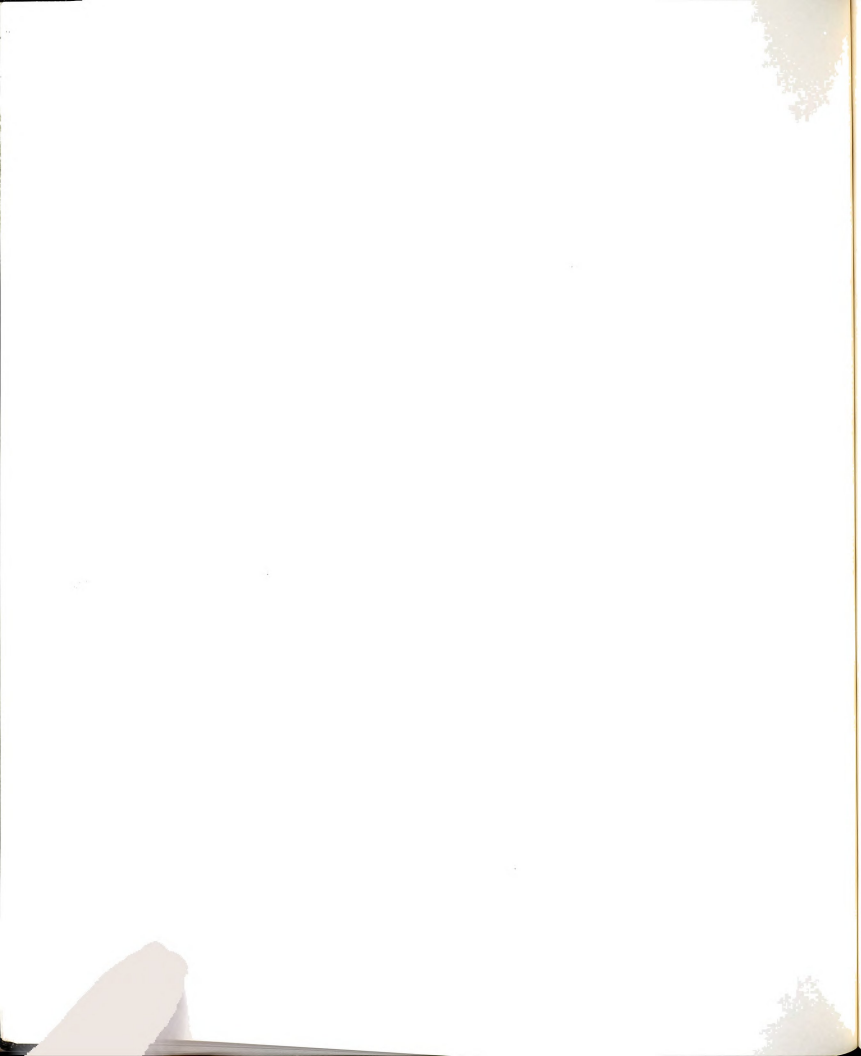
¹The exact state of these data is constantly changing. Numbers were compiled from interviews conducted during the Fall of 1987 and lists supplied by Dr. H. Bredeck in the Michigan State University Office of Research and Graduate Studies during August, 1987. They are, to the best of my knowledge, accurate as of that time.



The wide variety of institutions used for the transfer of software is not surprising. As copyrightable material, the University patent policy does not readily apply to procedures used by faculty members to transfer software. Increased awareness and activity in this area by both faculty and industry deserves attention to policy alternatives, potential problems, and structuring of an appropriate university environment. Treatment of these issues with regard to the unique aspects of computer software is beyond the scope of this study. However, the framework from this study could be employed to structure those issues in future work.

Institutions for commercial development of university research products at Michigan State University demonstrate a range of variability even though, historically, there has not been extensive activity in this area. The firms can be placed into three groups; those without licenses or contractual arrangements through the university, those with contractual arrangements in lieu of a license, and those with licenses through the university. There is some overlap in the latter two groups.

Institutions without licenses or contractual arrangements for the most part represent isolated instances and are not likely to become a dominant force in future activities without a substantial policy change (see Interview I policy results). For this reason the first five institutions listed below are not considered in this study. The sixth remains important but is not relevant to direct commercialization.



The list of non-licensing institutions used at Michigan State University since 1980 includes the following:

- Taken back to native country by co-investigator
- Sold to private company by investigator
- Sold rights to private company for \$1.00
- Marketed by private company with a basic controlling patent
- Given to the State or University for clinical application
- Given to public user groups

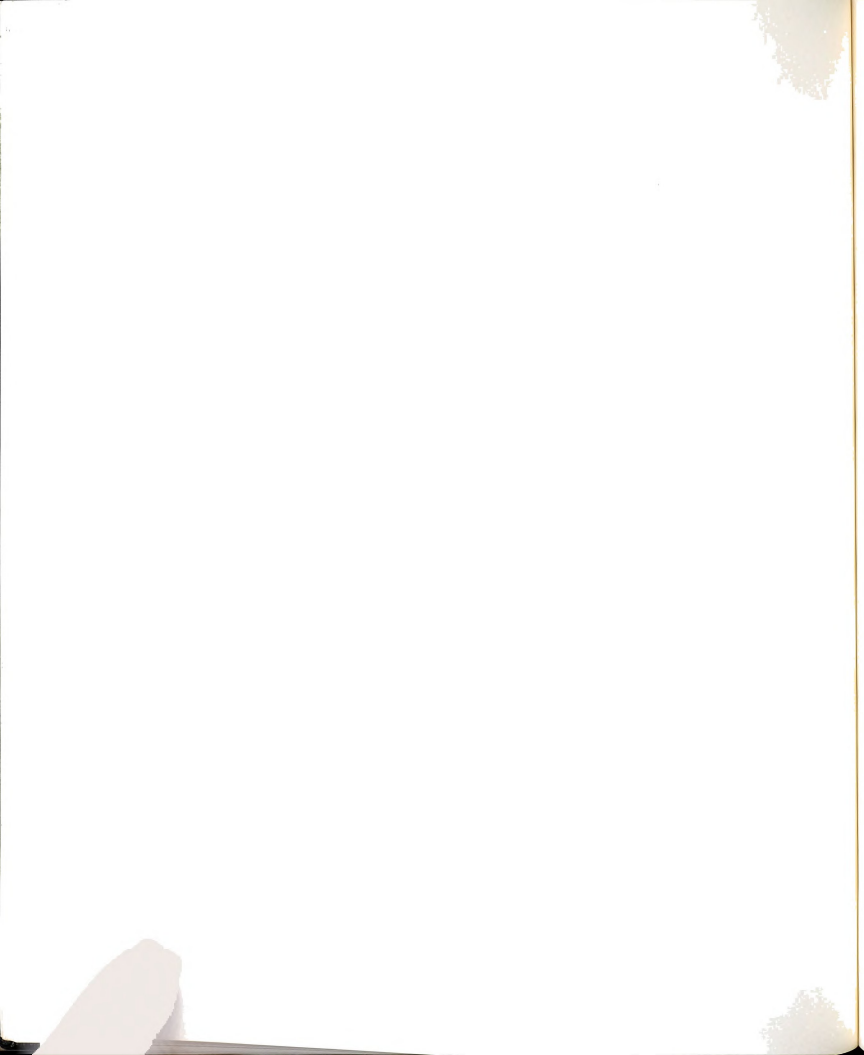
The seventh and eighth non-licensing institutions are either important now, or may become important in future activities, and thus deserve further attention. These are:

- University facilities
- Faculty owned companies

The second and third groups of institutions can be separated into several classes of structures even though the basic commercialization process is based on a licensing agreement. Since this study postdates 1980 transfer activities, and the inventory includes current institutions, some of the firms listed below have not yet been responsible for actual product commercialization. Some of the firms without a commercial product may be developing a product at this time or just be in the process of evaluating research for development and commercialization. Their inclusion reflects both their importance and their mission in projected economic development by Michigan State University and the State of Michigan.

Firms with contractual arrangements in lieu of a license include the following structures:

- University-financed center for university commercialization
- State-financed center for university commercialization
- Privately financed center for university commercialization



Their main mode of action to date has been contractual arrangements with the University which may or may not eliminate the structuring of a licensing agreement. As further technologies and relationships develop, licensing agreements may be put in place.

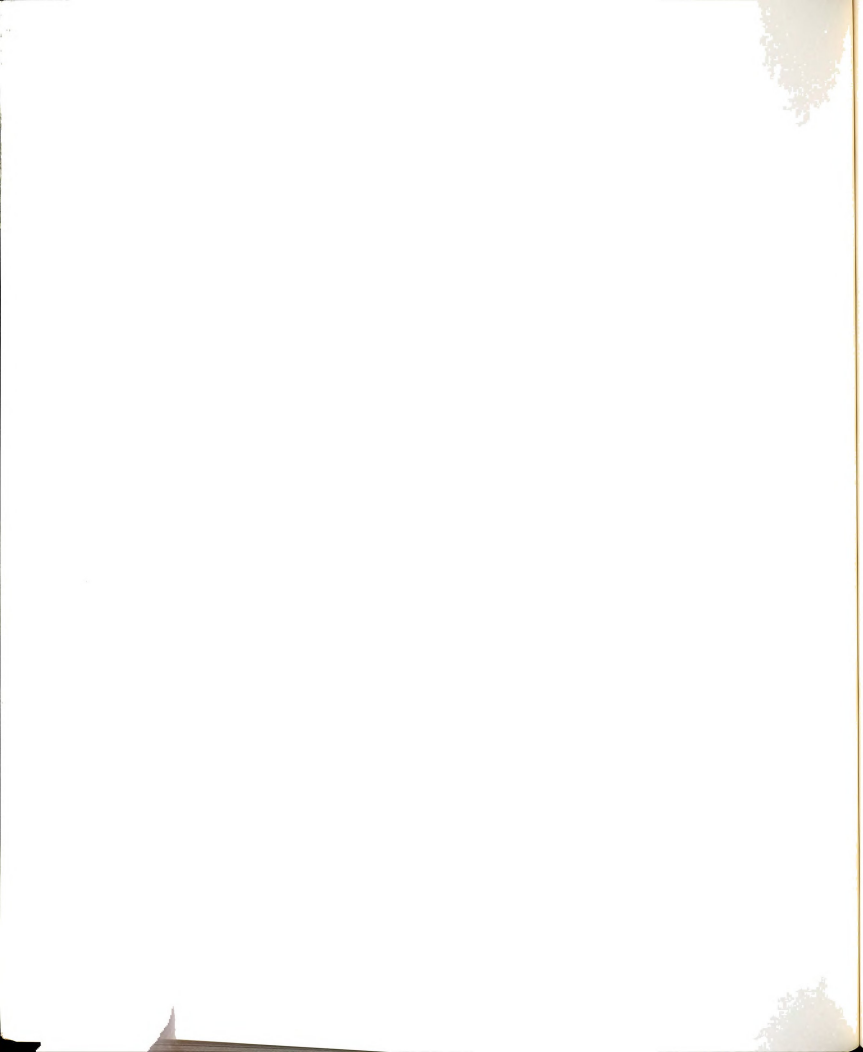
Firms which lead to licensing through the Michigan State University Office of Research and Graduate Studies predominate past transfer activities. These include the following structures:

- Third-party brokerage unit
 - internal
 - external (national and local)
- Faculty initiated company
 - research park
 - isolated
- University-based centers for industrial interaction
- Direct University licensing
 - exclusive
 - non-exclusive
 - U.S. agency and "exclusive"
 - U.S. agency

These, then, are the identified types of firms used for university research commercialization at Michigan State University. Their structural differences can be identified using alternatives for the set of variables selected in Section 4.3. Expected outcomes of the structural effect on performance measures for each of these types of mechanisms were examined in Sections 4.3 and 4.4.

6.3 Interview I: Policy

Ten policy questions were addressed during Interview I. These open-ended questions were often the most interesting part of the interview to department chairpersons. A few instances of contradiction and invalidity did occur though these were minor. Additionally, many chairpersons offered answers to questions before

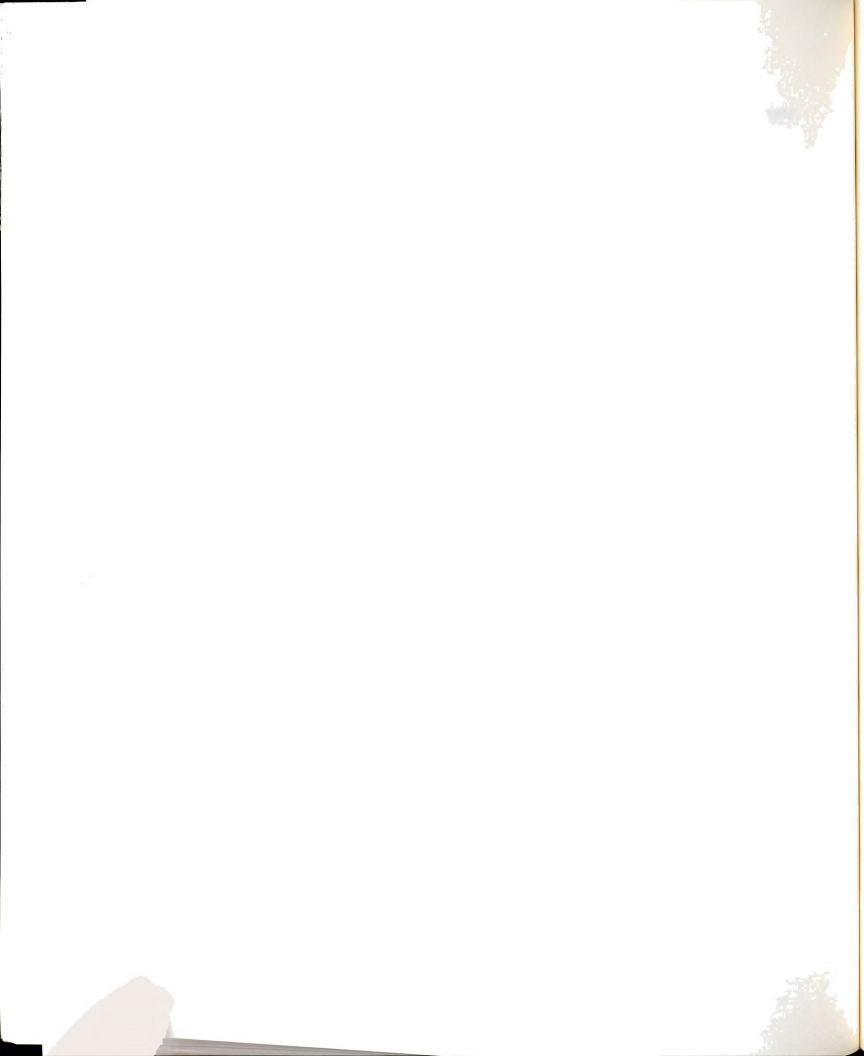


they were asked, indicating that these were important issues which they had previously thought about.

Responses have been edited and condensed. This gives a measure of protection to the promised anonymity of the respondents. An attempt has been made to provide the most salient points from the responses to each question. Failure to accurately portray individual opinions is an inherent part of this process. Because of the small sample size and potential future dialogue, it is hoped that initial respondents recognize this and do not feel that their answers were not considered. They were.

The remainder of this section outlines the responses to each question. Each table reports the results from that question in a condensed form and gives an unweighted frequency of response for each of the most frequent alternatives and a percentage of the unweighted response total for each of those alternatives. The number of responses can total more than 21 (the number of interviewees) due to multiple responses or can total less than 21 due to no responses by individuals for some questions. Percentages are based on the total number of responses.

Three non-interviews which represent twelve percent of the population should not introduce bias in the response rates because they represent three different colleges and varying degrees of invention activity. In other words they are a non-homogenous group and the reduction in sample should not be clustered. Non-response answers by interviewees were all treated as separate responses in isolated categories rather than distributing them among responses.



Question 1: Which type of transfer mechanism do you feel is most important to past, current, and future commercial development activities in your department and why?

Twenty of 21 chairpersons responded to this question. The options at the bottom of the interview inventory sheet were available to them for consideration. The response was almost always qualified by future development activity since chairpersons felt the inventory represented past and current development activity. Several chairpersons qualified their answers by field, type of technology, market size, or stage of development. These results are presented in Table 6.1.

The majority of chairpersons felt that University ownership and licensing through the administration, through an external brokerage unit, or through the department will continue to be the most important institution for research commercialization from the University. In fact, these accounted for 71 percent of the responses. The next two potentially important institutions cited were joint ownership and development, and faculty owned companies. The joint ownership term does not refer to property rights but to equity interest by university or faculty as part of the potential payoff from commercial development of their research. These two institutions accounted for 14 percent of responses. Only one mention of the research park concept was made in reference to the Hannah Technology Research Center, and surprisingly, none was made to state commercialization centers or the University centers for industrial interaction.

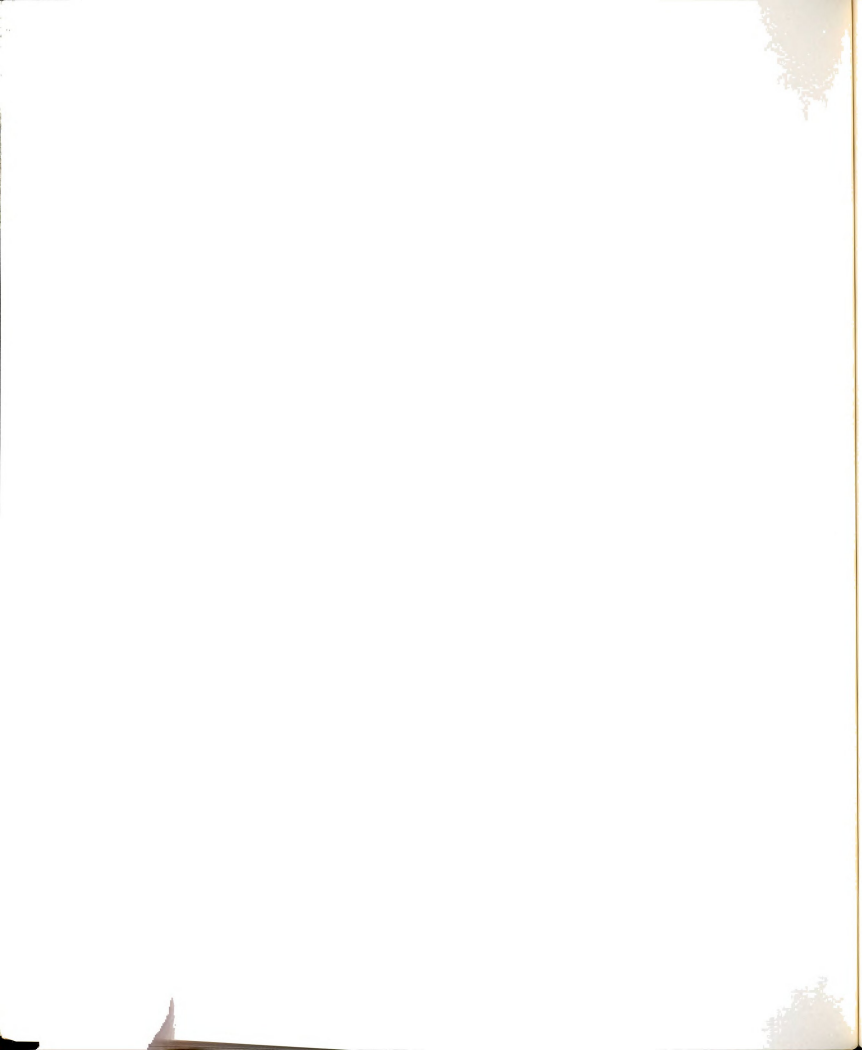


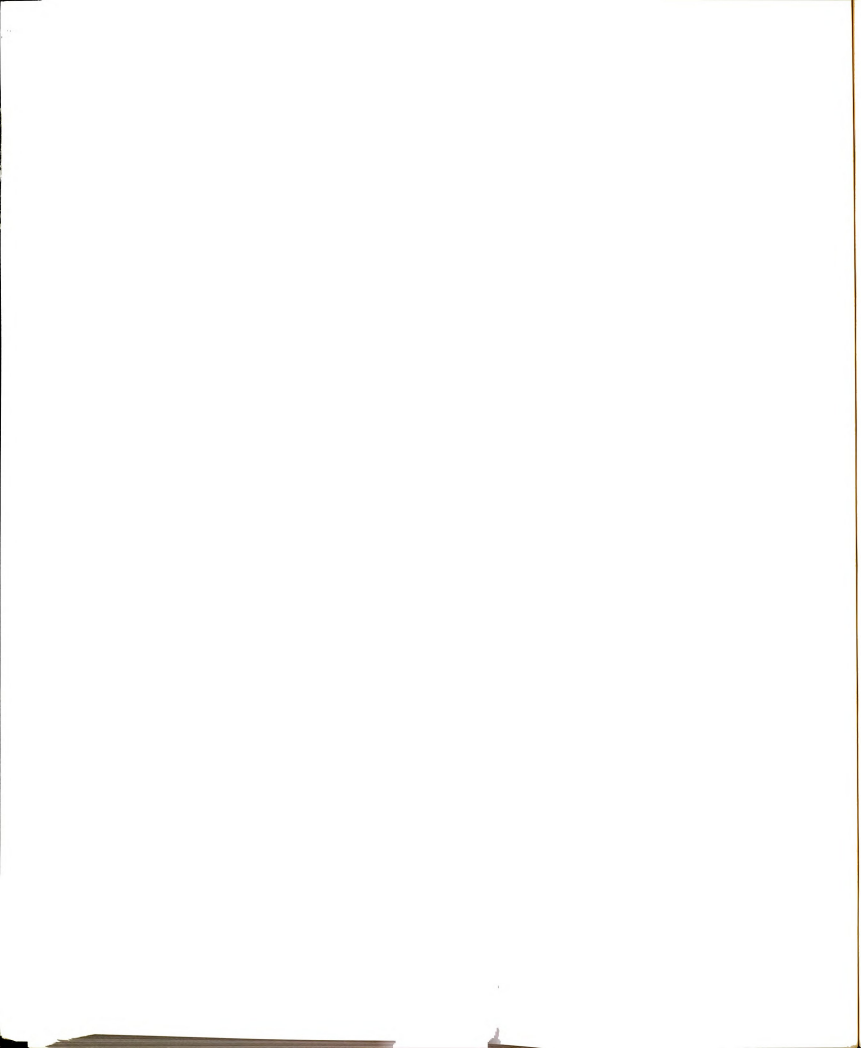
Table 6.1 Important transfer institutions to Michigan State University.

<u>Institution</u>	<u>Frequency</u>	<u>Percent</u>
University ownership and licensing by administration	10	37
University ownership and licensing by external brokerage units	5	19
University ownership and licensing by department	4	15
Joint ownership and development	2	7
Faculty owned companies (Private development)	2	7
Other	4	15

The response to this question indicates that the traditional is viewed as the picture of the future by chairpersons. This view is augmented by answers to later questions but places the anticipated evolution of future activities lies in negotiating rather than in institutions. The added layers of institutional structure such as the centers for commercialization, the centers for interaction, and the local fledgling companies are not perceived as an essential part of future Michigan State University research commercialization.

Question 2: What university do you feel does the best job of getting research products with commercial potential in your field out into the private sector and what do they do?

All 21 chairpersons responded to this question. A few qualified their answer by stating that it applied to all fields of

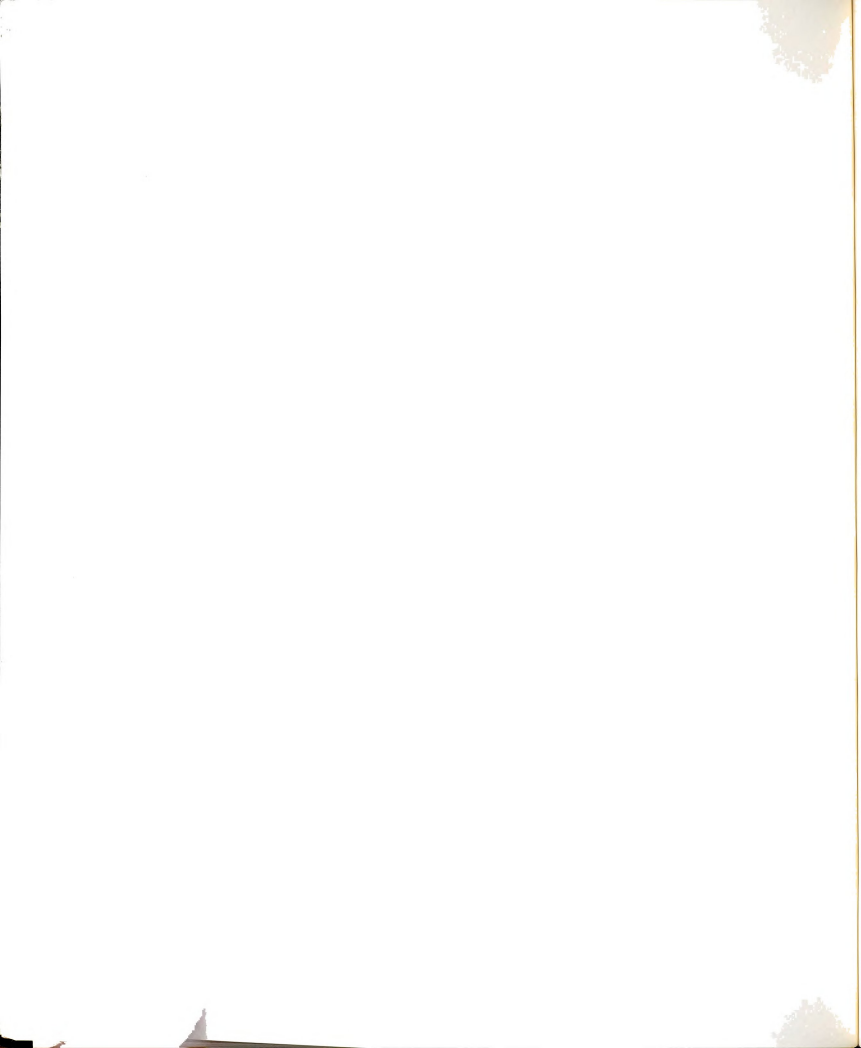


research. The universities, their institutions, and their frequency are reported in Table 6.2.

The single most often mentioned university as a success model was MIT which has structured faculty owned firms and a limited number of sector focused research centers. The next single most mentioned institution was the University of Wisconsin Research Foundation (WARF) but in aggregate, various sector focused research centers were mentioned as often as MIT. The research park concept was given equal standing to WARF but again it fell short of the MIT or sector focused research centers. University administration licensing and affiliated corporations were near the bottom of the list. Interestingly, only one university-industry cooperative was mentioned as a model of success, yet this is a topic of increasing interest and discussion, especially in the electronics industry.

Table 6.2 Best universities and institutions for research commercialization.

<u>University</u>	<u>Institution</u>	<u>Frequency</u>	<u>Percent</u>
M I T	Faculty owned firms	6	20
	Sector focused centers		
U of Wisconsin	Research foundation (WARF)	4	13
U of Utah	Research park	2	7
Stanford U	Research park	2	7
	Flexible administration		
UC Davis	Sector focused research	2	7
Other		15	46



The response by chairpersons to question 2 was almost the inverse of their response to question 1. They do not envision the success models which they have in their mind as the future models for commercialization at Michigan State University. The focus for these models is on institutional structure rather than on negotiating. This might imply that secondary benefits accrue more readily to the university from these structures than their alternatives.

One difficulty with interpreting the answers to this question is that people's perceived notion of success and what is reality are often quite different. A case in point is the example of WARF as a mechanism for research commercialization. WARF has been successful, both financially and with several inventions. However, much of its financial success, and hence its ability to support research at the University, was due to the investment and growth of its assets several decades ago by a member of its board who was also a member of the New York Stock Exchange. Few academicians are aware of this and continue to uphold WARF as a model for research development. Other examples may contain similar twists.

Question 3: University research commercialization is not the most common mode of interaction between academics and their user groups. Should we do more or less of it?

Twenty-one chairpersons responded to this question. There was strong consensus that the University should do more, although chairpersons added some cautionary notes about expanded activities.

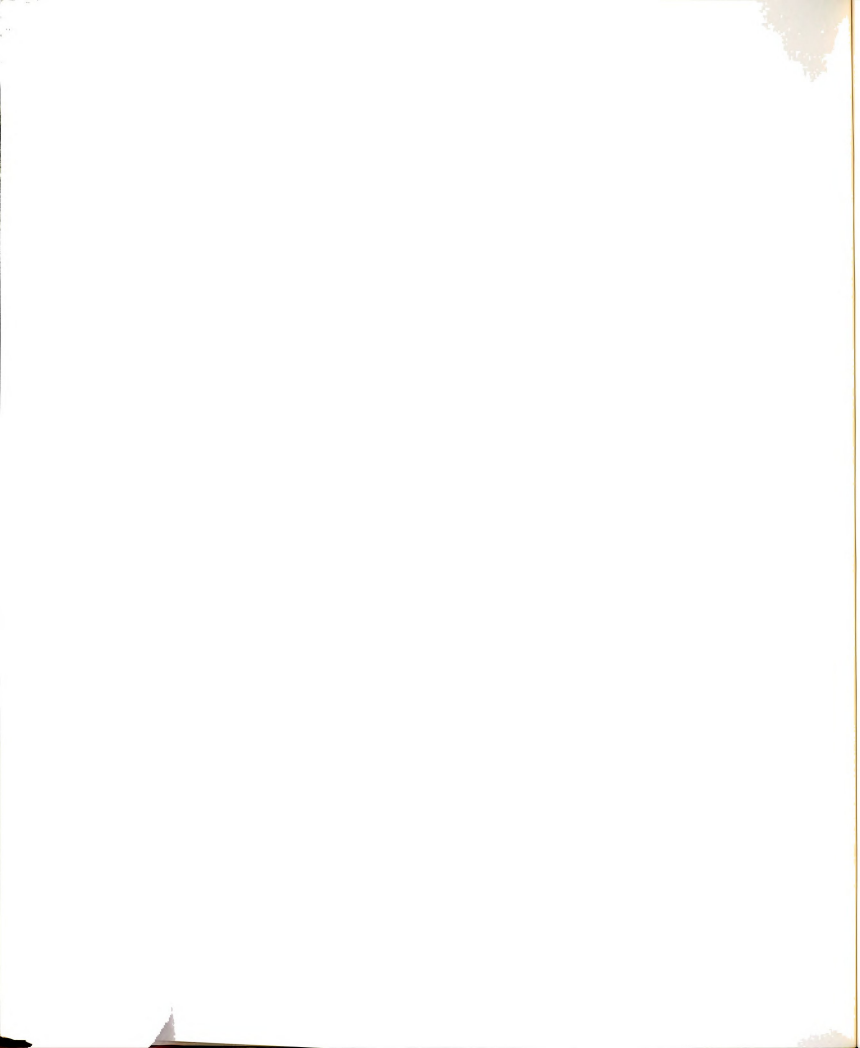
Table 6.3 Reasons and concerns for increased commercialization activities.

<u>Justifiers</u>	<u>Frequency</u>	<u>Percent</u>
Reasons:		
Research dollars and resources	9	38
Makes research available	5	21
Industry interaction and recognition	3	13
State economic development	2	8
Socially ready	1	4
None	4	16
Concerns:		
Maintain basic research	5	24
Education function	3	14
Open publications	1	<5
Time constraints	1	<5
Control or advantage by industry	1	<5
Industry is aware of U research	0	0
None	10	48

Table 6.3 demonstrates the consensus by 17 of the 21 chairpersons for more activities, including the reasons, the concerns, and their frequencies.

The primary reason cited by chairpersons to expand University research commercialization was the possibility of increased research dollars and resources. This was a good sign since a basic premise of this study is that the university is interested in money that is returned for research commercialization. This supports the notion of emphasizing returns to the university rather than just the ability of firms to capture rents.

Other primary reasons for increased commercialization were that it makes research available to the public and that it increases industry awareness. The latter translates into increased support for



research activities. It is interesting that State economic development received infrequent mention as a reason to increase commercialization and this is consistent with the lack of recognition in question 1 that the State commercialization centers will play an important role in future Michigan State University research commercialization.

One-half of the chairpersons that wanted increased commercialization added no cautionary notes. Of the other half, the primary concerns were that the University maintain its basic research and education functions. Structural assurance that the basic research function be maintained by the University can be, and is, incorporated in the investment cost variable of the framework. There is no reason that University policy cannot establish proportional limits for basic, applied, and development research costs undertaken by the University or paid for by industry if maintaining basic research is an academic concern in university-industry relationships. This has already been done by Monsanto and Washington University. It is a proportional figure and it can be negotiated.

Question 4: What have we learned from what has been done?

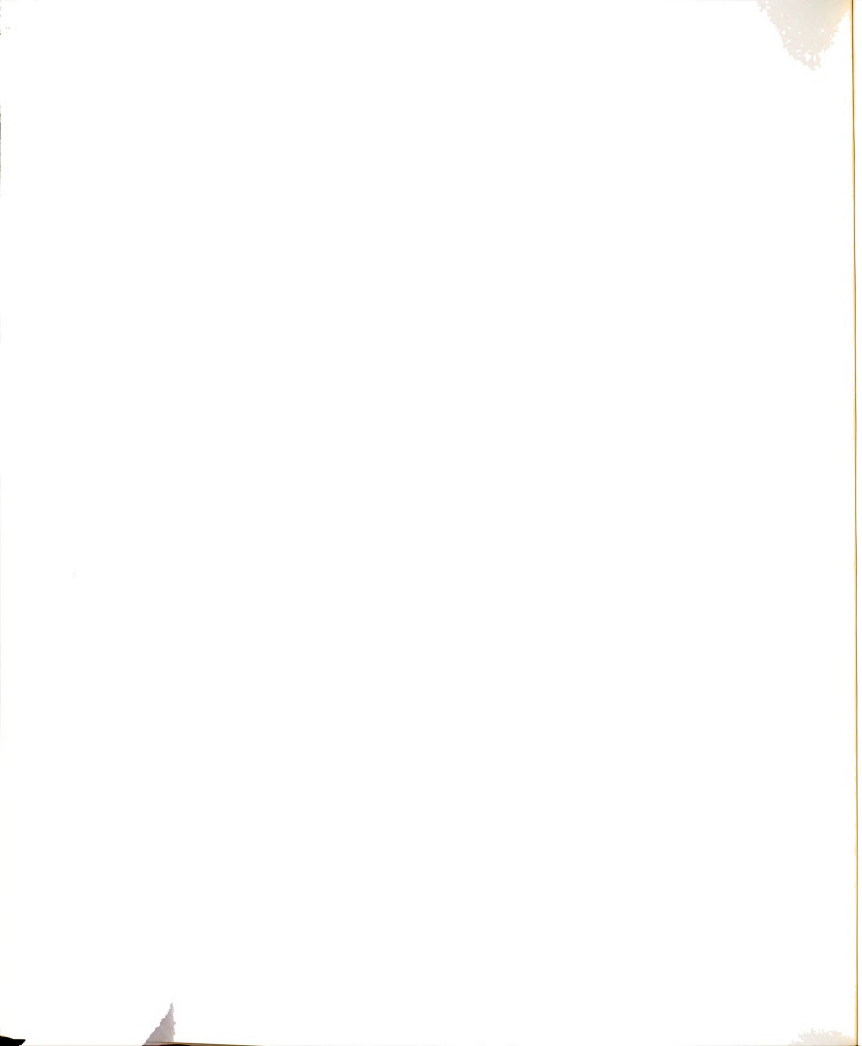
Eighteen of 21 chairpersons responded to this question. While the answers were extremely variable and some did not fit in the context of the framework, they are worth compiling to see the experiences which have been retained. Interestingly, perhaps due to the wording of this question, most were cautionary lessons, not

positive lessons. Table 6.4 presents condensed and tabulated results.

The primary lesson cited by chairpersons is that the University administration needs a better understanding of business and contracts. Secondly, it needs to be both more aggressive and more flexible in assessing and encouraging commercialization. These lessons account for some 39 percent of responses. They are also consistent with the vision that commercialization activities will remain at the University licensing level and not be delegated to second parties, and that the emphasis will remain on negotiating rather than on alternative institutional structures. One recognized problem is that there is no person at the University whose job it is

Table 6.4 What has been learned from past technology commercialization.

<u>Lesson</u>	<u>Frequency</u>	<u>Percent</u>
U administration needs better understanding of business and contracts	6	21
U administration too conservative in assessing and encouraging commercialization	3	11
Literature and markets will develop U research without U efforts	3	11
U administration needs more flexibility in business and contracts	2	7
Chairs and faculty need to document research and dollars	2	7
Other	12	43

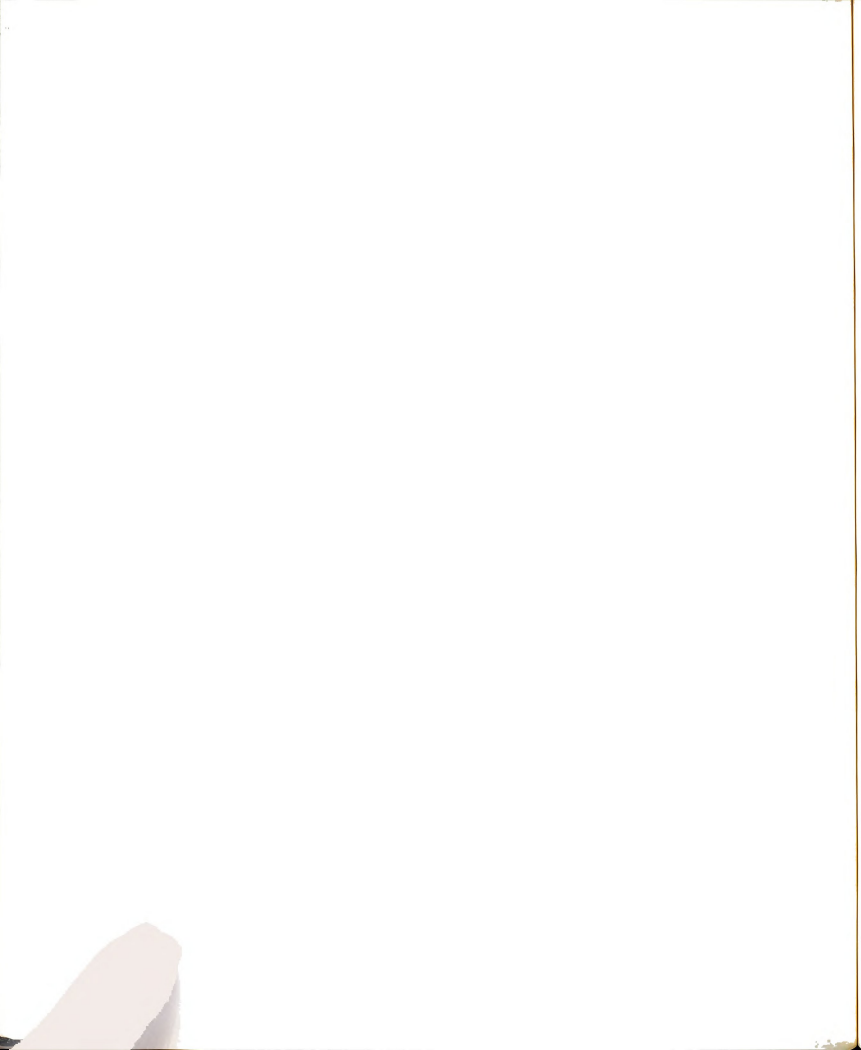


to actively pursue commercialization opportunities. The internal brokerage units may have too many roles to play to be placed in such a position.

Another of the more frequently mentioned lessons was that industry will find research at the University that it wants to commercialize via academic channels without the outward push of the University. This is consistent with some of the reasons given in question 3 for not increasing commercialization activities. It may be the most common way that University research eventually enters markets. That does not imply that it is efficient in returning rents. Publishing and patent disclosures are information costs to the University. If the University is not responsible for initiating development efforts then it is likely that the University will receive few returns.

Question 5: Is it important that Michigan State University be recognized as the source of a new design or technology that goes out to industry. Why or why not?

Twenty-one chairpersons responded to this question and again there was a strong consensus. Sixteen gave answers in the affirmative while four more gave qualified replies. Nearly all chairpersons, however, did say that the University should not endorse a product in commercial markets. Appropriate forms of name recognition have many alternatives and would require some creative marketing. In the interviews, a common form of suggested recognition was a statement to the effect that a given product was developed in

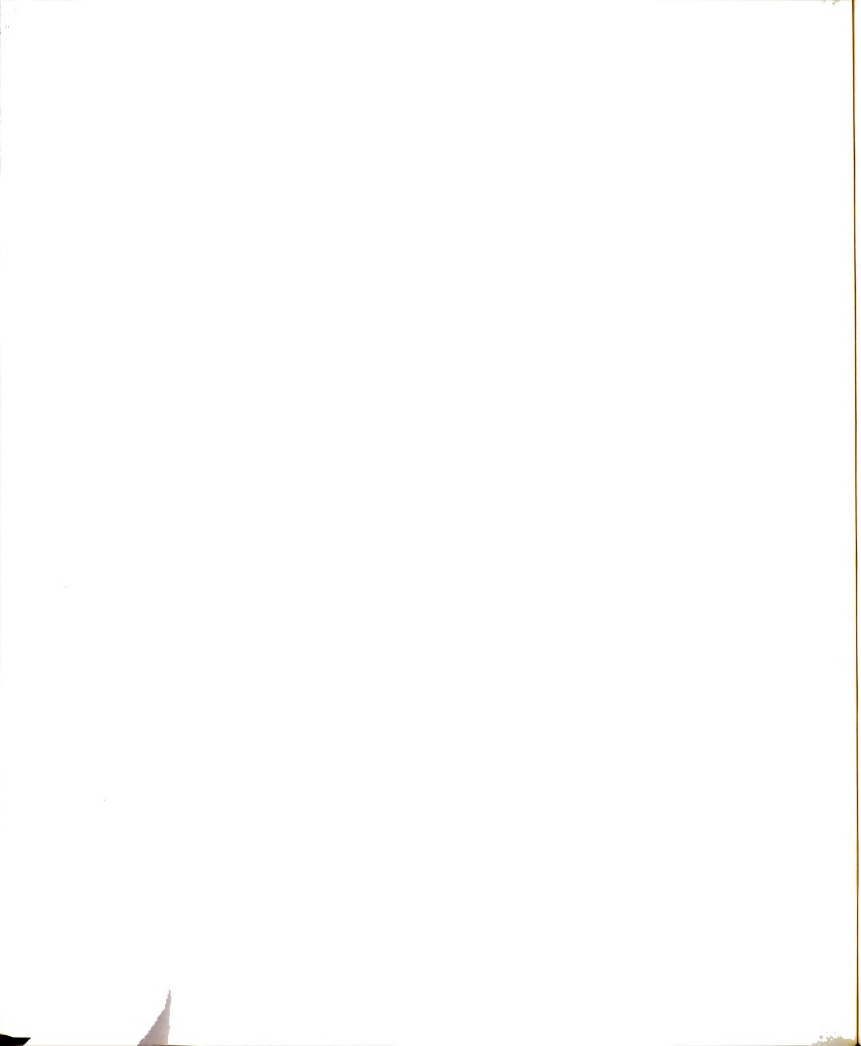


part through research conducted at Michigan State University. The general response and reasons are reported in Table 6.5.

The overwhelming positive response to this question is supported by chairpersons who believe that attaching the Michigan State University name to commercialized research leads to industry, public, and legislative recognition; and that recognition, in turn, leads to dollars and resources. Only one chairman, with real experience, cited a premium value from the University name. There may be three aspects to the use of the University name; an indirect financial effect as suggested by the chairpersons, a price effect as suggested by one chairman, and a marketing effect as suggested in Section 4.3. All are consistent in their expected influence on performance by the transfer firm but the indirect effect is not measured in the study.

Table 6.5 Response to whether the MSU name should be attached to commercialized research.

<u>Response</u>		<u>Frequency</u>	<u>Percent</u>
Yes:	U recognition by industry and public	13	57
	U recognition by legislators	3	13
	Recognition leads to dollars and resources	4	17
	U name adds value to product	1	4
	None	2	9
Depends:			
Yes:	U recognition by industry and public	2	33
	U recognition by legislators	1	17
	If good for commercial development	1	17
	If a humanitarian contribution	2	33
No:	Professionals know anyway	1	25
	If bad for commercial development	1	25
	If not a humanitarian contribution	2	50



Question 6: Please name three products or technologies from other departments at Michigan State University which have been transferred to the private sector.

The results from this question are somewhat surprising. The answers were often not the products, but rather the researchers name or the company name, because the product or technology was not known. These were counted in the results since some recognition was present. Three chairpersons had no trouble naming more than three developed technologies, five named three, two named only two, six could name one, and five could name none.

The frequency of recalled inventions is interesting to observe. Of the fifteen chairpersons that named any other developed technologies, nine named cisplatin. Of the five chairpersons that named only one developed technology, three named cisplatin. The inventions and firms mentioned and their frequency of response are tabulated in Table 6.6.

The obvious success story is cisplatin. There is no question that it has received a great deal of attention and has widespread recognition on campus. What is interesting is that while chairpersons identified strongly with university ownership and licensing of technologies as the future Michigan State mechanism of importance (question 1), and this was the model for cisplatin, they diverged from this in their success models (question 2). Aside from cisplatin the most frequently recalled inventions were from University financed commercialization centers or from faculty initiated companies.

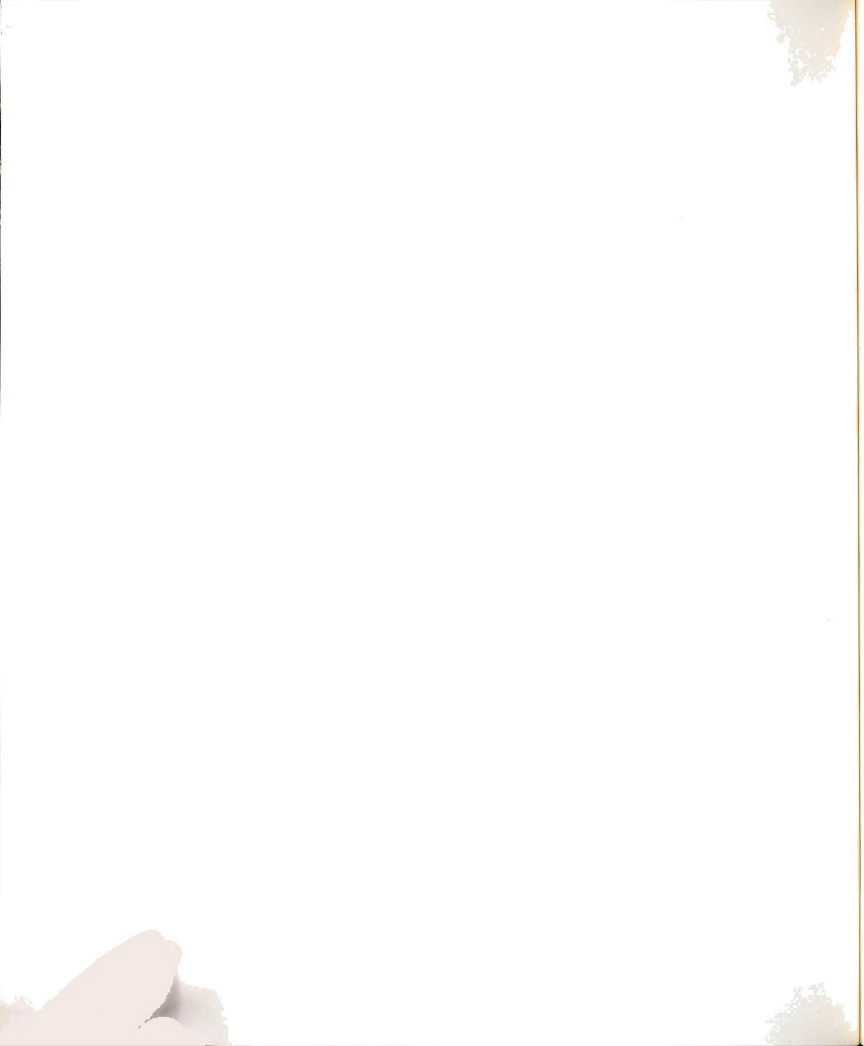
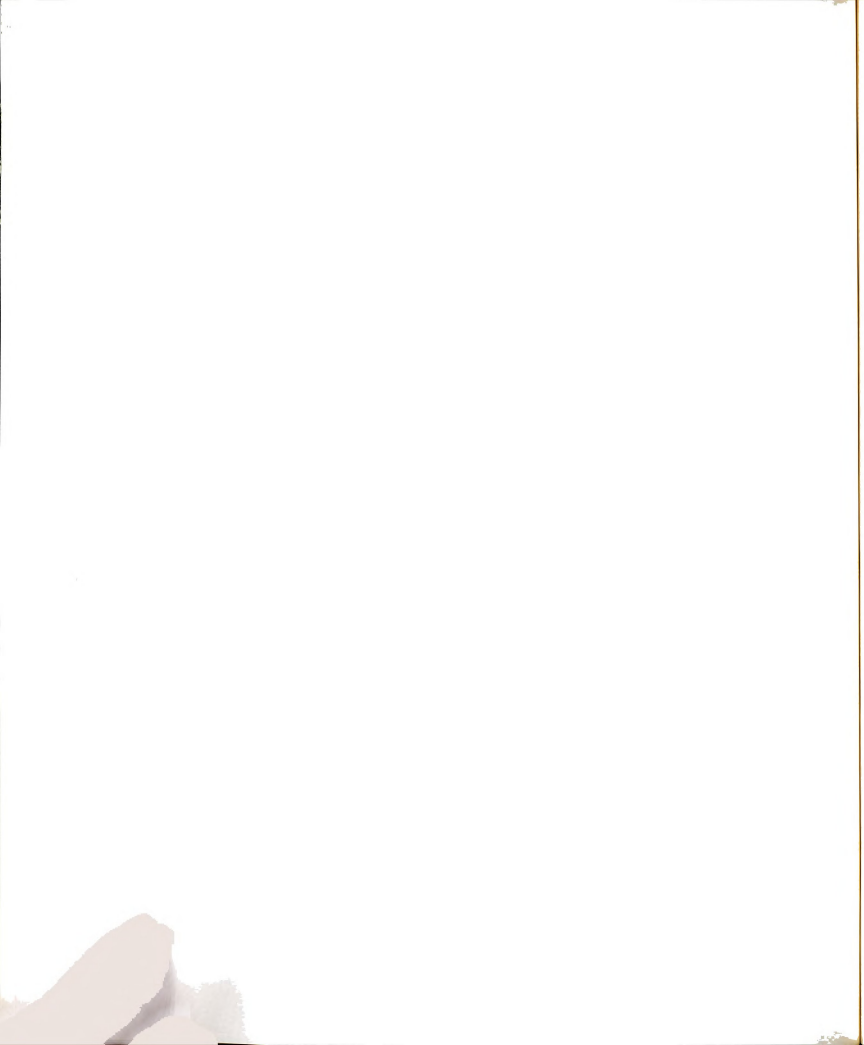


Table 6.6 Products or firms mentioned and frequency of times mentioned by chairpersons in response to question 6.

<u>Product or Firm</u>	<u>Frequency</u>	<u>Percent</u>
Cisplatin	9	21
University financed center (one)	7	16
Faculty initiated firm (one)	6	14
Crop varieties	4	9
Other	16	40

Chairpersons see the importance of name recognition in commercialization (question 5) and feel that benefits accrue to the University from this factor in development. There may be an intangible recognition effect supplied by a closely linked firm which helps explain the strong response for this type of mechanism as a success model (question 2). University licensing to an independent firm may offer the potential to capture greater rents, but there is both a potential loss in returns and a potential loss in name recognition. The value of name recognition and the indirect financial effects using a closely linked firm may outweigh the loss in captured rents from not using an independent firm.

There are a number of commercial success stories stemming from research at Michigan State University. They may not have made the University rich but they could be responsible for image enhancement and indirect returns. If department chairpersons are unaware of these success stories, or at least cannot recall them when asked to do so, how can the University expect to appropriate credit and



returns from industry, the public, or the legislature. It may be necessary to advertise more aggressively in order to maximize those potential credits and returns.

Question 7: What are the current policy needs for product or technology transfer which are not being met at Michigan State University?

Surprisingly, four of 21 chairpersons had no response to this question though the 17 chairpersons that did respond had more lengthy responses than for other questions. It was not difficult to characterize the answers. Their first priority is to increase external communication with industry by University and College administrators and their second (equally frequent but more diverse) priority is to increase internal communication with chairpersons and faculty by University administrators. Some specific suggestions were made on the latter point along with a variety of other policy suggestions. The general responses are reported in Table 6.7 along with their frequency of response.

The policy suggestion of increasing external communication with industry was centered around action by University and college administrators, at least for initial efforts. While there is a perceived need for increased external communication, there may be a lack of awareness of just what is being done by the University. Most chairpersons were either unaware of, or uncertain of, activities by the Industry Development Institute (this reflects the chairpersons's second response for increased internal communication). In addition,

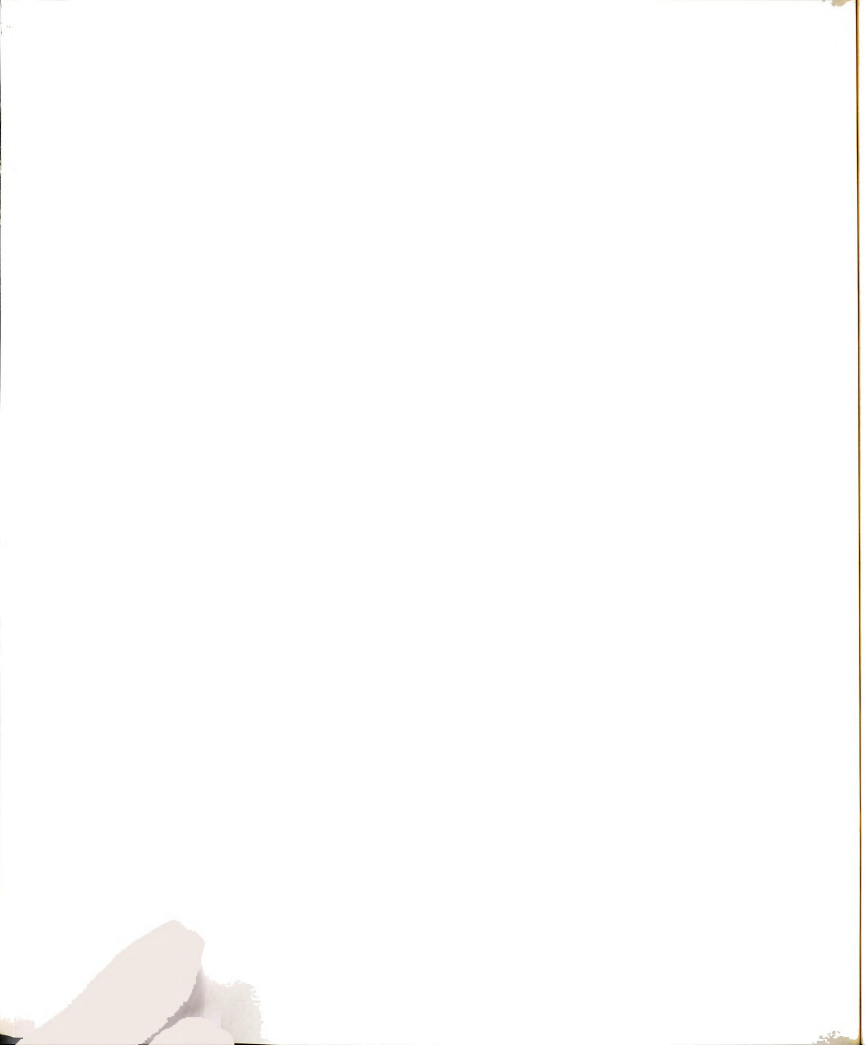
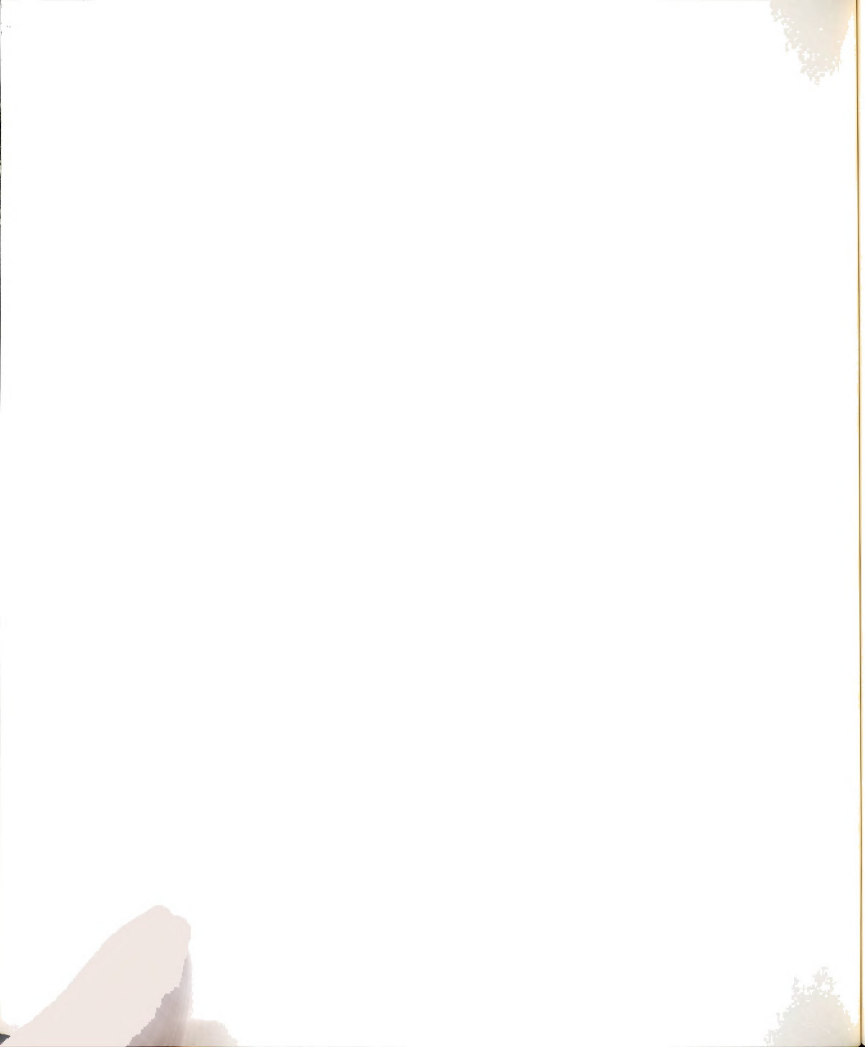


Table 6.7 Policy considerations for increased research commercialization at Michigan State University.

<u>Current needs</u>	<u>Frequency</u>	<u>Percent</u>
Increased external communication with industry by University and College administrators	12	28
Increased internal communication with chairs and faculty by University administrators	12	28
- Identify alternatives for commercialization		
- Identify policy and procedures for commercialization of products, software, and books		
- Role models for networking and marketing		
- Workshops on administration, legal and business aspects, and ethical issues		
Increased business, contract, and market assessment	4	9
Patent ownership flexibility	3	7
Other	12	28

while the academic response has been to establish a multitude of on-campus institutes for industrial interaction, these are not seen as taking the place of communication by administrators.

The policy suggestion of increasing internal communication with industry was also centered around action by University administrators. There is little doubt that chairpersons want to increase commercialization activities (question 3) but there is a great deal of uncertainty at the departmental and faculty level about what the options are, what steps are involved with each option, and what the costs and benefits might be. They need help with this information in order to pursue opportunities more aggressively and make educated choices in those pursuits.



Question 8: What institutional arrangements promote or inhibit the return of economic benefits to the University by a product transfer mechanism?

Only 14 chairpersons had a response to this question. There are several points which confirm policy issues identified in other questions and some unique issues not brought out elsewhere. Some interesting results turned up and these are reported in Table 6.8 along with their frequency of response.

It should be noted that all reported responses, which reflect actual responses, are points which inhibit economic returns. It should be said that the recent change in the royalty distribution policy, the efforts by the Administration in accommodating and experimenting with new relationships, and the perceived current environment were recognized as positive forces in promoting economic returns to the University.

The most frequently mentioned institutional barrier was the lack of recognition for faculty involved with technology transfers. There may be an interest in crediting faculty with technology transfer activities for tenure and promotion. The second most frequently mentioned barrier was the University mission and its public ethics.

University patent ownership and University overhead were again identified as barriers to economic returns to the University. Contract inflexibility is an administrative issue but was identified as a barrier to economic returns.

It is interesting that two University services, the consulting practice and the extension service, received comments as being

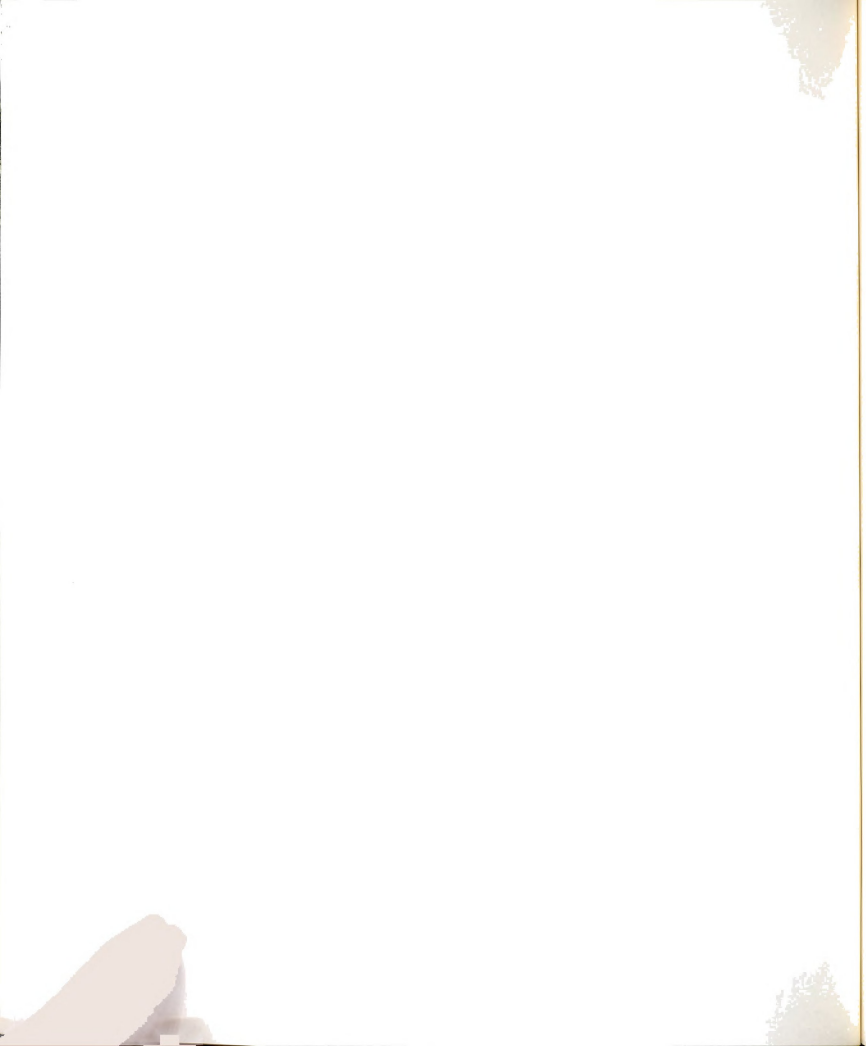


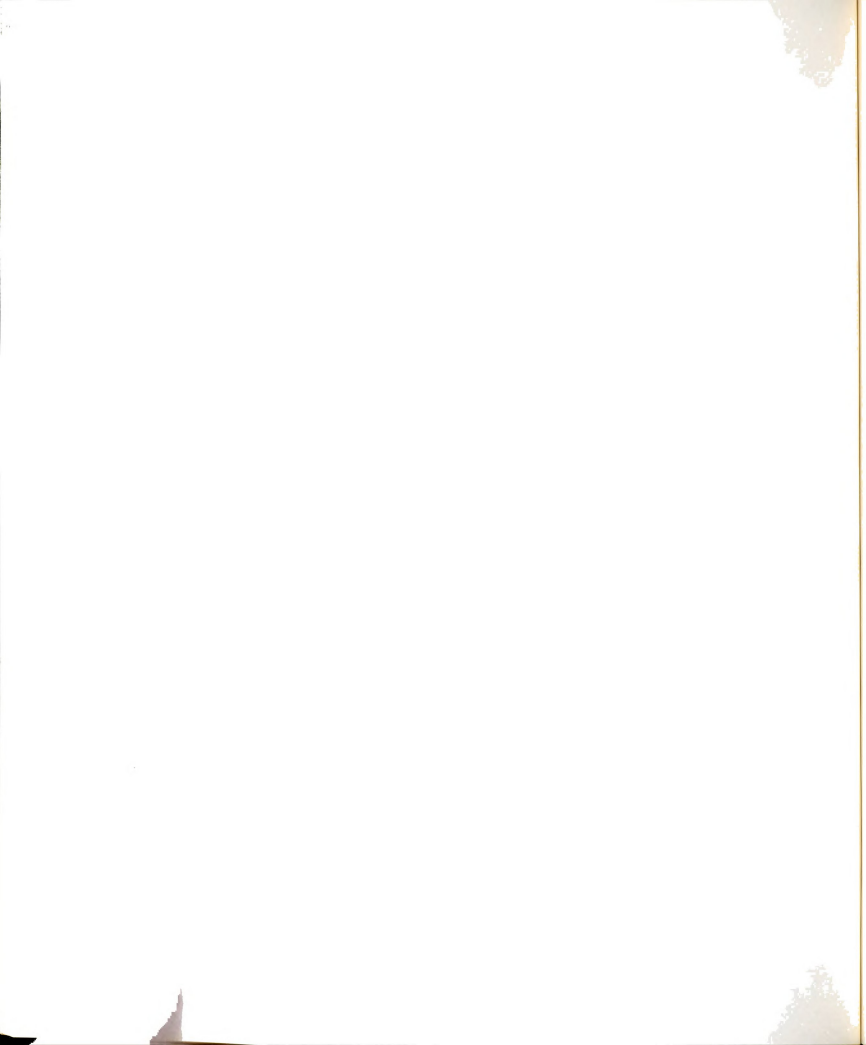
Table 6.8 Institutional arrangements that inhibit economic returns to the University.

<u>Institutional arrangements</u>	<u>Frequency</u>	<u>Percent</u>
Lack of recognition for faculty involved with technology transfers	4	15
University mission and public ethics	3	11
Patent ownership policy	2	7
Contract inflexibility	2	7
University double-dips - overhead and licensing	2	7
Consulting practice limitations - look at alternatives	2	7
Other	14	46

limiting in their current format. Suggestions were made that the University might possibly benefit from evaluating creative alternatives which augment the potential for recognition of faculty using these routes and augment the direct or indirect returns to the University by clientele using these routes.

Question 9: What are the major conflicts between academic goals and commercialization of University research?

Twenty-one chairpersons had a response to this question though it often occurred during an earlier part of the interview and they referred to it when asked this question. The primary concern seemed to be free information exchange and changes in publication rights. There was also agreement that time and resource conflicts in the



University were a problem. This was perhaps best stated by the chairman who was concerned that we expand the size of the pie, not just cut smaller pieces. The responses and their frequencies are compiled in Table 6.9.

Time allocation in the University is a structural issue that is not included in this study. The concerns are perhaps related more to monitoring and enforcement of current policies than of the policy itself since all appointments have time allocations stipulated in the contract. Resource allocation is a structural issue for its financial aspects which were discussed in question 3. Resource allocation for University space and facilities devoted to commercialization activities is a real problem which is not included in the discussion.

Free information exchange and publishing are structural issues identified by chairpersons as a conflict between academic goals and commercialization. There is no resolving this conflict. It will remain a tradeoff between the academic and entrepreneurial tendencies of any given faculty member. Patents and delayed publications are the currently accepted mode for campus development activities. One reason that the trade secret route has not found greater acceptance on campus is that it implies not publishing rather than delayed publishing. As patent and publication screening methods become more sophisticated (electronic data bases) there may be more use of trade secrets. This would lower information costs to the transfer firm and encourage returns to the university.

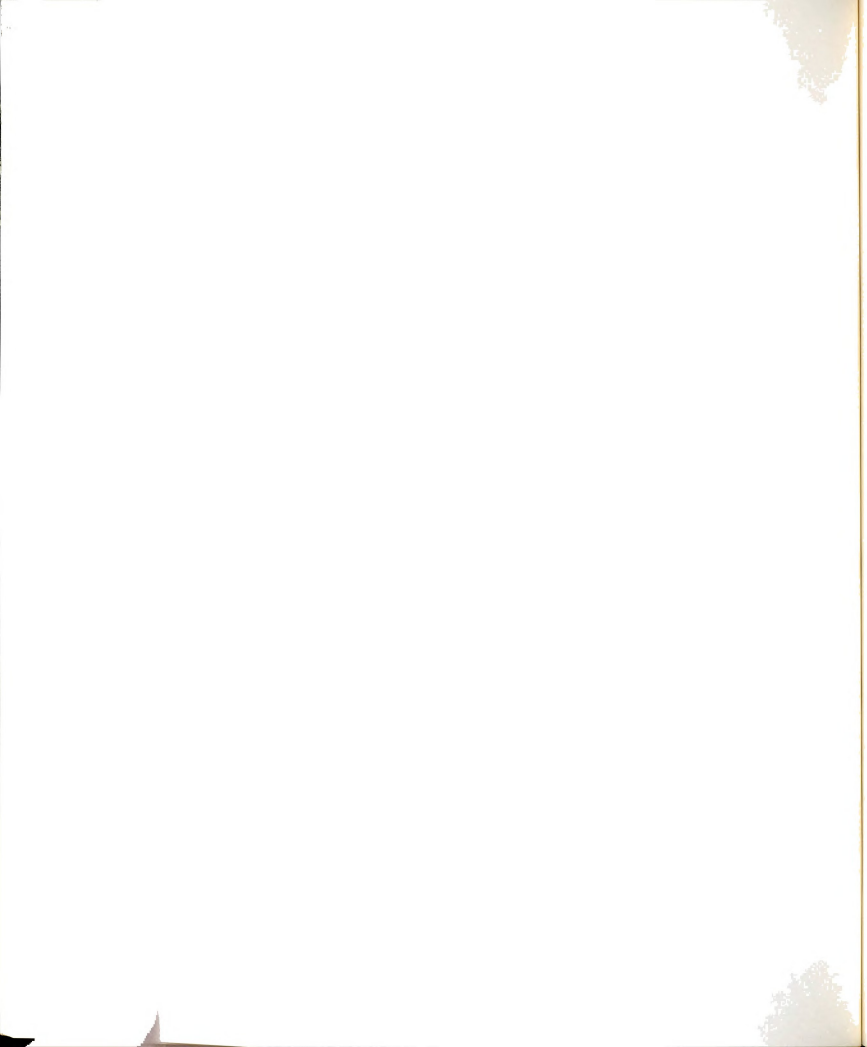
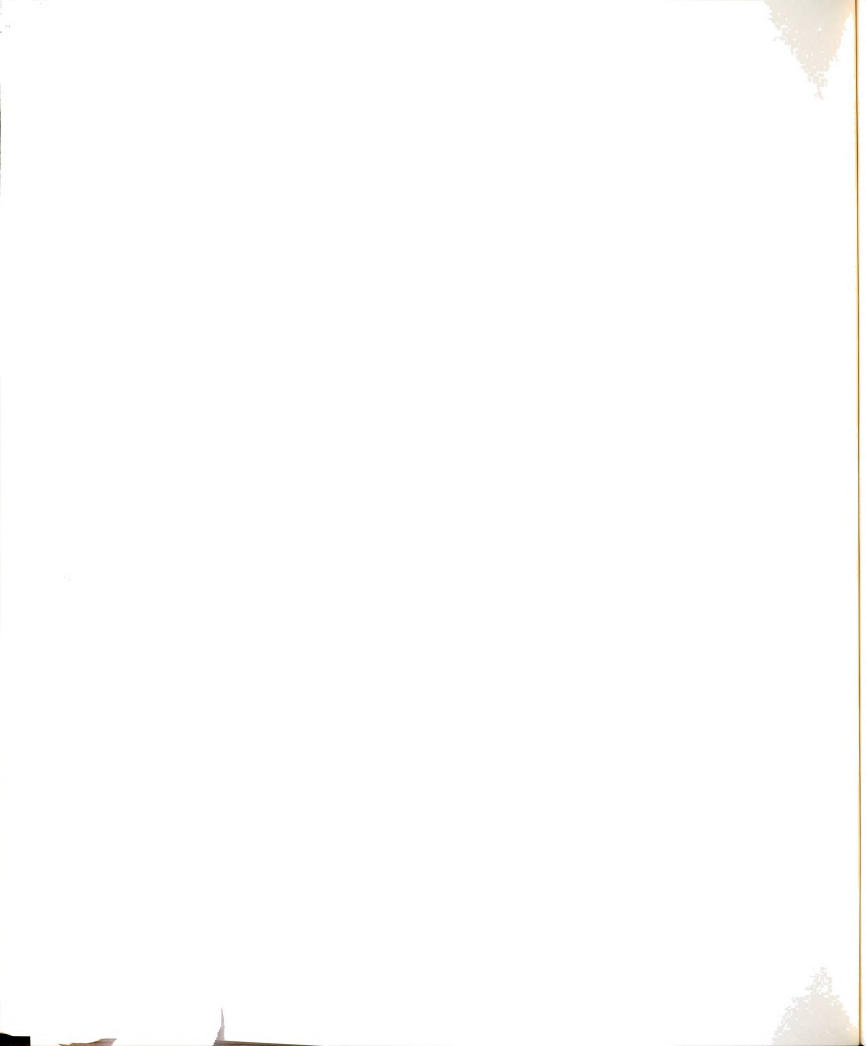


Table 6.9 Conflicts between academic goals and research commercialization.

<u>Conflicts</u>	<u>Frequency</u>	<u>Percent</u>
Time and resource allocation in the University	9	26
Free information exchange and publishing	8	24
Mission (education and extension) leads to non-commercial values	5	15
Fundamental research problems versus problem solving for dollars	5	15
Product development time in University is extended	4	12
Other	3	8

There is no question that other conflicts include the mission and research time-frame of the university which do not match the current values of U.S. industry. The mission conflict in which the University is committed to the public good, and the time-frame conflict in which the University takes longer to research and develop a product, may in some ways be a benefit to commercialization. The perceived value of the University mission, and the longer time and testing for product development at the University, may increase the ability to price and sell the technology. As long as these remain in conflict with the private sector there may be some value to them. When there is no longer any conflict the value may be lost.

The other frequently mentioned conflict was fundamental research versus problem solving research at the University. Again, this can be a committed policy structured into any institution (policy) or



relationship (contract) which that institution enters. Perhaps it should not be viewed as a conflict but rather as a choice.

Question 10: What are the most important issues regarding the broader area of university-industry relationships?

While the respondents reiterated several points already discussed in the interview a few new ones did turn up. Table 6.10 presents the condensed answers and their frequency from 17 respondents.

The issue of communication with industry topped the list. Following that was the issue of academic freedom. These are not new responses. A third issue was the increased understanding and formalization of ground rules for the new university-industry relationships. This reflects their evolutionary stages.

One of the more interesting comments not previously mentioned was the need to smooth out the cyclical nature of university interest in expanding its corporate connection. This cycle can be tempered by imposing and monitoring limits as already discussed (question 3 and question 9) but this remains an administrative choice. Such a cycle might not occur if industry relationships were not perceived so much as a way to acquire funds (contracts, royalties or otherwise) but as a way to expand opportunities. Such an attitude would preclude the basis for this study. However fiscal realities set in and a focus on the financial opportunities for technology transfer surface.

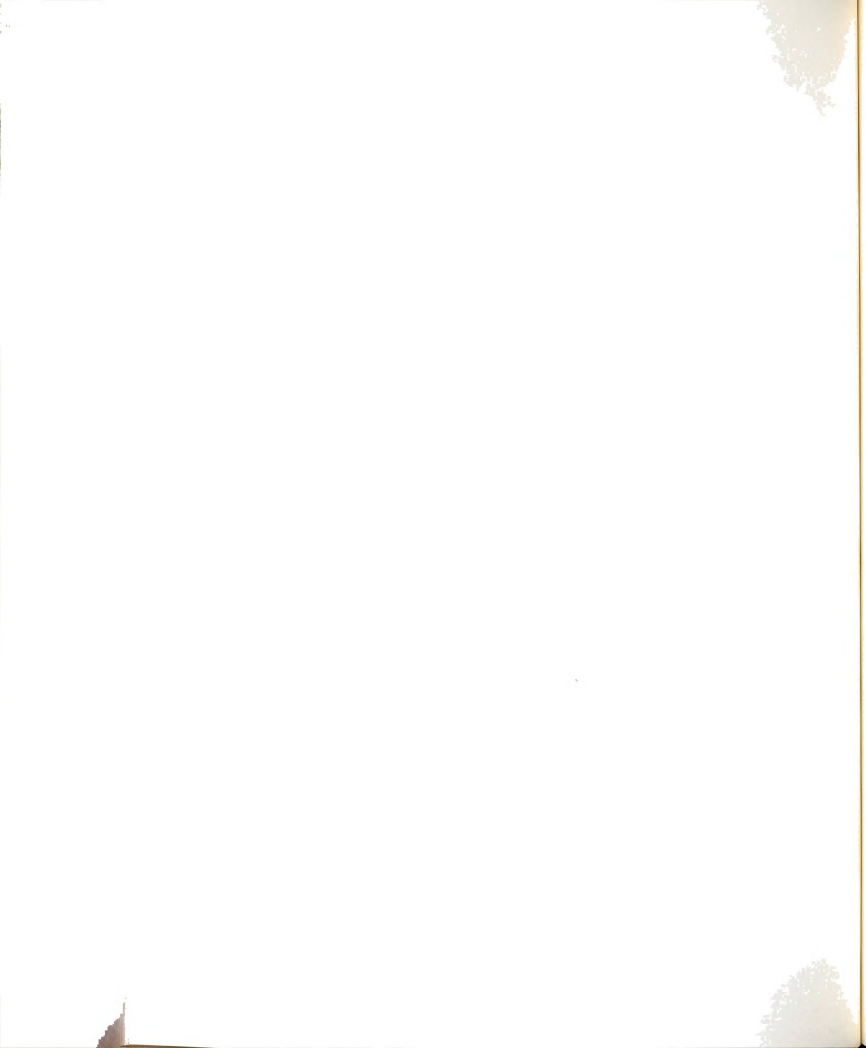


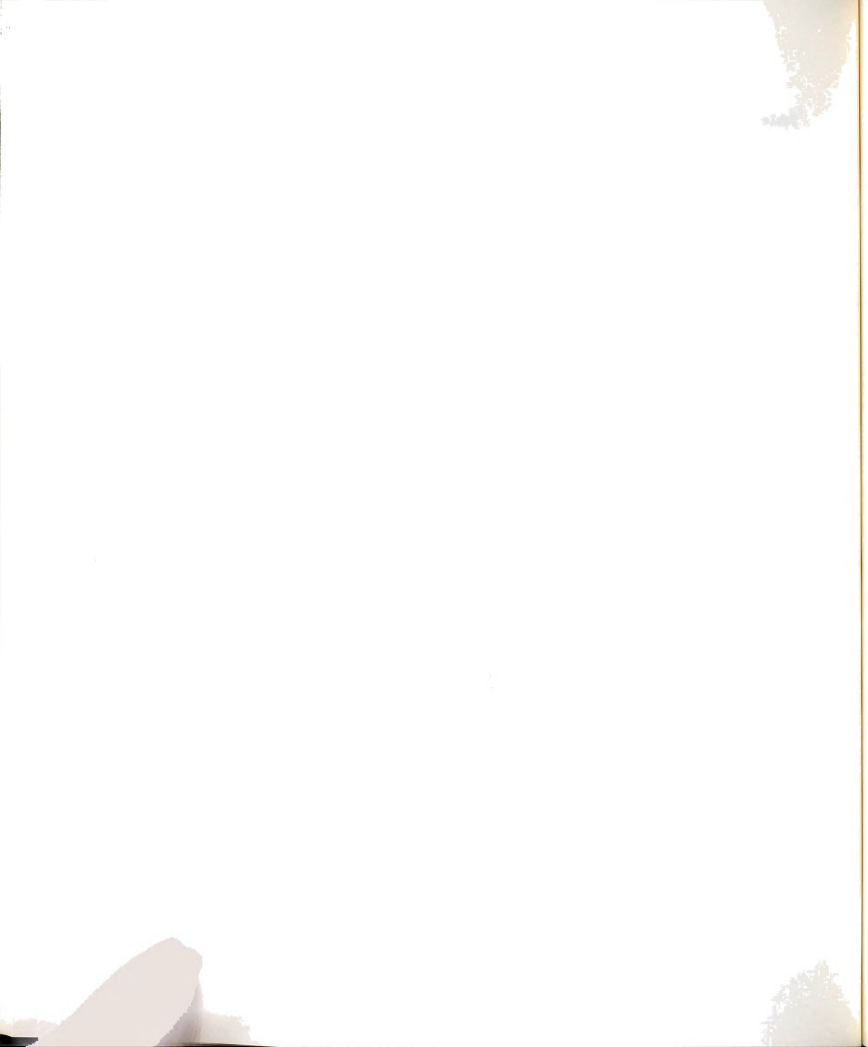
Table 6.10 Important issues in university-industry relationships.

<u>Issues</u>	<u>Frequency</u>	<u>Percent</u>
Communication and cooperation with industry	7	26
Academic freedom	4	15
Understand and formalize the ground rules for research centers and other mechanisms	2	7
Other	14	52

6.4 Interview II: Influence of Structure on Performance

Seven different firms were interviewed in the second part of this study. Two of the seven firms had enough internal structural variation and differentiation in performance that they are treated separately in the presentation of the results. One of the seven firms had a technology whose economics could not be resolved into user cost savings. Data on this firm are not presented in the analysis although comments on pricing and policy issues are considered in the discussion.

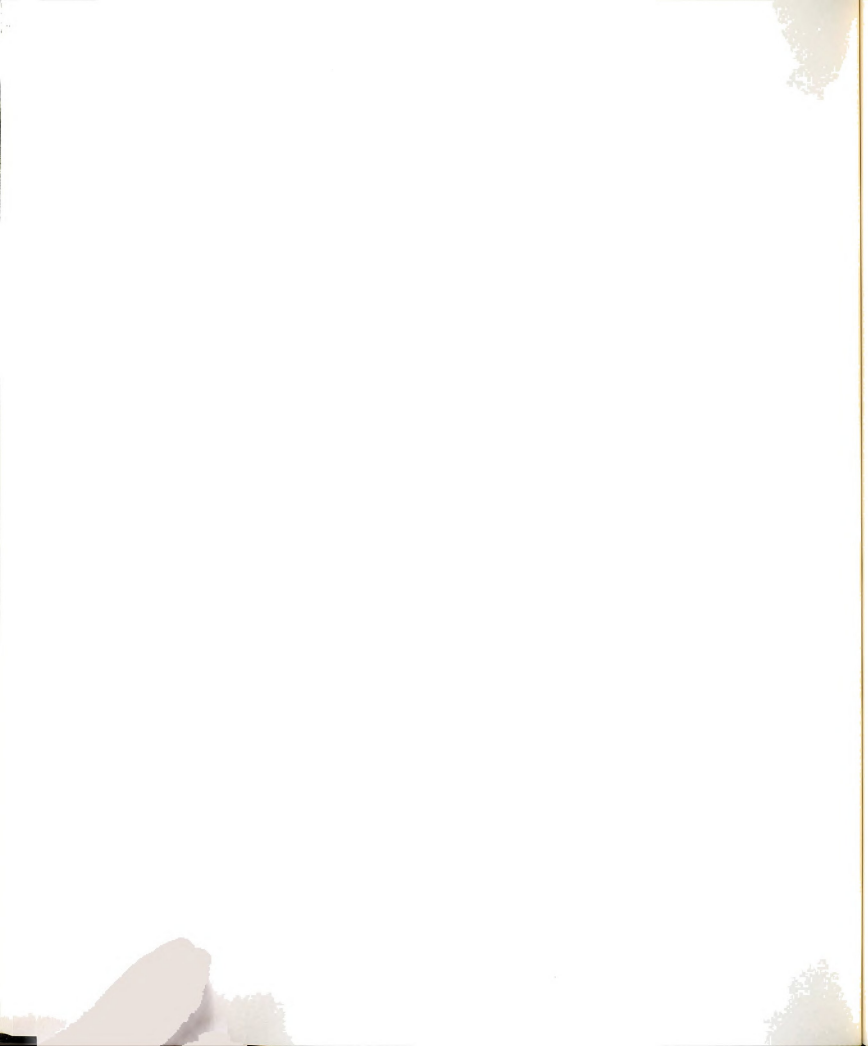
In this section eight distinct structures (representing six of seven firms) are identified, their performance is given a range, and a set of tables presents this information for consideration of the five hypotheses outlined in Section 4.3. The next section of this Chapter presents some policy issues discussed during Interview II. The final section of this Chapter compares the study results to the expected outcome of influence on performance by the variables included in the hypotheses.



Due to the small sample size, the use of non-random sampling procedures, and the nature of the data, statistical tests of association or inference should not be used. This position was supported by Pigozzi (1988). They are, however, presented in familiar $n \times n$ tables for ease of interpretation. While the hypotheses of Section 4.3 cannot be tested statistically, each variable of interest can be discussed as an allowable condition rather than a causal condition. Apparent results can then be compared to expected results.

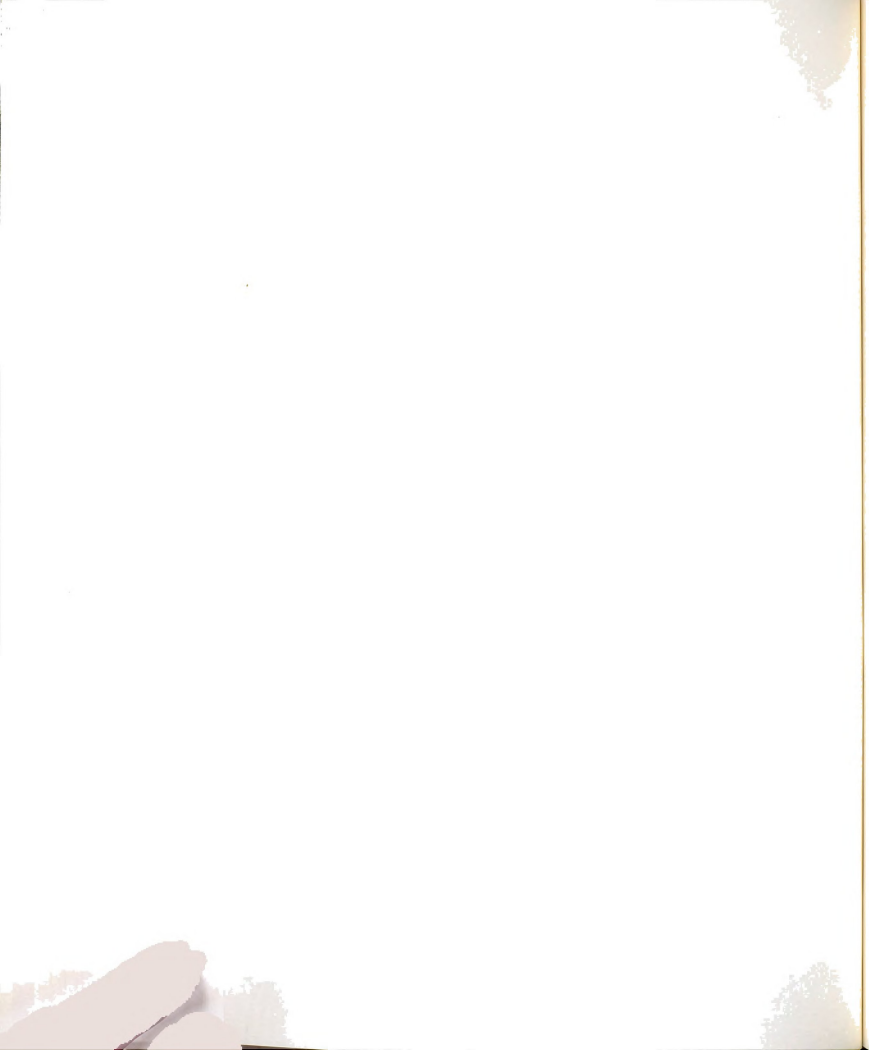
Figure 6.1 presents the structural characteristics of the firms interviewed for this study. Financial and administrative controls are outlined in Section 4.3.1. Economic objectives are outlined in Section 4.3.2. Property ownership and licensing rights are outlined in Section 4.3.3. Information costs are outlined in Section 4.3.4. Investment costs, administrative costs, overhead, policing costs, and patent costs are outlined in Section 4.3.5. License fees, minimum royalties, and rents are discussed in this section. Figure 6.1 also presents the performance of firms interviewed for this study for the percentage of available rent captured by the firm, and the percentage of available rents returned to the University. A third performance measure presented in Tables 6.11 - 6.21 is the percentage of available rents returned to the University. This is simply the product of the first two measures.

The firms interviewed for this study range from internal University facilities to closely associated private firms to disassociated University licensees. Two have non-exclusive



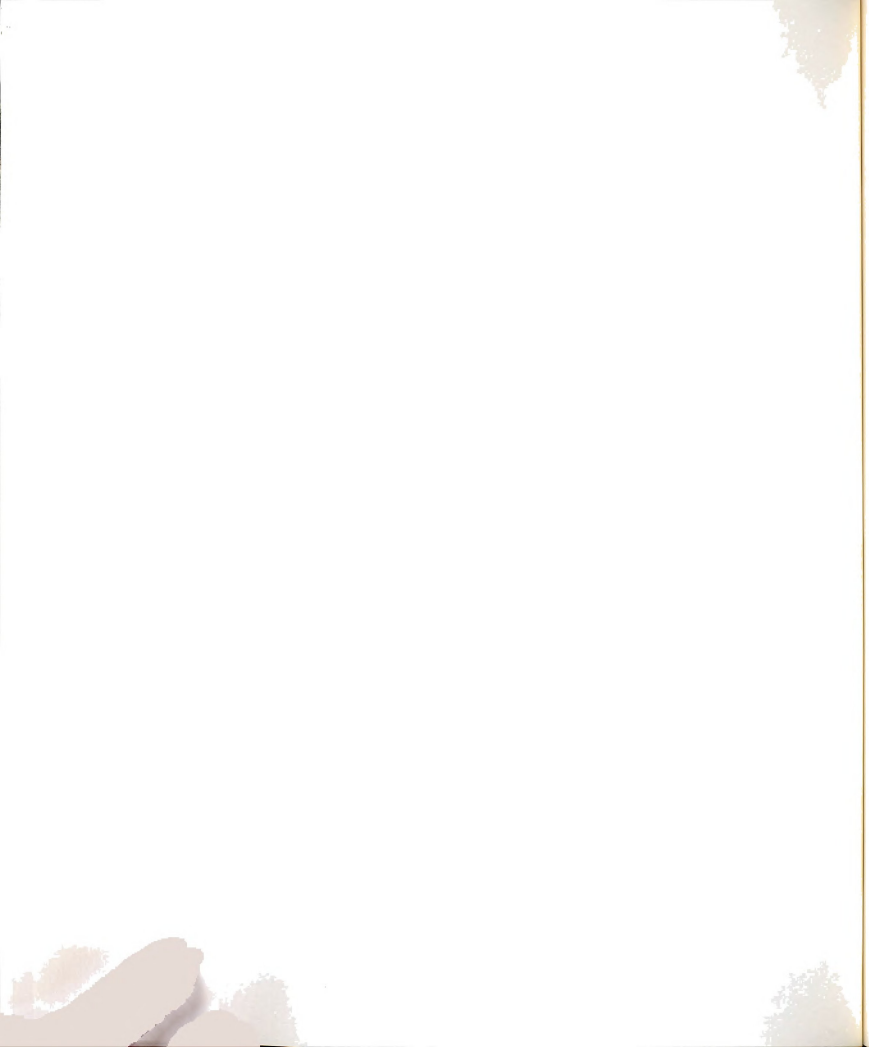
Firm	A	B	C	D
Financial Control	Private	Mixed	Mixed	Private
Administrative Control	Private	Mixed	Mixed	Private
Economic Objective	Profit/Quality	Growth/Quality	Growth/Quality	Growth/Quality
Property Ownership	University	Private	University	University
Licensing Rights	Multiple	Exclusive	Exclusive	Exclusive
Quality Control: U	Yes	No	No	No
Information Costs: U	No	No	No	No
Investment Costs: Firm	Yes	Yes	Yes	Yes
Administrative Costs: Firm	Yes	Yes	Yes	Yes
Overhead on Returns	No	Yes	Yes	No
Policing Costs: Firm	No	Yes	Yes	Yes
Patent Costs: Firm	No	Yes	Yes	Yes
License Fee	No	No	Yes	Yes
Minimum Royalty	No	No	Yes	Yes
% Captured	0-5	25-75	5-25	5-25
% Returned	25-100	0-5	5-25	5-25

Figure 6.1 Structural characteristics of six firms (or eight identified structures) from Interview II.



Firm	E	F	G	H
Financial Control	Private	Private	Public	Mixed
Administrative Control	Mixed	Mixed	Public	Public
Economic Objective	Quality/ Quantity	Quality/ Quantity	Quality/ Research	Quality/ Research
Property Ownership	University	University	University	University
Licensing Rights	Multiple	Exclusive	Exclusive	Exclusive
Quality Control: U	Yes	Yes	Yes	Yes
Information Costs: U	No	No	Yes	Yes
Investment Costs: Firm	No	No	Yes	Yes
Administrative Costs: Firm	Yes	Yes	Yes	Yes
Overhead on Returns	No	No	No	No
Policing Costs: Firm	No	Yes	Yes	Yes
Patent Costs: Firm	No	No	Yes	Yes
License Fee	No	No	No	No
Minimum Royalty	No	No	No	No
% Captured	0-5	25-75	25-75	25-75
% Returned	25-100	25-100	25-100	5-25

Figure 6.1 (cont'd.).

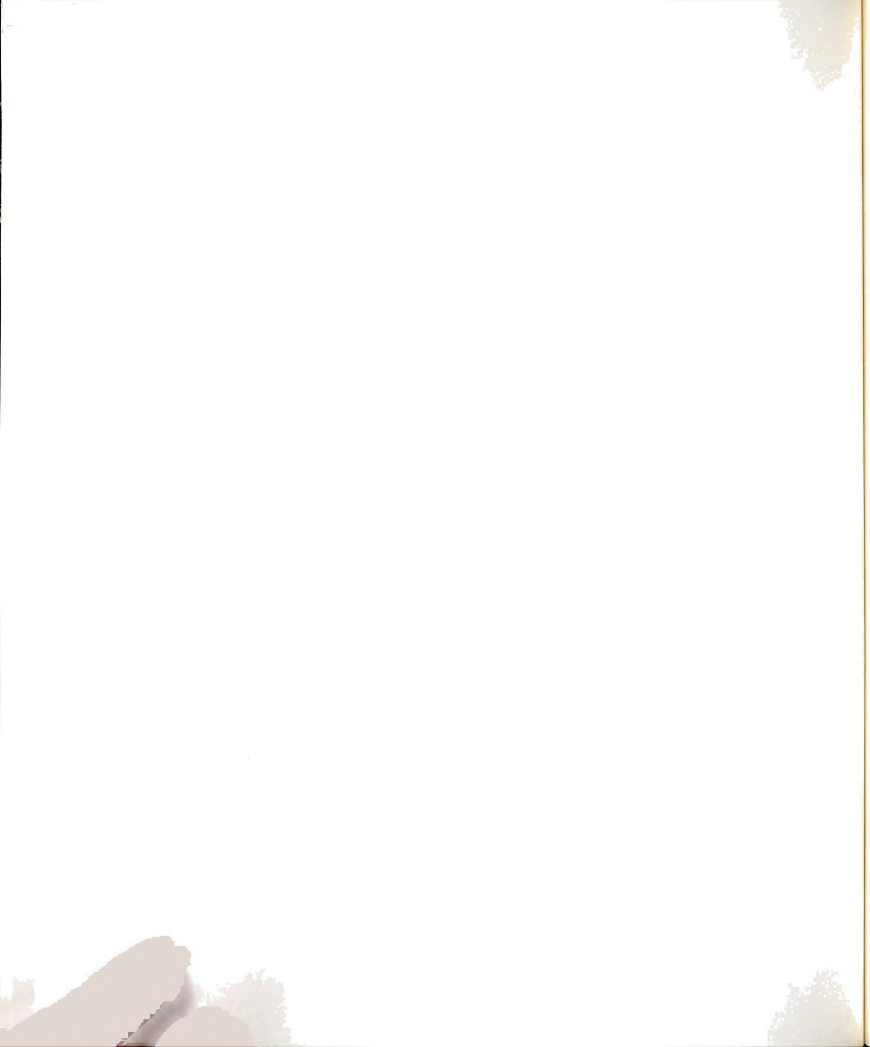


licensing, one has private ownership of University research, two have joint ownership of the firm, five deal with genetic stock, all deal with new technologies, and all appear to be concerned with quality, either primarily or secondarily. The exact combinations are seen in Figure 6.1.

Measuring performance through the proxy of captured rents in the form of user cost savings was a difficult choice when developing this study. Technologies can be perceived in this manner but most firms do not make in-depth analysis of the numbers. Six of nine institutions had previously thought about user cost savings and had ideas as to what these values were even though they were not always used in pricing. The results of this study are not representations of an exact dollar cost analysis but are a reflection of discussions with the firm representatives regarding user cost savings. In some cases, this part alone of Interview II lasted up to one hour in length, being representative of the excellent cooperation and interest shown by participants.

Three firms (four structures) generally operate on a cost plus basis. One of these structures also prices to maximize quantity sold. Current cost of substitutes and user willingness to pay are also considered. One firm (two structures) uses auction bids or prices to enter markets and then charges maximum user willingness to pay. Another firm tries to estimate user willingness to pay and prices by perceived values. All firms charge to cover costs.

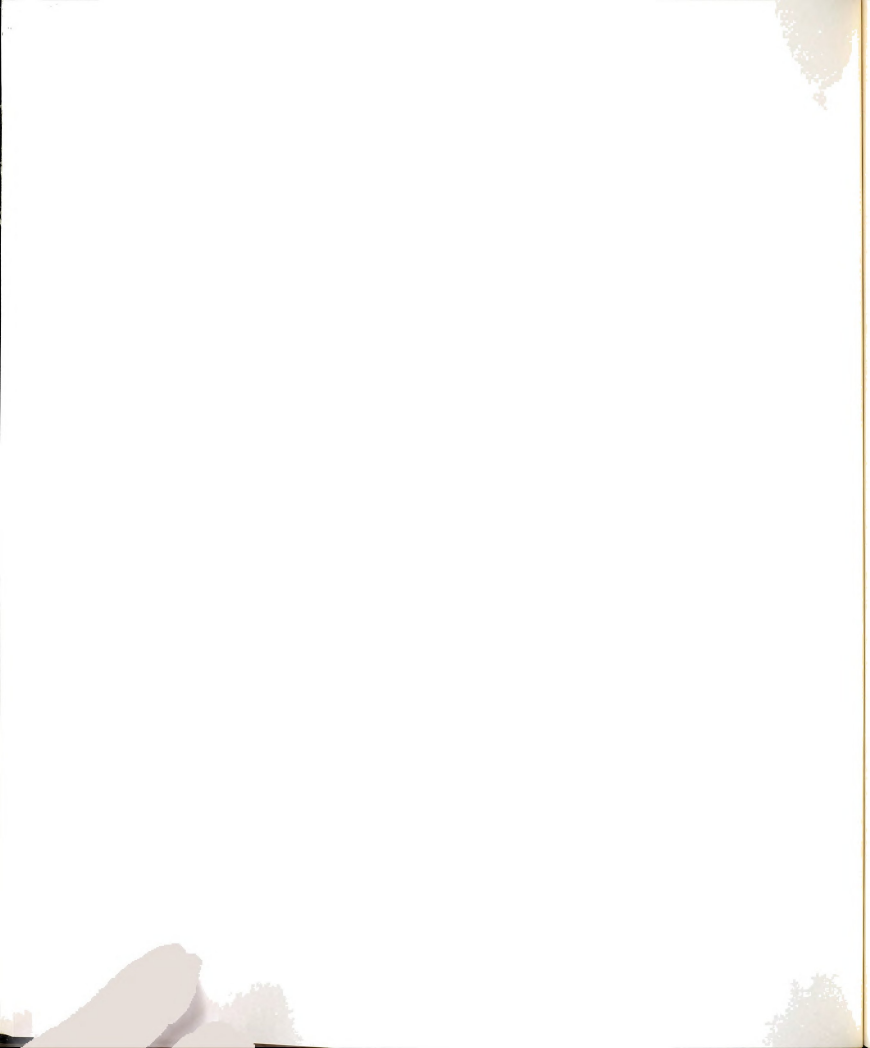
In one case a user cost savings approximation could not be estimated and these data have not been included in this section.



Perceived value was available in this case but not costs savings. The firm representative encouraged me not to use this value. Multiple cost savings were suggested by six structures. In most cases however there was one cost savings that had firmer numbers associated with it and this is the figure that was used. This choice to limit possible user cost savings inflates the percentage captured by the firm and the percentage returned to the University. The decisions were made as consistently as possible given the diverse nature of the data. Including the alternatives usually did not shift the results from the given ranges.

When cost savings could be carried out over the life of a machine or several generations of genetic stock they were limited to the first two years. Several reasons led to this choice. New technologies may have hidden costs which surface during later periods, advantages of genetic stock may be diffused over time, user cost savings are less certain in later periods, and future technologies will preclude the user cost savings in one to several years so that a new choice of technologies and inputs can be made by the user.

The representative for Firm A did not give exact numbers for pricing or cost savings so prices from an identically structured firm were used in conjunction with user cost savings estimates by a representative of the inventor. This was possible because of multiple licenses and close working knowledge of several University representatives. The savings used was a one-time production cost savings.



The representative for Firm B gave two estimates for two similar uses of the user cost savings of the invention. Both fell within the same range on the scales chosen for the study. The savings was a unit cost savings over the closest substitute.

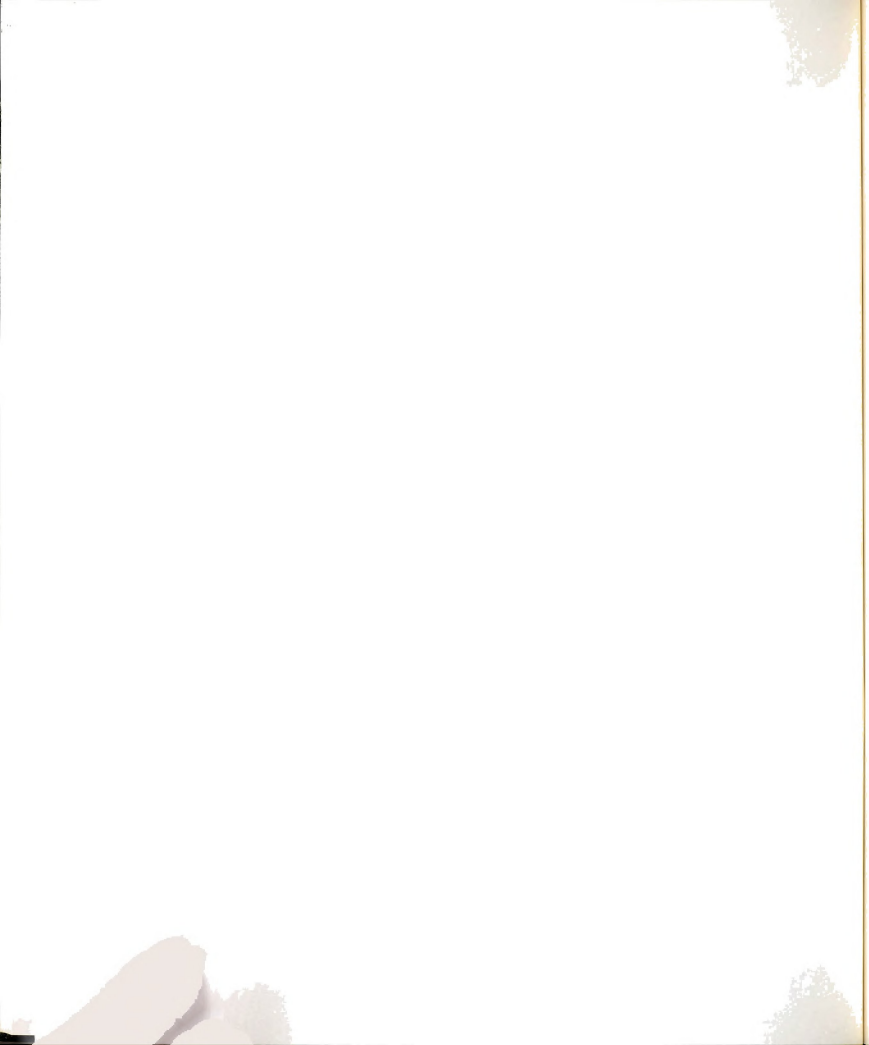
The representative for Firm C gave what was felt as a conservatively documented production increase available to users. Other values were clear but not easily justified for all users.

The representative for Firm D had two customers who had documented dollar cost savings for him voluntarily. He claimed they were similar and was confident in their value. The savings was a direct cost savings of production inputs over use of the closest substitute.

The representative for Firm E gave several estimates for user cost savings but determined that the one that most reflected reality was purchase price savings over the closest substitute. The same was true of the representative for Firm F.

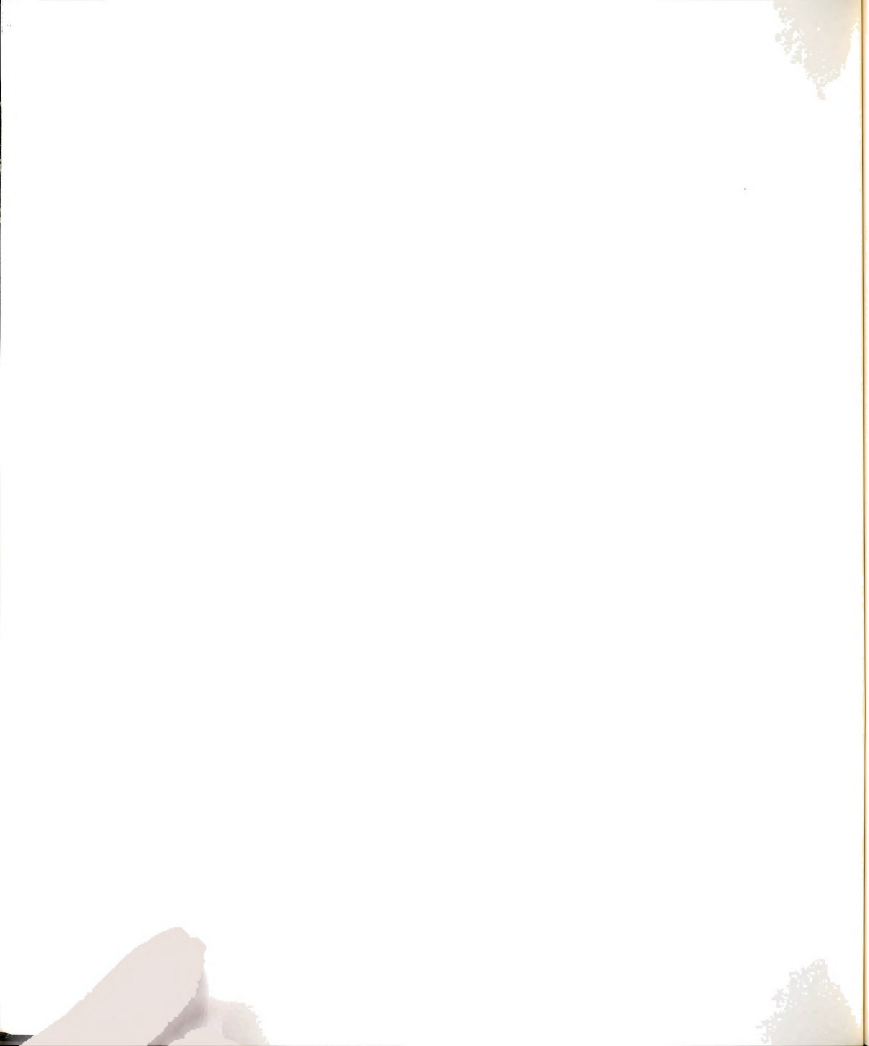
The representative for Firm G gave a best estimate of the perceived needed return by users for their premium in the purchase price. It was fortunate that a user happened to visit the office at the time of the interview and the observation was confirmed to the point of maintaining the range of performance values.

The representative for Firm H gave a documented estimate of first and second generation potential production increases over the average production by possible substitutes. Actual prices for the stock and the average substitutes were used in the calculations.



The percentage of available rents captured by the firm are determined by prices on sales by the firm. The percentage of returned rents are direct returns to the University related to sales of a commercialized product; not contracts, gifts, or services before commercialization, for additional work, or possible future returns. Direct returns to the University come in several forms. There may be an up-front license fee which the firm pays in order to obtain rights to the patent. There may be an annual lump-sum minimum royalty the firm must pay to the University. There may be a percentage royalty based on sales. Sales based revenues are usually defined in the licensing agreement. There may be a set fee assessed on each unit sold which is then returned to the University. Lump-sum gifts may also be used. And there may be sales revenues which come directly to the University. Again, it is recognized that additional returns do exist but this study is concerned with how structure influences direct returns to the university. Additional returns might come in the form of research contracts, gifts, gains from equity interests, and indirect benefits as outlined in Section 4.1.

Three ranges were chosen to represent measures of performance outcomes for the percentage captured of available rents, the percentage returned of captured rents, and the percentage returned of available rents. This helps provide anonymity to participants, lends credibility to the nature of the data, and reduces the number of cells in presenting data for such a small sample size. The results for these measures were presented in Figure 6.1.



6.4.1 Public Controls

It could be suggested from the information in Figure 6.1 that public financial controls in a firm might imply that there will be public administrative controls. Mixed controls exist when there is both public and private financing or administrative representation. Financial interest by the public sector which leads to administrative control may cause difficulties and provide perspective for the firm.²

Hypothesis 1 suggested that public or university involvement in a transfer firm would lead to inefficiencies capturing rents but enhance direct returns to the university. The data are separated into financial controls of the firm and administrative controls of the firm.

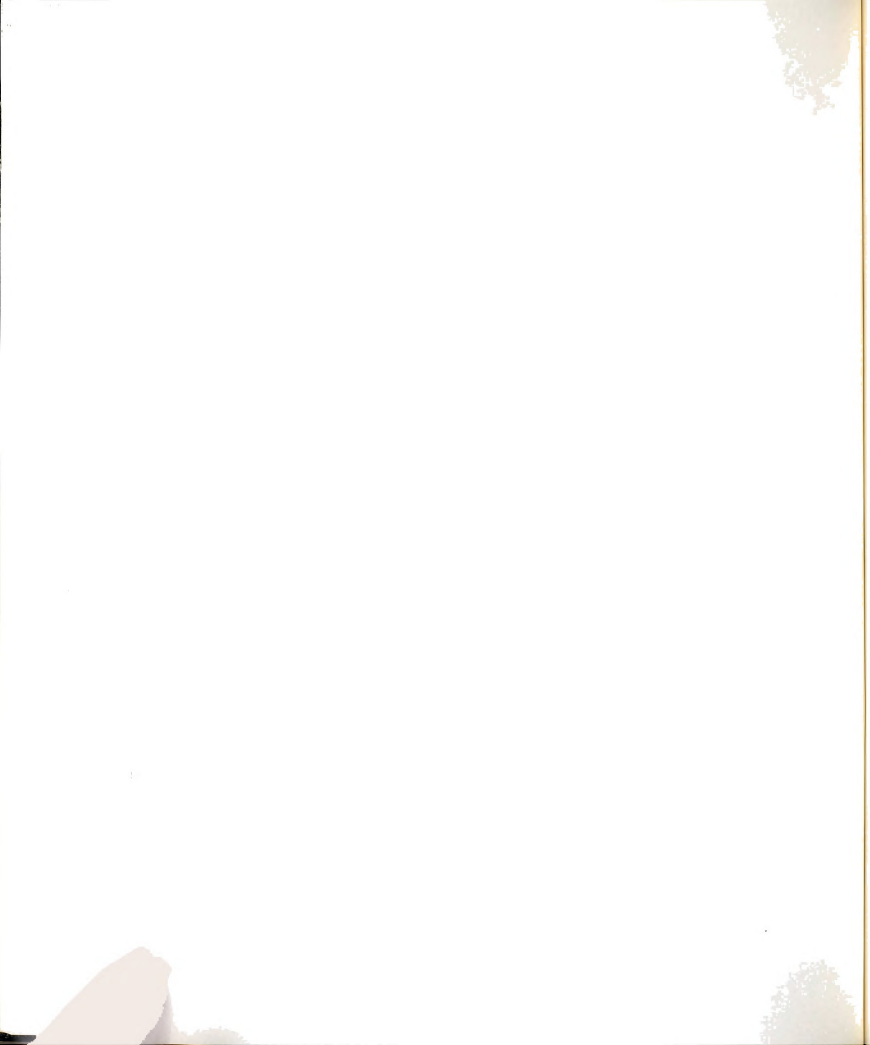
Table 6.11 demonstrates that public financial controls of the firm do not necessarily lead to inefficiencies in capturing rents

²Public controls may cause the following difficulties:

- Public financing may impose public administrative controls (eg. board member) which turn out to be inadequate representatives for either the public or private agenda.
- Public financing may impose restrictions on the use and holding of public funds and restrictions on the operating ratios of the firm.
- Public controls tend to continue a project for the sake of the science.
- Public controls may find conflicts between the interest of the firm and academic recognition.
- Public initiated firms lack capital for growth, business experience, and accountability, and may be limited to a single product market.

Public controls also prove to be of great value in a transfer firm. Some contributions include the following points:

- Public controls help maintain the original objectives of the firm.
- Public controls impose broader horizons and encourage diversification into peripheral areas of interest.
- Public financing and control allows more risk (support projects which would not be funded by an outside investor or support technologies which are only outstanding) because they are not as dependent on short term returns.



since the publicly financed firm is in the top range and the mixed firms have two in the top range and one in the middle range for capturing rents. Table 6.11 also demonstrates that a publicly financed firm will return as large a percentage of captured or available rents as the firm with mixed or private financial controls. The firms with private financial controls tend to return available rents in the lowest percentage range.

Table 6.12 demonstrates that firms with public administrative controls tend to capture a larger percentage of available rents than firms with private administrative controls. Table 6.12 also demonstrates that firms with public administrative controls tend to return a larger percentage of available rents, though not necessarily of captured rents, than firms with private administrative controls.

It seems that public financial or administrative controls do not prevent a transfer firm from capturing a larger percentage of available rents than the alternative privately controlled firm. In addition, the firm with public controls may return a larger percentage of available rents to the university. It would be wrong to imply a causal relationship but the interesting point is that strong public involvement does not necessarily lead to inefficiencies in capturing rents for transferred technologies.

6.4.2 Economic Objectives

Economic objectives of the transfer firm are the most loosely defined variable in the framework. There is little doubt that

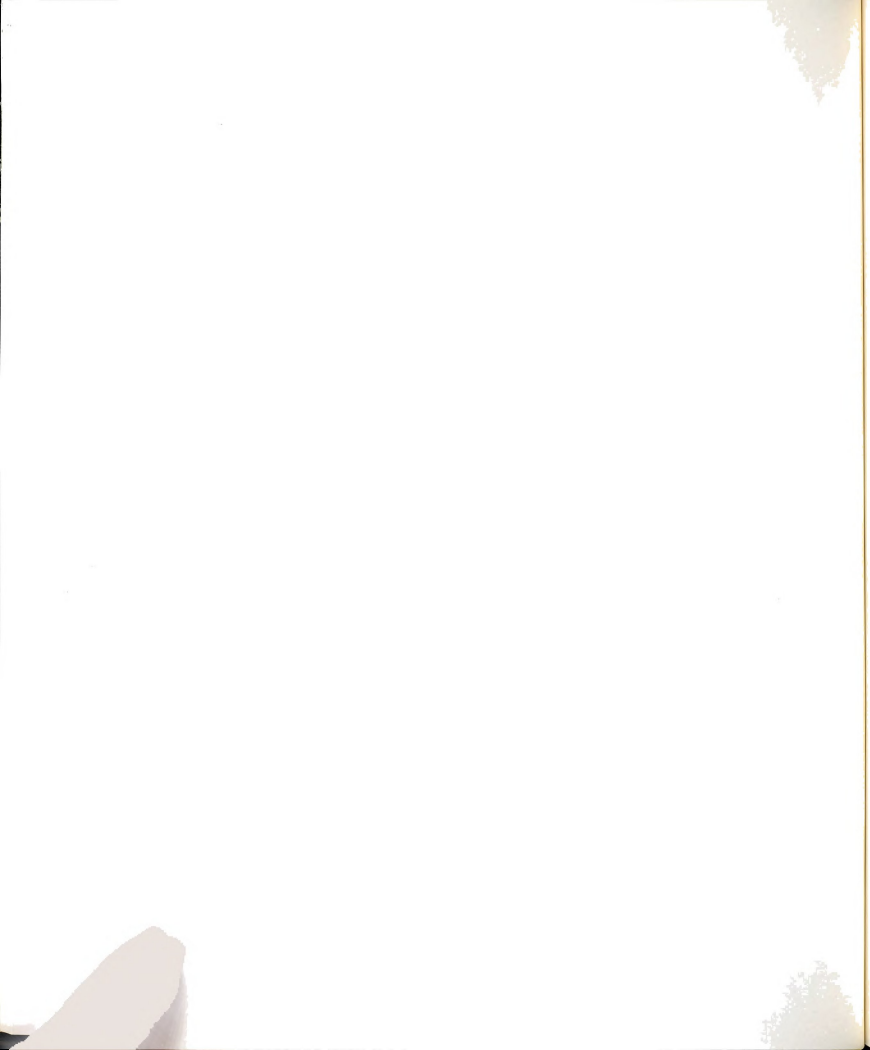


Table 6.11 Frequency of firms with public, mixed, and private financial controls and their performance outcomes.

<u>Performance Outcomes</u>		<u>Financial controls of the firm</u>		
		<u>Public</u>	<u>Mixed</u>	<u>Private</u>
Percent captured of available rent	0-5			2
	5-25		1	1
	25-75	1	2	1
Percent returned of captured rent	0-5		1	
	5-25		2	1
	25-100	1		3
Percent returned of available rent	0-5		2	3
	5-25		1	
	25-50	1		1

Table 6.12 Frequency of firms with public, mixed, and private administrative controls and their performance outcomes.

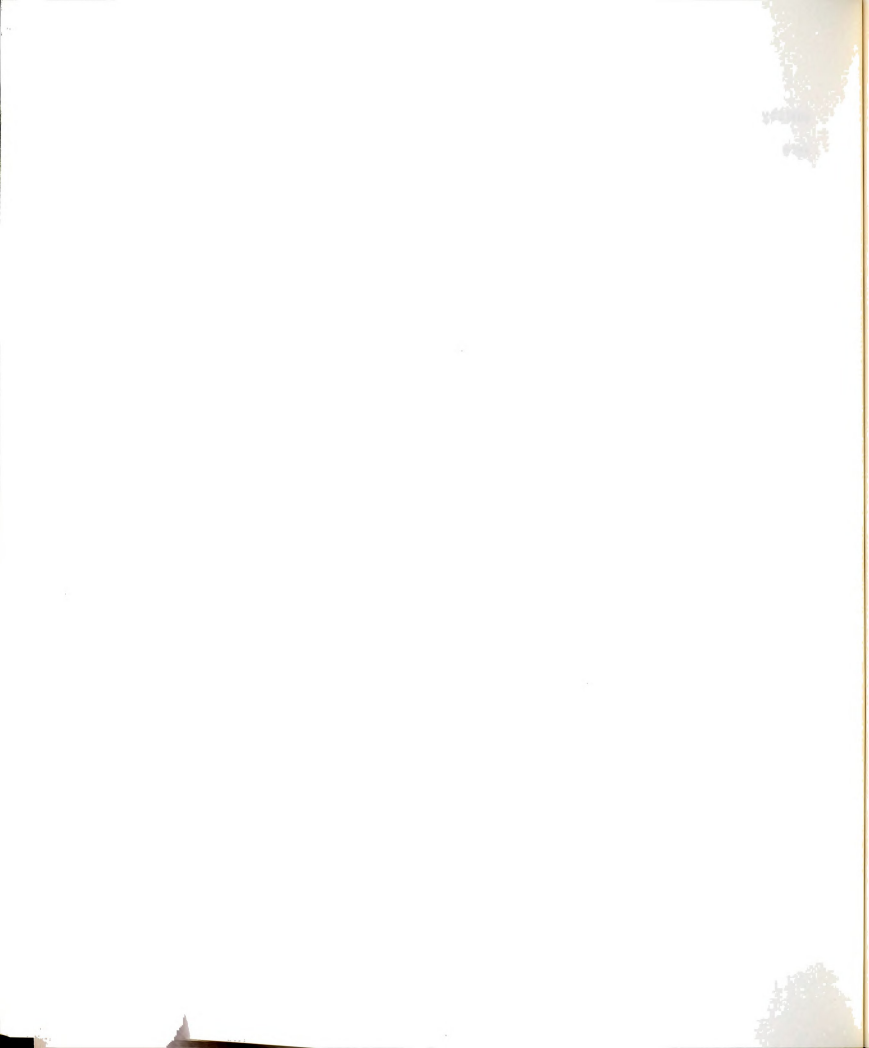
<u>Performance Outcomes</u>		<u>Administrative controls of the firm</u>		
		<u>Public</u>	<u>Mixed</u>	<u>Private</u>
Percent captured of available rent	0-5		1	1
	5-25		1	1
	25-75	2	2	
Percent returned of captured rent	0-5		1	
	5-25	1	1	1
	25-100	1	2	1
Percent returned of available rent	0-5		3	2
	5-25	1		
	25-50	1	1	



quality is either a primary or secondary objective of the firms that were interviewed (Figure 6.1). This may be in part a function of their developing and marketing emerging technologies. Quality remains a primary objective for those firms most closely associated with the University while it becomes a secondary objective for those firms more distant to the University.

One common theme that ran through the responses about economic objectives of the firm was diversification. Diversification was seen as a precursor to growth and necessary in order to maintain the economic viability of the firm. Research was seen as a precursor to diversification. This is not a unique train of thought. What was apparent, however, was the recognition by both private and public firms that public controls and relationships with the University help lead to diversification.

Firms A-D have profit or growth as a primary objective. Including the firm with unmeasured rents, four of the five stated growth as a primary objective. This, too, may be a function of their developing and marketing emerging technologies. Hypothesis 2 suggested that profit objectives would lead to more efficient capture of rents than firms with non-profit objectives. The one firm that did not state growth as a primary objective, firm A, was found to capture the least amount of rent on a percentage basis (Figure 6.1). This may be caused by one of two factors: 1) The firm may be in a truly competitive industry where profits are zero; or 2) The inefficiency in capturing rents may be caused by some other structural characteristic. Two of the other firms with growth



objectives were in the mid range of capturing rents and one was in the top range. Growth objectives might prevent firms from capturing rents because of pricing limitations.

Table 6.13 demonstrates that quality objectives do not prevent a firm from efficiently capturing rents. One interviewee stated that quality is the way to capture higher prices. It is interesting to speculate as to whether quality objectives lead to more efficient capture of rents, though perhaps, with lower volume of sales. One reason might be that quality objectives lead to higher production costs which are captured from available rents by the firm. Another reason might be that quality products have larger absolute rents than inferior products. However, this does not imply that the quality objective firm captures a larger percentage of those rents.

Hypothesis 2 also stated that firms with non-profit objectives would return a greater portion of rents to the university than firms with profit objectives. Other structural characteristics (i.e. closer university ties) may be responsible for the results in Table 6.13 that a firm with quality objectives returns a greater percentage of either captured or available rents. These results may also be due to the fact that the quality objective firms capture a larger percentage of rents and hence have more to return to the University on a percentage basis.

6.4.3 Property Ownership

Hypothesis 3 stated that public or university property ownership leads to inefficiencies in capturing rents and may detract from



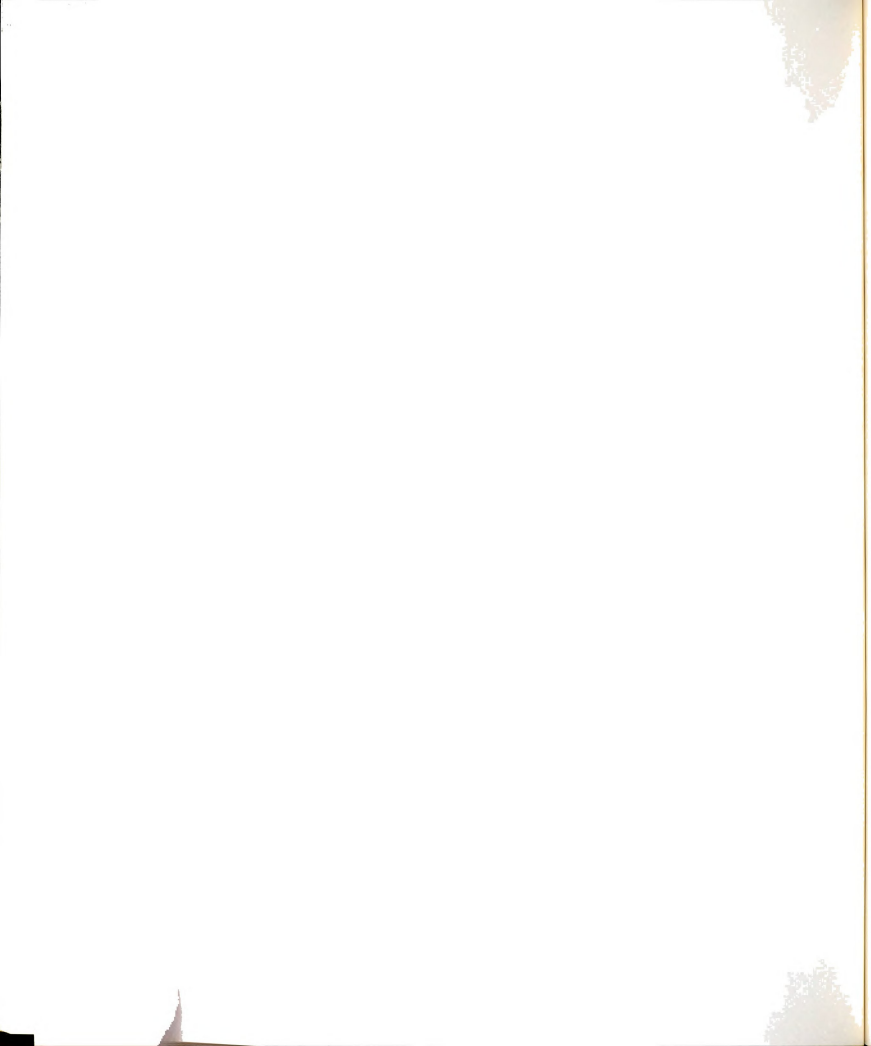
Table 6.13 Frequency of firms with quality/research objectives or growth/profit objectives and their performance outcomes.

<u>Performance Outcomes</u>		<u>Economic Objective of the firm</u>	
		<u>Quality/Research</u>	<u>Growth/Profit</u>
Percent captured of available rent	0-5	1	1
	5-25		2
	25-75	3	1
Percent returned of captured rent	0-5		1
	5-25	1	2
	25-100	3	1
Percent returned of available rent	0-5	1	4
	5-25	1	
	25-50	2	

direct returns to the university. Public ownership refers to licensing rights and university ownership refers to patent assignees.

University patent or certificate ownership is retained in all cases but one as shown in Table 6.14. Of those firms where university ownership is retained, there seems to be no inefficiencies introduced to the firm's ability to capture rents. The one firm that has obtained private ownership of the patent lies in the top range of captured rents.

University ownership may enhance direct returns to the University. Table 6.14 shows that the seven firms with university ownership performed in the top two ranges of returning captured rents and the one firm with private ownership performed in the bottom range. While the spread of captured rents pulls down the performance



for some firms on returning available rents there is a similar spread and result for the two performance measures. It should be noted that these results apply to direct returns, not indirect or potential future returns. The suggested tradeoff for giving up patent ownership may be a larger long-term payoff than for retaining ownership but this cannot be determined at this time.

One additional point is that patent ownership of genetic materials by a private firm prevents a university inventor from further using the materials without paying a price. In some cases, maintaining the genetic stock as a trade secret at the university and only leasing it to a private firm for production purposes may provide adequate protection and availability for both parties. Firms could then be assessed a per unit fee or other non-royalty fee for the chosen dispensation of returns.

Contracting for residual rights is fairly well outlined in licensing agreements but probably needs to be defined on an individual basis in the courts. All developments and issued patents based on a prior patent are retained by the University except when giving up patent ownership. In addition, if the previous inventor remains at the University all new developments and issued patents belong to the University. If a third party discovers a completely new use for a developed technology and it is determined to be "new art" and is issued a patent, most firms feel the issued patent would belong to the inventor with a question of paying royalties on a basic patent. Development rights followed patent ownership and the results would appear as in Table 6.14.

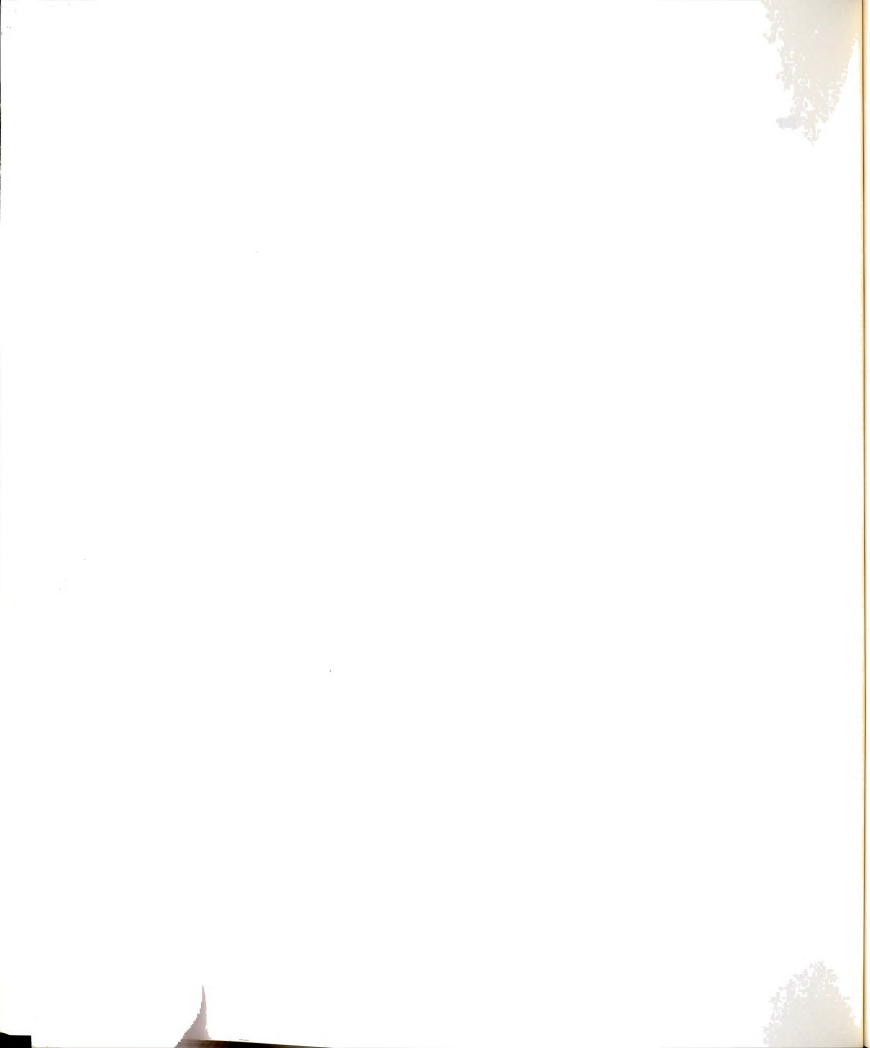


Table 6.14 Frequency of firms with university or private patent or certificate ownership and their performance outcomes.

<u>Performance Outcomes</u>		<u>Patent or certificate ownership</u>	
		<u>University</u>	<u>Private</u>
Percent captured of available rent	0-5	2	
	5-25	2	
	25-75	3	1
Percent returned of captured rent	0-5		1
	5-25	3	
	25-100	4	
Percent returned of available rent	0-5	4	1
	5-25	1	
	25-50	2	

Quality performance standards imposed by the University on the transfer mechanism do not appear to influence the capture of rents. Table 6.15 shows firms with no imposed quality standards perform in the top two ranges while firms with imposed quality standards perform in the top and bottom ranges. However, there may be some association, though not causality, for imposed quality standards and returns of rents. It appears in Table 6.15 that firms with imposed quality standards perform better with respect to returns of rents than firms without imposed quality standards. This result is complicated by the possibility that the economic objective of the firm might have a stronger influence than the imposed quality restrictions.

The second part of property ownership has to do with licensing rights. Table 6.16 demonstrates that those firms that have non-

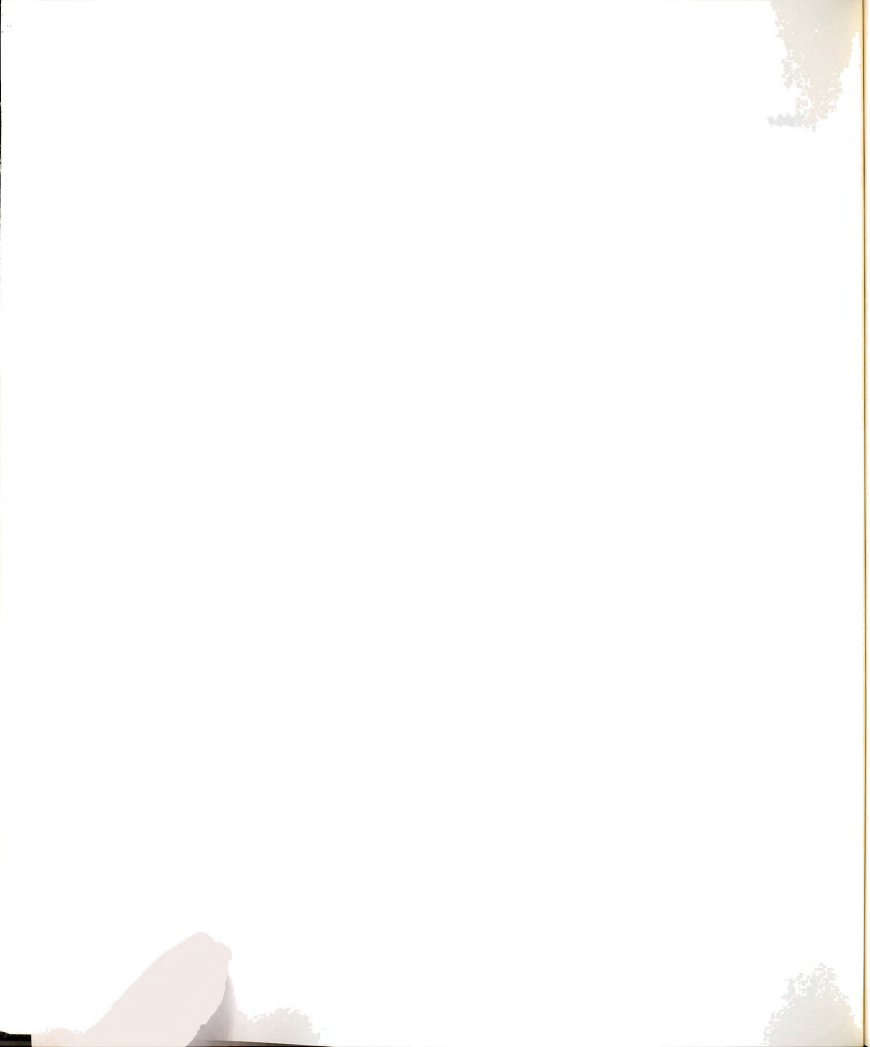
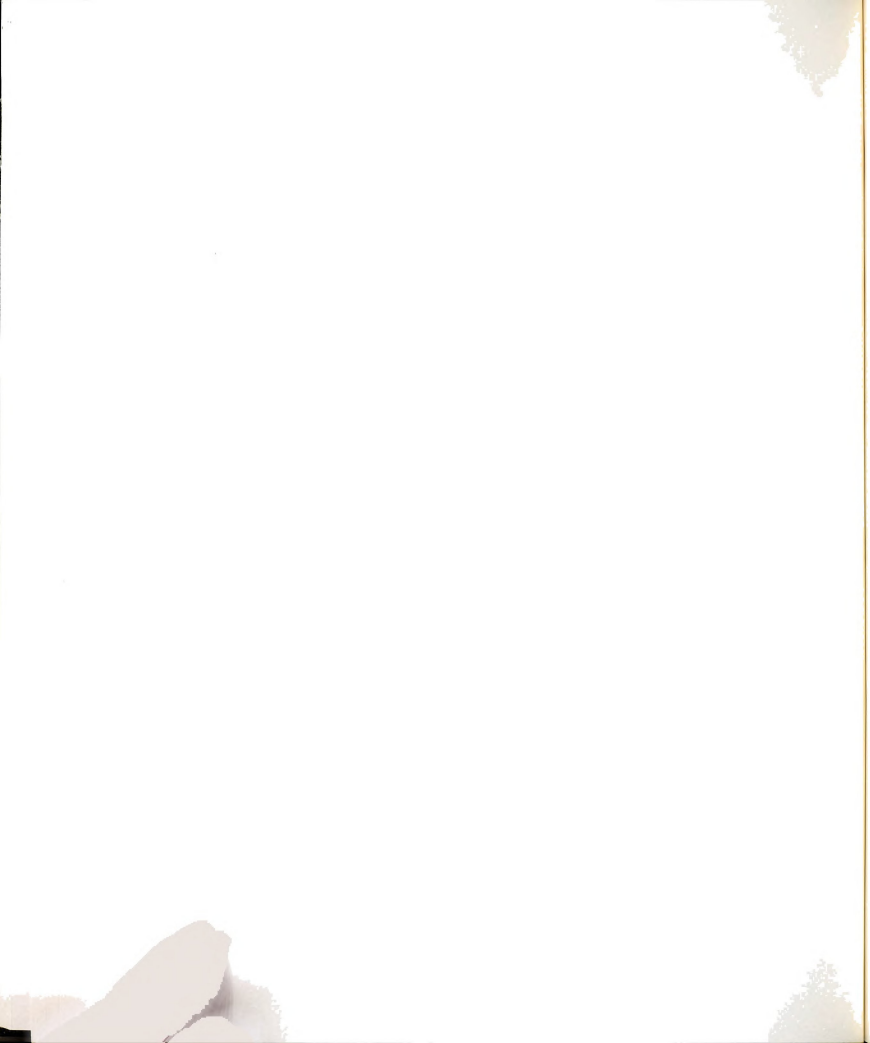


Table 6.15 Frequency of firms with university imposed quality performance standards and their performance outcomes.

<u>Performance Outcomes</u>		<u>Performance standards: Quality</u>	
		<u>Yes</u>	<u>No</u>
Percent captured of available rent	0-5	2	
	5-25		2
	25-75	3	1
Percent returned of captured rent	0-5		1
	5-25	1	2
	25-100	4	
Percent returned of available rent	0-5	2	3
	5-25	1	
	25-50	2	

Table 6.16 Frequency of firms with exclusive or non-exclusive development rights and their performance outcomes.

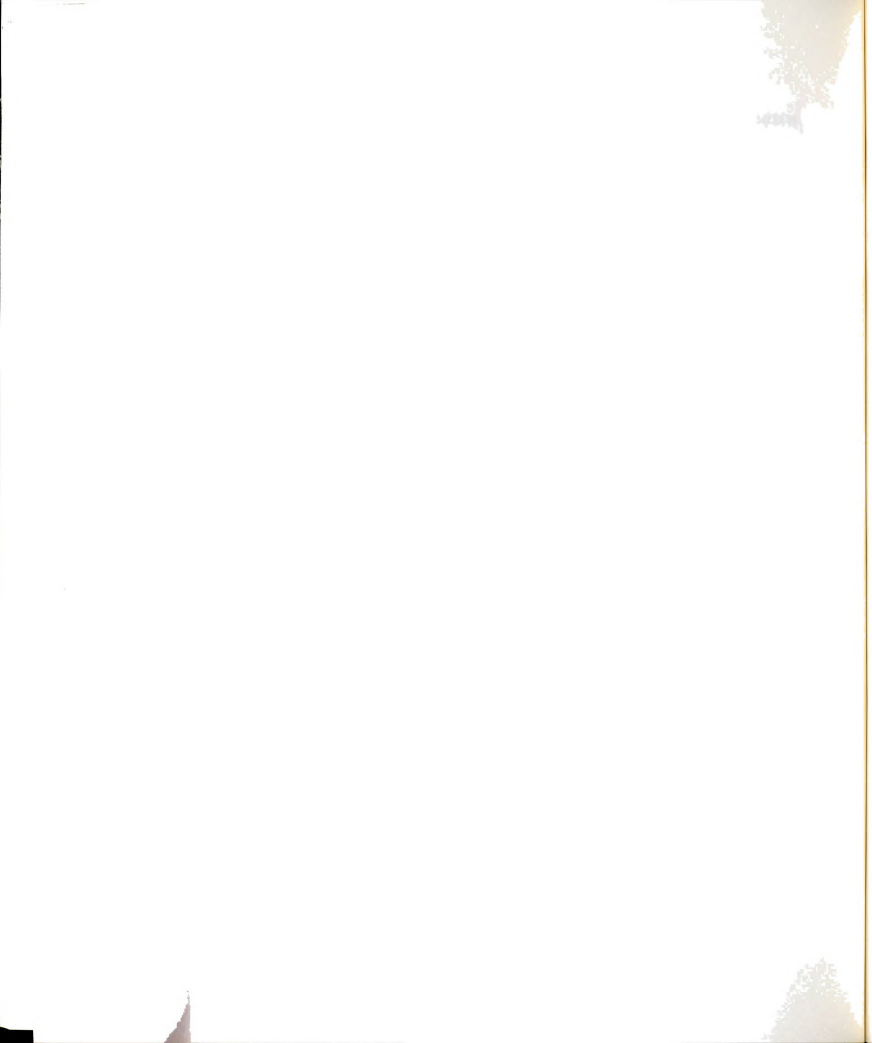
<u>Performance Outcomes</u>		<u>Licensing rights of the firm</u>	
		<u>Exclusive</u>	<u>Multiple</u>
Percent captured of available rent	0-5		2
	5-25	2	
	25-75	4	
Percent returned of captured rent	0-5	1	
	5-25	3	
	25-100	2	2
Percent returned of available rent	0-5	3	2
	5-25	1	
	25-50	2	



exclusive or multiple licenses perform in the bottom range of capturing available rents while those firms that have exclusive rights or licenses perform in the top two ranges of capturing available rents.

Table 6.16 also demonstrates that those firms with non-exclusive licenses may return a large percentage of captured rents. However, they are returning a large percentage of a small percentage of captured rents and therefore under-perform those firms with exclusive licenses. Exclusive rights do not guarantee greater returns since other structural characteristics may overpower their influence but they appear to improve the capture and return of rents as suggested in the framework. It is also possible that non-exclusivity overpowers other structural characteristics and causes under-performance by a firm that is otherwise structurally adequate for a large direct return of rents.

Two other points were raised by firm representatives regarding licensing. The first was a concern that non-exclusive licensing may force early development of a technology without allowing an adequate testing period by the responsible firm. The second was a concern that given the option, a firm that chooses an exclusive license over a non-exclusive arrangement, needs a good way to demonstrate to the public and the university that "profits" from an exclusive release are put to use in the public interest rather than made at the expense of the public.



6.4.4 Information Costs

Hypothesis 4 stated that information costs borne by the university lead to more efficient capture of rents and enhance direct returns to the university. The framework divided information costs borne by the university into two alternatives. One was being supported by the extension service for a product and the other was use of the University name in publicizing a product.

All firm representatives indicated that they did not get direct support from the Extension Service. At most, their product was treated as one of several products which might be on demonstration. Several firms expressed the desire for increased support of new University technologies by the Extension Service.

The use of the University name in publicizing a product is a difficult quality to assimilate. The inventors name and the name of the institution are often used in technical brochures and papers which do not truly publicize the product. Even this practice seems to be discouraged by the University. The inventor may also publicly talk about the product at meetings in order to gain wider acceptance. There were only two structures that used the university name in advertising and this is shown in Table 6.17.

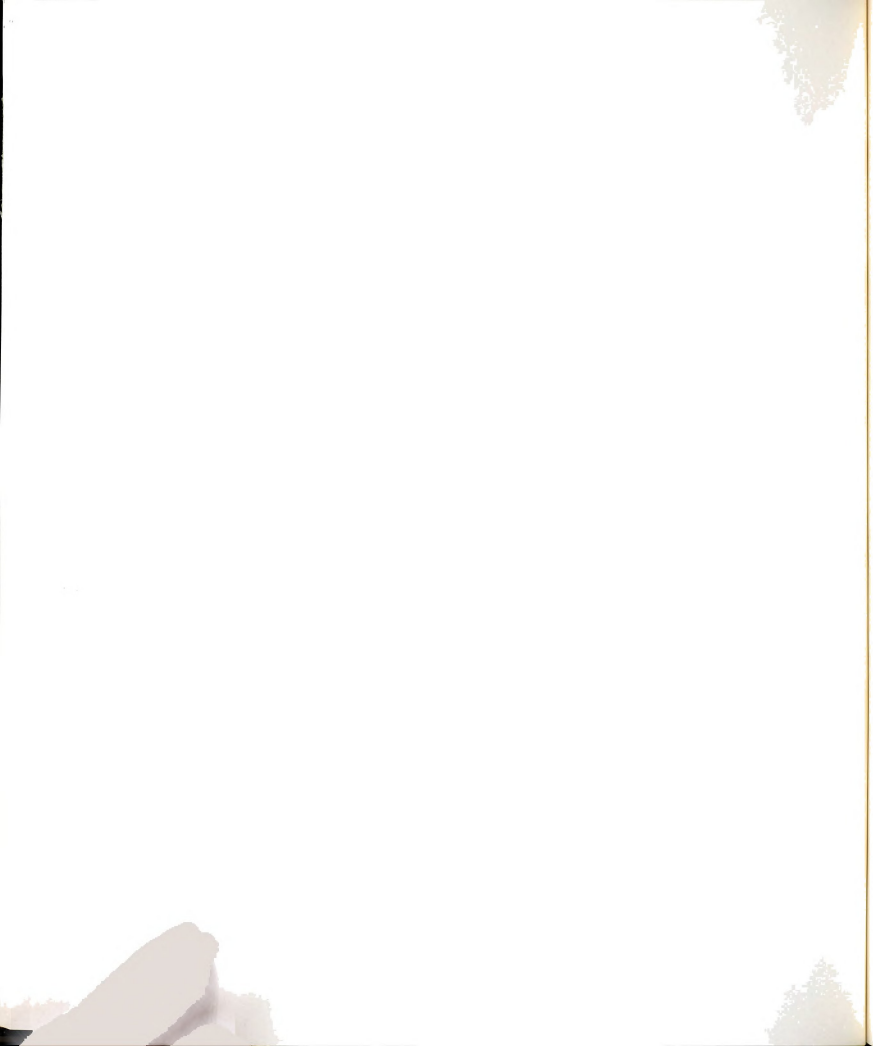
Most firms felt use of the University name would be an asset but that it would not have a direct impact on sales or pricing. In addition, the value of the University name may be sector oriented. One firm felt that association with the University name would have a negative influence on sales.



For the two structures that use the University name in their advertising it is apparent that they do well. The top range of captured rents is achieved and returns of rents are in the two top ranges. The University name may be an important factor influencing performance, at least in identified sectors. On the other hand there is no distinction in performance of captured rents for those firms that do not use the University name. Neither is there distinction in performance of return of captured rents. They do however, with one exception, under-perform on the final measure of return of available rents.

Table 6.17 Frequency of firms with information costs born by the University and their performance outcomes.

<u>Performance Outcomes</u>		Information costs born by the University	
		No	Yes
Percent captured of available rent	0-5	2	
	5-25	2	
	25-75	2	2
Percent returned of captured rent	0-5	1	
	5-25	2	1
	25-100	3	1
Percent returned of available rent	0-5	5	
	5-25		1
	25-50	1	1



6.4.5 Investment Costs

Hypothesis 5 stated that investment costs, administrative costs, and exclusion costs borne by the transfer firm can lead to more efficient pricing and detract from direct returns to the university. These could all be treated as a generic cost to the firm but the structural variation is not the same so they are treated separately here.

Table 6.18 shows that there appears to be little relationship between investment costs and performance measures of the study though one trend emerges. The percentage of captured rents that are returned to the university may be influenced by investment costs of the firm. The two structures that have no investment costs (i.e. they receive a product from the University that is ready for commercialization) are in the top range of returns while the structures that have investment costs tend to average returns in the middle range.

Table 6.19 shows firms that pay overhead on non-rent returns to the University are more likely to capture a top range of available rents and return a low range of available rents than firms that do not pay overhead on non-rent returns. It is not clear whether the performance of firms that do not pay overhead is related to the percentage of captured rents or the percentage returned of captured rents.

Patent costs are generally covered by the firm in the relationships examined by this study. While they do not perfectly correlate with policing costs they come close and are overpowering in

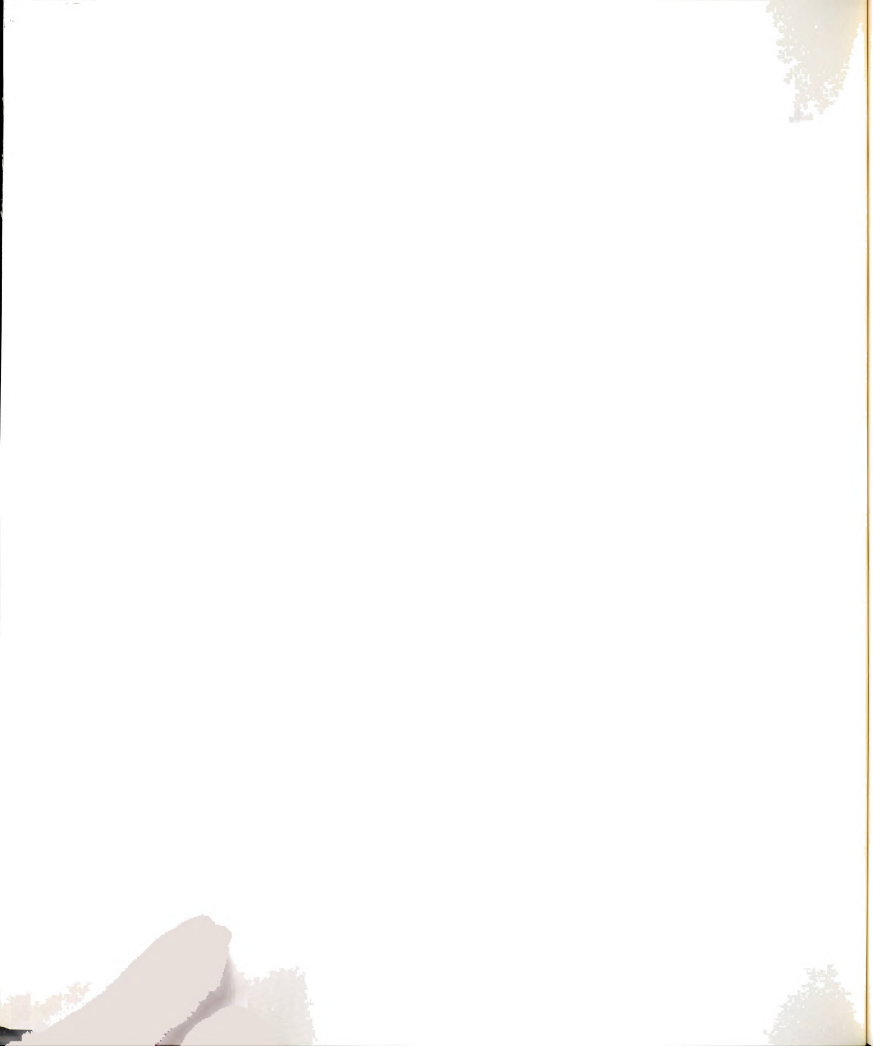
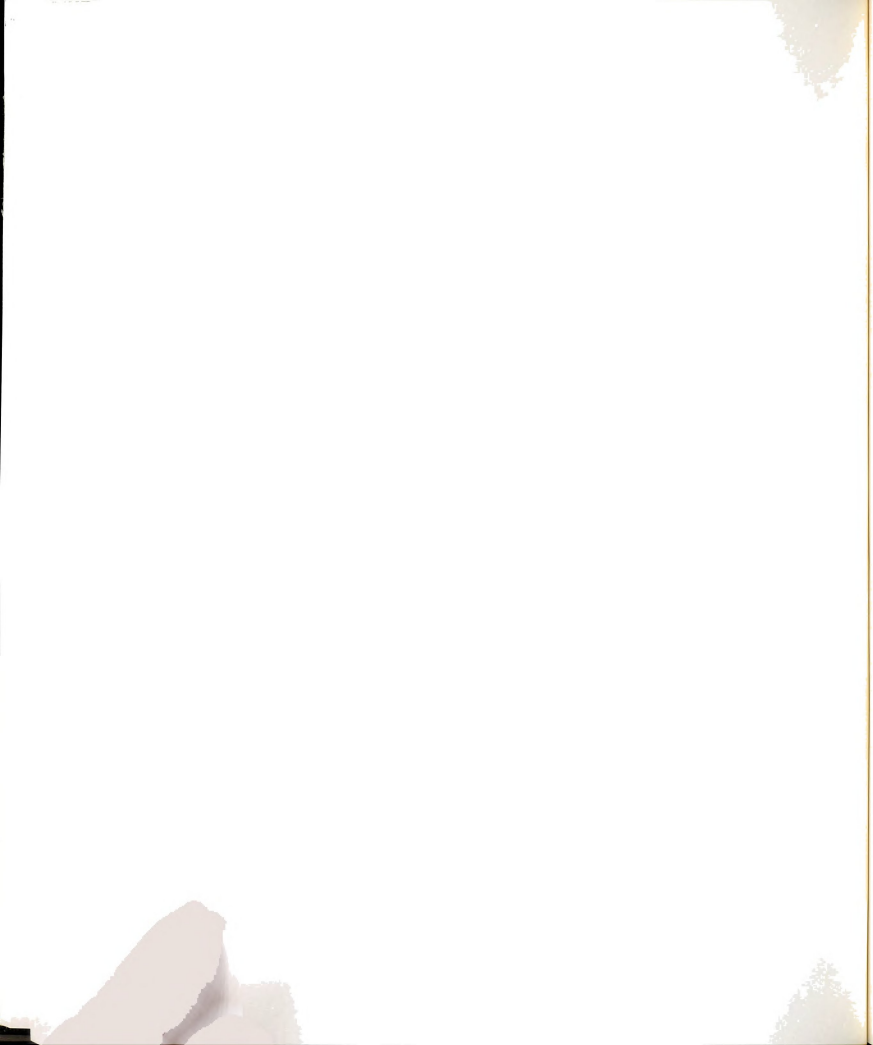


Table 6.18 Frequency of firms with investment costs and their performance outcomes.

<u>Performance Outcomes</u>		<u>Firm investment costs</u>	
		<u>Yes</u>	<u>No</u>
Percent captured of available rent	0-5	1	1
	5-25	2	
	25-75	3	1
Percent returned of captured rent	0-5	1	
	5-25	3	
	25-100	2	2
Percent returned of available rent	0-5	4	1
	5-25	1	
	25-50	1	1

Table 6.19 Frequency of firms paying overhead on non-rent returns and their performance outcomes.

<u>Performance Outcomes</u>		<u>Overhead on non-rent returns</u>	
		<u>Yes</u>	<u>No</u>
Percent captured of available rent	0-5		2
	5-25	1	1
	25-75	1	3
Percent returned of captured rent	0-5	1	
	5-25	1	2
	25-100		4
Percent returned of available rent	0-5	2	3
	5-25		1
	25-50		2



relative amounts. This may be caused by the early stage development and marketing of emerging technologies representative of most sample relationships. For this reason the data in Table 6.20 follow the structure of patent costs to the firm. These data show that structures with patent costs capture the top two ranges of available rents while structures with no patent costs capture in the top and bottom ranges. Patent costs may provide an incentive for efficient capture of rents but a lack of patent costs does not preclude efficient capture of rents.

The data in Table 6.20 also show that firms with patent costs tend to return a percentage of captured rents in the middle range while firms without patent costs tend to return a percentage of captured rents in the top range. Performance for the percentage of available rents returned to the university spreads out due to the range of performance for the first two measures.

Firms that have an actual license fee and minimum royalty standard are shown in Table 6.21 to perform in the middle range of captured rents, in the middle range of returning captured rents, and in the bottom range of returning available rents. Those firms with no license fee or minimum royalty perform across the ranges for each measure.

Overall, the data on investment costs, administrative costs, and exclusion costs tend to support the idea that such costs may encourage more efficient pricing and detract from returns to the university. The data do not imply causality but are interesting to consider in comparison to those for non-cost variables such as

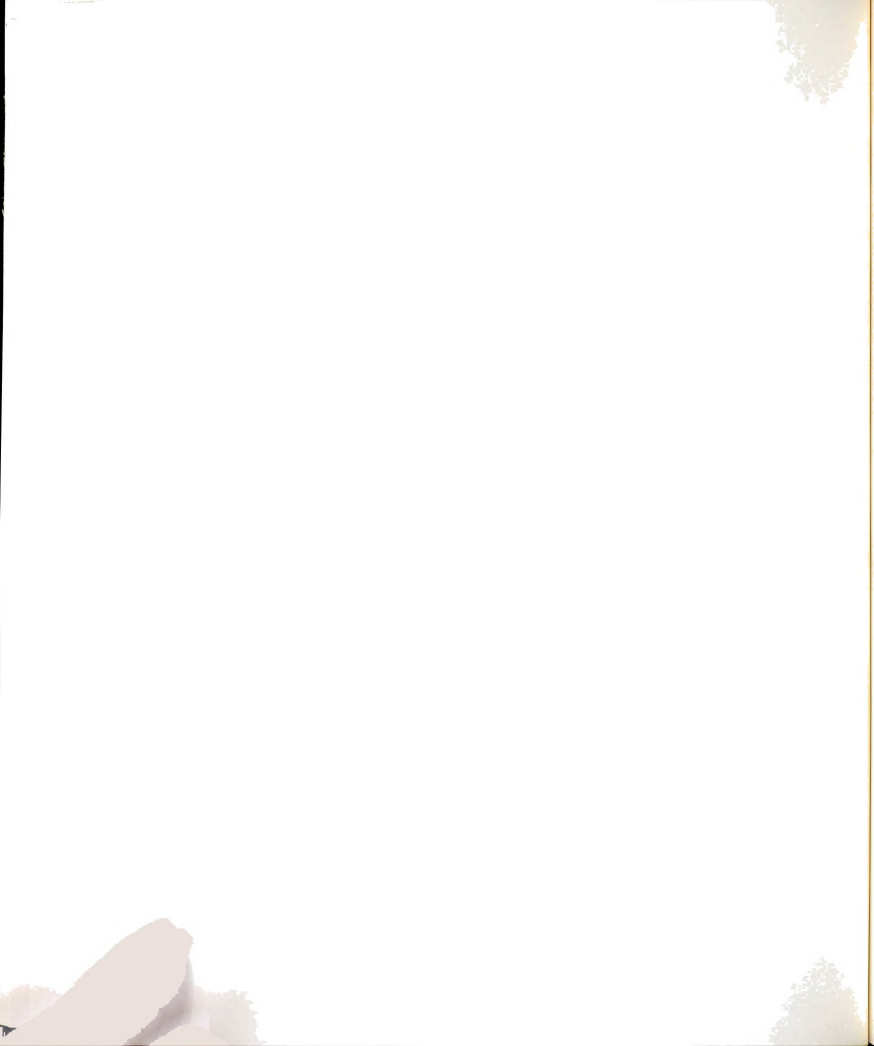
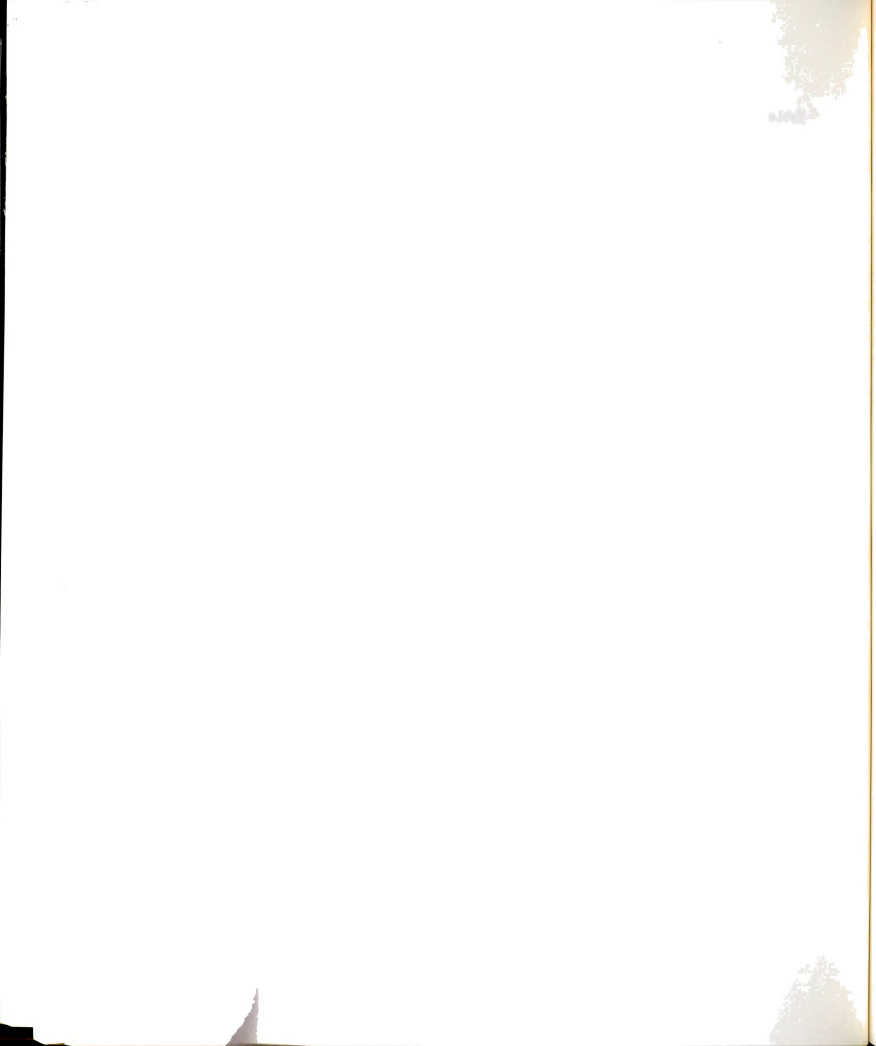


Table 6.20 Frequency of firms with patent and policing costs and their performance outcomes.

<u>Performance Outcomes</u>		Firm exclusion costs: Patent and policing	
		Yes	No
Percent captured	0-5		2
of available	5-25	2	
rent	25-75	3	1
Percent returned	0-5	1	
of captured	5-25	3	
rent	25-100	1	3
Percent returned	0-5	3	2
of available	5-25	1	
rent	25-50	1	1

Table 6.21 Frequency of firms with license fees and minimum royalty payments and their performance outcomes.

<u>Performance Outcomes</u>		Firm exclusion costs: License Fee and minimum royalty	
		Yes	No
Percent captured	0-5		2
of available	5-25	2	
rent	25-75		4
Percent returned	0-5		1
of captured	5-25	2	1
rent	25-100		4
Percent returned	0-5	2	3
of available	5-25		1
rent	25-50		2



economic objectives. A cost factor (situational characteristic) which leads to efficient capture of rents does not encourage returns to the University while a non-cost factor (structural characteristic) which leads to efficient capture of rents may also encourage returns to the University.

Two additional points are worth mentioning under the umbrella of contractual licensing. The first is that the University seems to give more favorable licensing terms to faculty initiated firms. Costs and terms are more lenient and may encourage a fledgling company in its early stages. The other is that minimum royalty structures might be altered to enhance the evaluation phase of product development. Recognizing that there may be a problem of shelving a technology when there is no penalty, contracts could incorporate a larger initial license fee and a larger future balloon payment with a relaxation of early minimum royalty schedules. The balloon payment might be precluded by a conditional level of royalty payments.

6.5 Interview II: Policy

Several points were raised when firm representatives were asked what structural changes might be made to encourage firms to develop products and share profits with the University.

One point was to allow direct returns to the research program. The obvious problem is to avoid overhead costs. The data of Section 6.4.5 showed that firms that do not pay overhead on returns to the University may return a larger percentage of captured rents. Some

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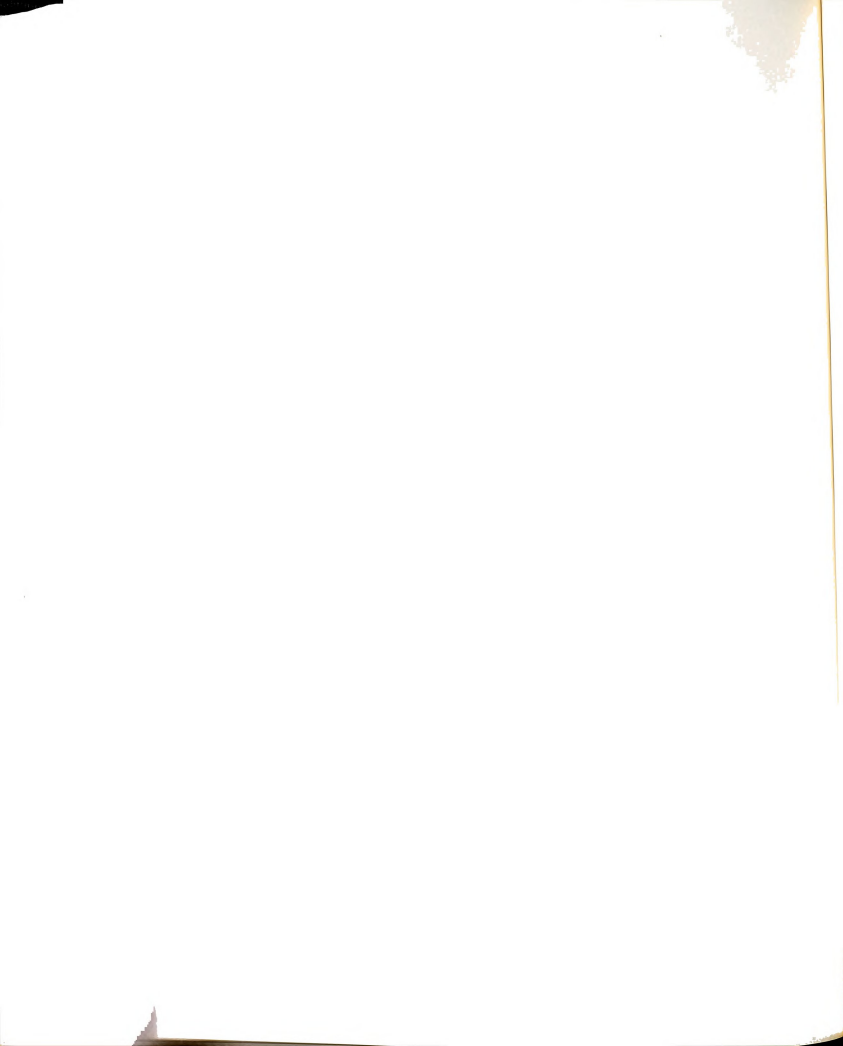
firms also suggested that not paying inventor rewards (not distributing royalties) may also lead to a larger percentage of captured rents being returned to the University.

A second point was that when firms continue to receive benefits in their relationships with researchers or the University they are more likely to share profits than try to minimize royalties. Attendant to this was the point that firms need to demonstrate a long-term commitment to merchandising University products in order to successfully capture rents and share profits. The nature of these comments seemed to be that using any opportunity to commercialize University research (i.e. the highest bidder or even the only current bidder) may not result in a shift of thinking about sharing profits. A package of technology is needed to get a commitment from a firm and a commitment from the firm is needed to successfully develop products. This leads to the possibility of mutual development efforts and increased benefits.

A third point was that the University might benefit by selecting the correct size firm. It was felt that small firms have more to offer the University, especially in non-rent benefits than large firms. This attitude may have been a function of the sample as much as any factor.

A final point, and perhaps the most common one, was that the University needs to commit more resources and share in the risks of product development in order to gain a change in attitude by firms about sharing profits. Three suggestions dominated this discussion:

- 1) The University could benefit by releasing fully developed products



with ample supporting documentation of the technology; 2) The University could benefit by incorporating interdisciplinary resources in a project at various stages to help complete research, regulatory testing, packaging, extension and promoting, and marketing; and 3) The University could benefit by treating product development as an investment (like its stock holdings) with the potential for a large payoff. The downside is complex relations and diluted equity as the structure of the firm changes over time.

The general idea is that if the University makes a direct investment in product development it stands to receive a larger payoff. However the question remains whether the firm will perform as well in capturing rents if its own investment has been reduced by the University commitment of resources.

Aside from ideas to encourage profit sharing some policy issues were raised that bear repeating. These are presented only briefly because for the most part they do not have structural implications for university-industry relationships. They are interesting because they mimic many of the issues raised by department chairpersons in Interview I. They include the following points:

- The University needs to maintain open communication and an understanding of what each firm does in its relationship with the University.
- The University needs an understanding of business needs, the cost of doing business, and the promotion of science versus product development.

- The University needs to maintain flexibility in its industry relationships and broaden the possibilities for new relationships. Issues of property ownership, trade secrets, and distribution of non-royalty returns are seen as potential future stumbling blocks.
- The University researcher needs to be accountable for dollars when working with small firms that need to see an immediate concrete return on their investment unlike public agencies and larger corporations.
- The University needs someone looking around the university and identifying research with commercial possibilities.

Again, except for the ownership and distribution issue, these points do not have structural implications for university-industry relations but are remarkable in their similarity to issues raised by department chairpersons.

6.6 Interview II: Comparing Results to the Expected Outcome

With the results outlined in the first part of this section the next step is to compare the perceived influence of each variable to the expected influence of each variable as discussed in Section 4.3. This can be most easily accomplished by using the compiled figure of expected results (Figure 4.2) and overlaying the study results. This is done in Figure 6.2. The alternatives for public controls, for economic objectives, and for investment costs are condensed to reflect the nature of the data. The alternatives for policing rights, license termination rights, publication delays, extension support and separate administrative budgets are eliminated from

<u>Variables (Alternatives)</u>	<u>Captured rent</u>	<u>Returned rent</u>
<u>Assertion 1: Public Controls</u>		
Source of funds for transfer firm:		
Public	- (+)	+ (+)
Mixed		
Private	+ (?)	- (?)
Public directorates of transfer firm:		
Public	- (+)	+ (+)
Mixed		
Private	+ (-)	- (?)
<u>Assertion 2: Economic Objective</u>		
Economic objective of transfer firm:		
Growth/Profit	+ (-)	- (-)
Quality/Research	- (+)	+ (+)
<u>Assertion 3: Property Ownership</u>		
Patent ownership:		
University	- (?)	- (+)
Private	+ (+)	+ (-)
Other rights:		
Quality standards	- (?)	- (+)
Licensing rights:		
Exclusive	+ (+)	+ (+)
Non-exclusive	- (-)	- (+)
<u>Assertion 4: Information Costs</u>		
Marketing costs paid by university:		
University name	+ (+)	+ (+)
<u>Assertion 5: Investment Costs</u>		
Investment costs paid by transfer firm:		
Firm costs	+ (+)	- (-)
Administrative costs paid by transfer firm:		
University overhead	+ (+)	- (-)
Exclusion costs paid by transfer firm :		
Patent and policing	+ (+)	- (-)
License and minimum royalty	+ (?)	- (?)

Figure 6.2 Structural alternatives for selected variables of the framework, their expected impact on performance measures of rent, and the study results showing potential impact on performance measures of rent (in parentheses).

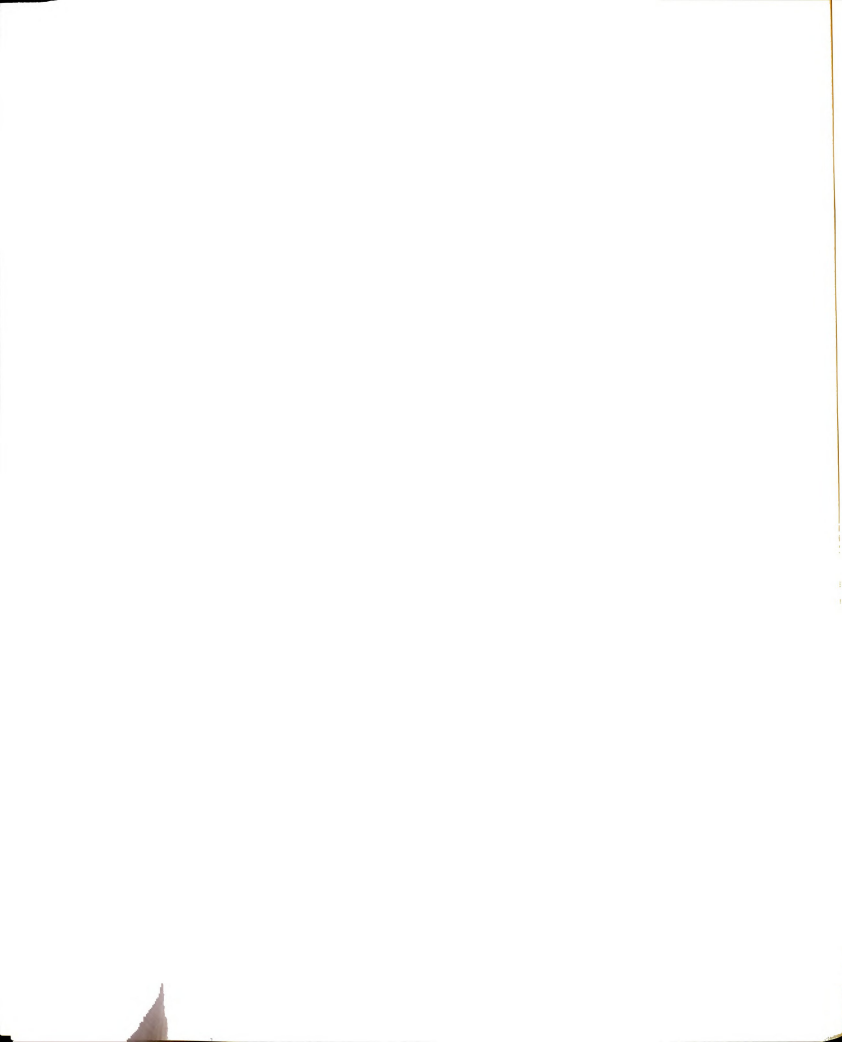
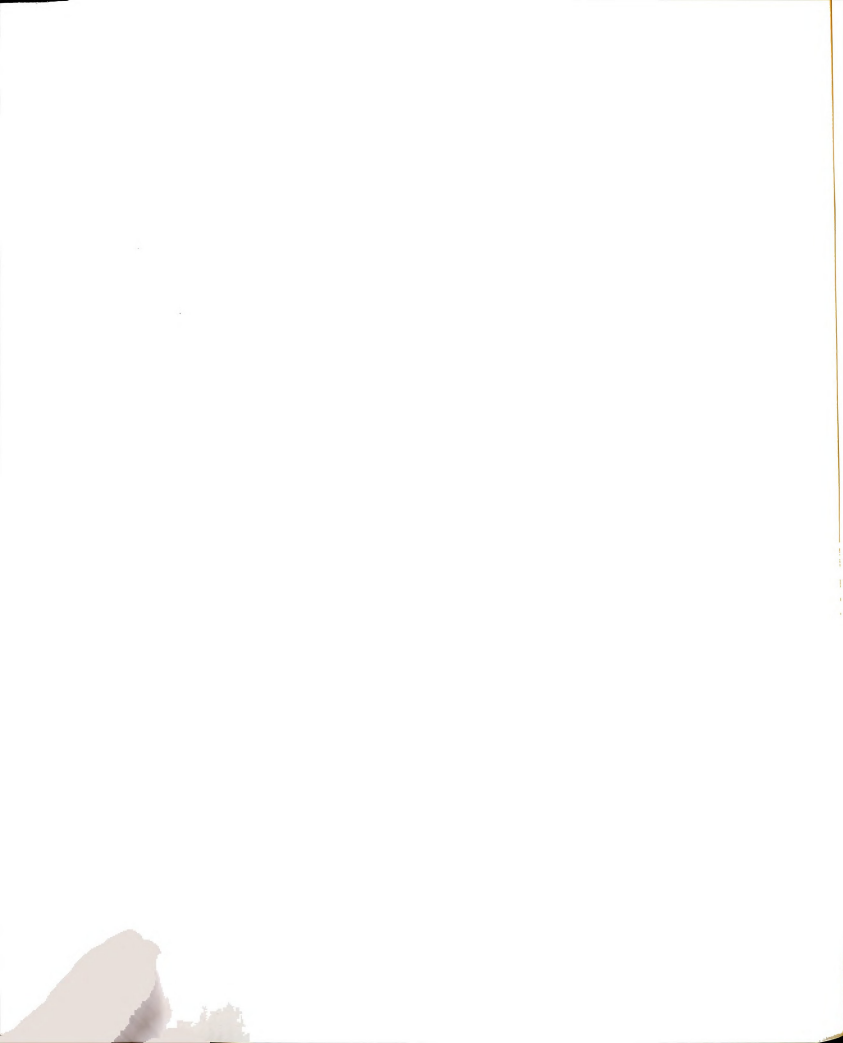


Figure 6.2 because variability was not measured in these parameters in the sample of the study. That does not mean they should be eliminated from the framework as they may remain relevant to other structures.

Figure 6.2 demonstrates that the expected influence of public controls on the percentage of rent that is captured by a transfer firm were not found in the study sample. Firms with public controls appeared to capture a larger percentage of available rents. On the other hand the expected influence of public controls on the percentage of returned rents agrees with that found in the study sample. Figure 6.2 also demonstrates a similar dichotomous outcome for economic objectives of the firm.

Privately controlled firms tend to have growth/profit objectives while publicly controlled firms tend to have quality/research objectives. Growth/profit objectives may limit pricing in a competitive industry so that while market share may be captured there is a limit on the percentage of available rents which may be captured using this strategy. On the other hand quality/research objectives may allow pricing to capture more rents while there is no gain in market share.

Figure 6.2 shows that the expected results for property ownership were found to hold true for captured rents in the study sample but not for returned rents. The question of patent ownership is complicated by the issue of direct versus non-direct returns. While private patent ownership led to lower than expected direct returns, the potential for future returns remains. The University

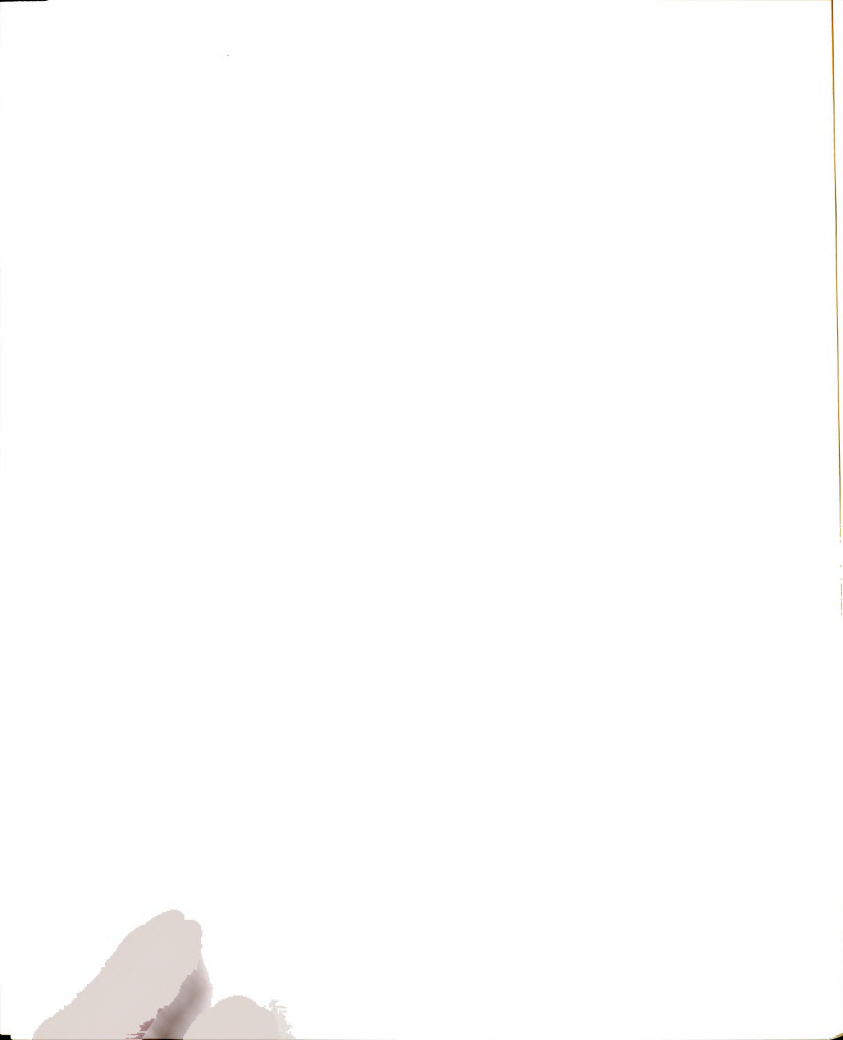


might consider extracting direct returns and future returns for relinquishing patent ownership. This would reduce the potential payoff but would also reduce the risk of no payoff.

University imposed quality standards do not prevent a firm from giving up large returns. This is especially important when considering alternatives for marketing genetic stock. These results may also be tied to the economic objective variable, since with one exception, those firms with imposed quality standards also had primary quality/research objectives.

The influence of exclusive licensing rights were shown to agree with the expected outcome for both captured and returned rents. In the case of non-exclusive rights, while there is inefficient capture of rents there may be no blockage to return a large percentage of those rents. Again, this may be a market share issue where a firm is willing to take on a non-exclusive license in order to capture and retain small marginal returns on a large volume item. There are problems with adopting this reasoning. The firm has little incentive to capture a large market share with a non-exclusive license that promises small returns since there are few (or smaller) up-front costs. In addition, competition may limit possibilities for capturing rents, at least on a regional basis, and this would tend to limit potential returns to the University.

The study results agreed with the expected outcome for information costs and for investment costs as discussed in Sections 4.3.4 and 4.3.5 and shown in Figure 6.2.



CHAPTER 7

INFLUENCE OF STRUCTURE ON PERFORMANCE BY FIRMS WHICH COMMERCIALIZE UNIVERSITY RESEARCH

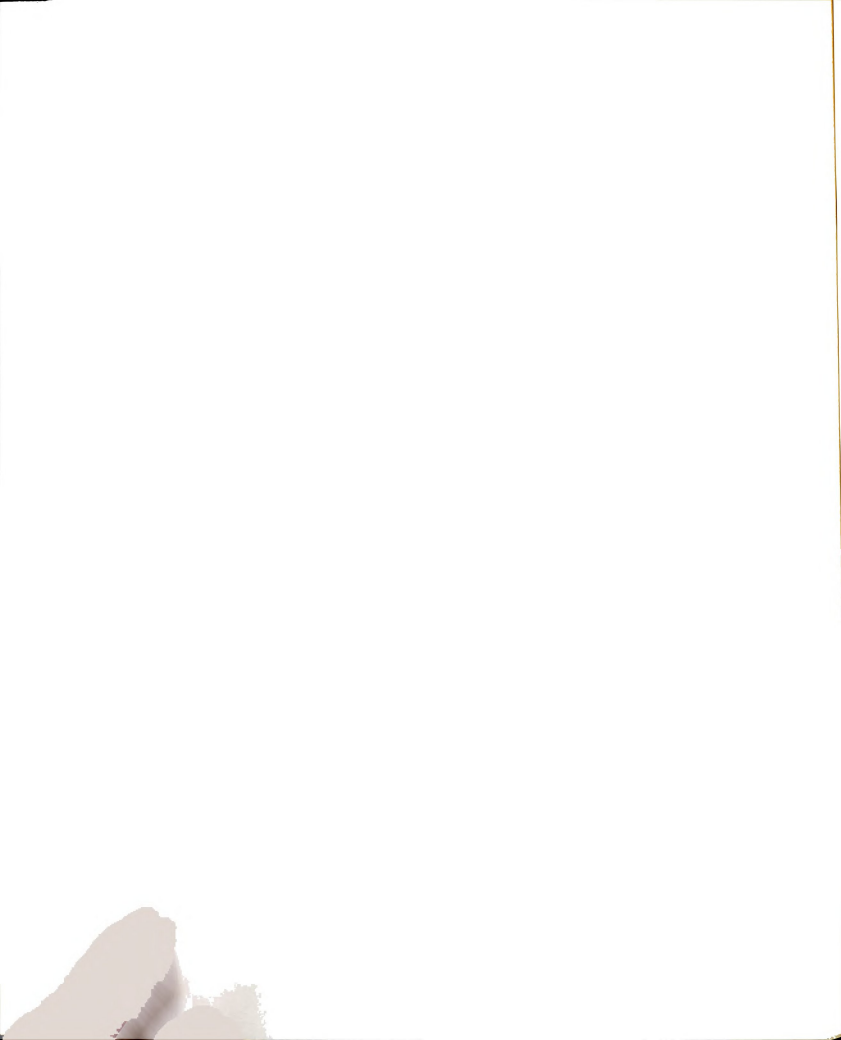
7.1 Summary of Study Results

Most University inventions reported since 1980 are not commercialized. Only half have applied for a patent. One quarter have a licensing agreement and many of these have been cancelled. Only two-thirds of the licensing agreements are truly exclusive. The number of active licensing agreements at the University is small.

Other structures exist at the University for commercializing research. These exhibit a range of variability from internal units with a focus on industry relationships to research commercialization centers that work around, or with, licensing to private firms. Structural variability is found in their degree of public controls and attachment to the University, their economic objectives, the ownership patterns and rights, and a series of transaction and other costs arranged contractually and otherwise. Ten structure types at Michigan State University were identified in the first part of this study and five structure types with commercialized products were interviewed for the second part of this study.

Because the sample size and selection procedures did not permit statistical analysis of the data, no links of causality or inference can be made. The following patterns emerge:

1. Financial or administrative public controls do not prevent a firm from capturing a large portion of available rents. They may even



capture a larger portion of available rents than purely private firms.

2. Financial or administrative public controls appear to enhance the return of captured rents to the University.

3. Primary economic objectives of growth/profit may lead to inefficient capture of rents while primary economic objectives of quality/research do not prevent a firm from capturing a large portion of available rents.

4. Primary economic objectives of growth/profit may detract from the return of captured rents to the University while primary economic objectives of quality/research appear to enhance the return of captured rents.

5. Private patent ownership may lead to efficient capture of rents but did not prove to be a tradeoff for the University to receive a larger portion of direct returns. The problem of future potential returns complicates this picture.

6. University imposed quality standards did not prevent firms from efficient capture of rents which may in turn have led to enhanced returns of rents. Economic objectives complicate this picture.

7. Non-exclusive licensing rights appear to lead to inefficient capture of rents. This result supports the model. They do not prevent a large portion of the small amount of rent that is captured from being returned to the University.

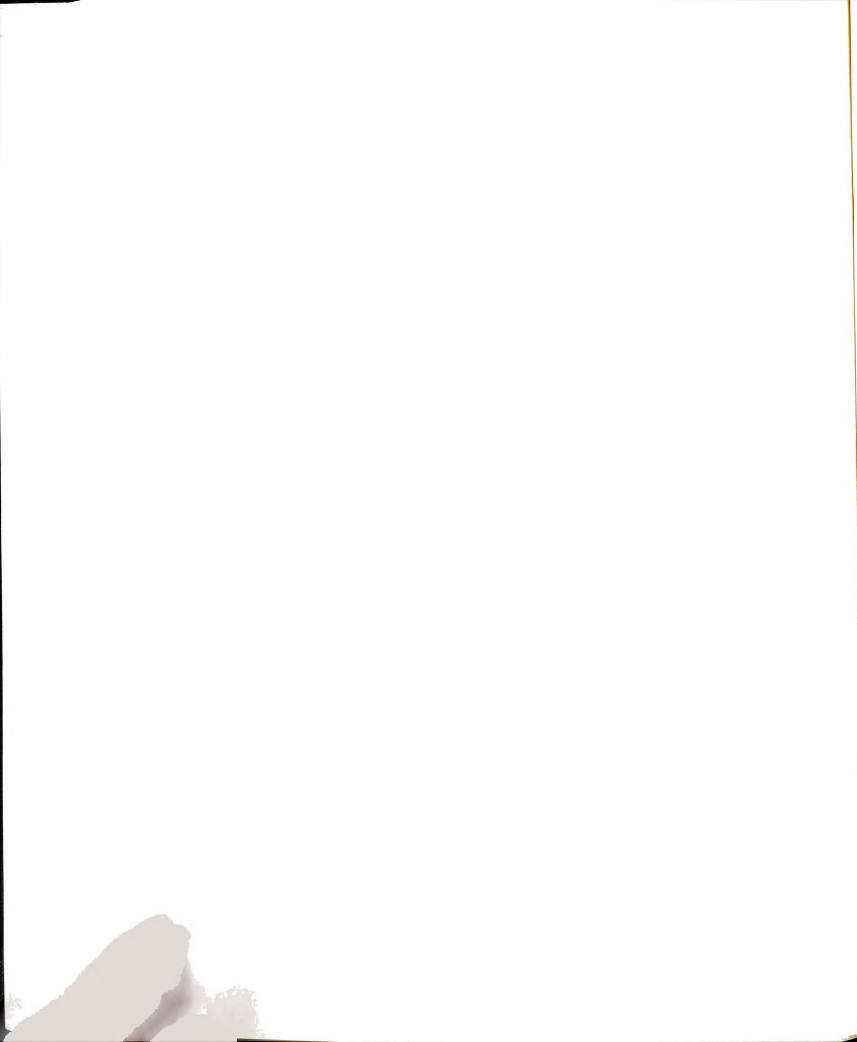
8. Marketing costs paid by the University may lead to more efficient capture of rents and larger returns to the University. Other structural issues may have imposed this result and most firm

representatives do not feel the University name is a commercial asset.

9. Investment costs, administrative costs, and exclusion costs paid by the transfer firm appear to lead to more efficient capture of rents and detract from returns to the University.

In general, it appears that public controls, quality/research objectives, private ownership or exclusive licensing, University borne marketing costs, and firm borne investment and transaction costs do not preclude, and may possibly lead to, efficient capture of rents. It also appears that public controls, quality/research objectives, and University borne marketing costs do not preclude, and may possibly lead to, efficient returns of captured rents. Private controls, private ownership, and costs borne by the firm may possibly lead to less efficient direct returns of captured rents.

The most common suggestion for structural change which could lead to a sharing of profits by the firm with the University, rather than a minimization of royalties, was a stronger commitment of resources by the University towards research commercialization. This view is consistent with the results of the study. Public financial controls and University borne marketing costs may lead to more efficient returns of captured rents, while firm borne investment and transaction costs may lead to less efficient returns of captured rents. On the other hand, public controls and University borne marketing costs may also lead to efficient capture of rents but University borne investment and transaction costs may lead to less efficient capture of rents by the firm. Would the subsequent return

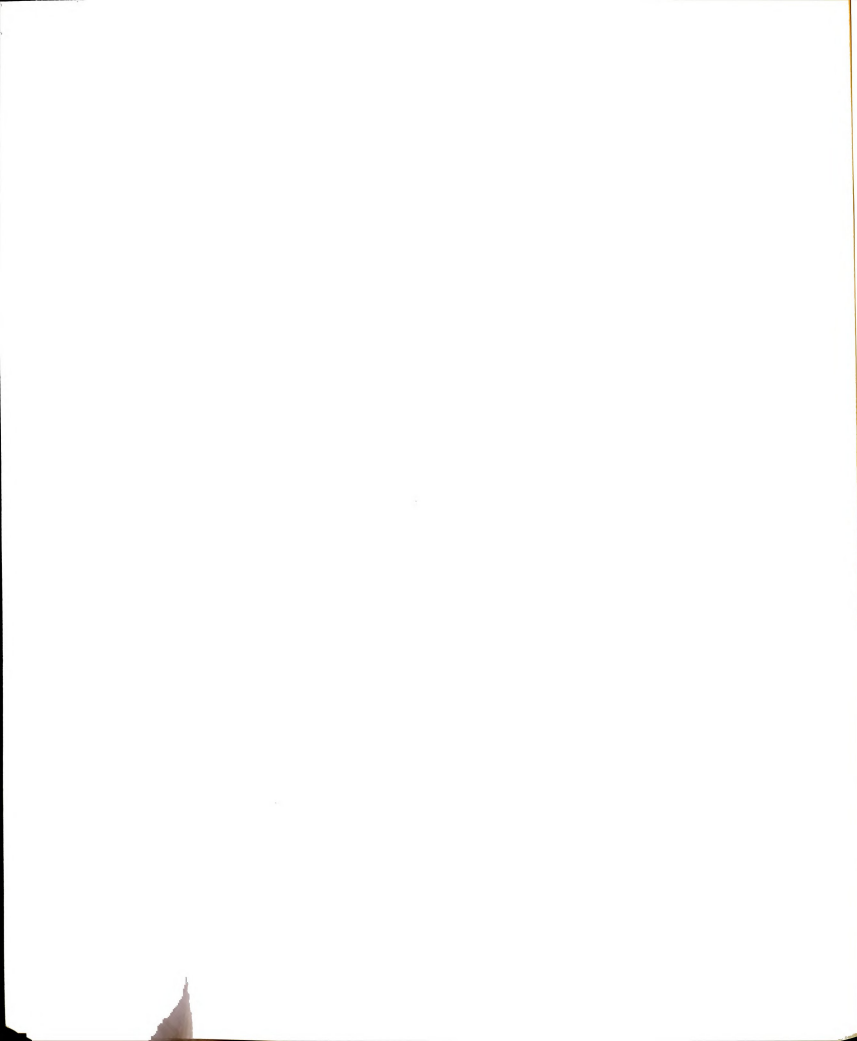


of available rents (percentage basis; captured rents times the return of captured rents) be the same with or without an increased commitment of University resources?

Several other policy issues were of concern to both department chairpersons and firm representatives if the University is to increase its commercialization efforts. Increased internal and external communication by the University administration is seen as having a positive impact on development projects. Increased understanding of business costs, functions, and needs by the University administration and the University community is also seen as having a positive impact on development projects. Ownership rights and distribution of receipts for property that do not reside under the umbrella of University-owned patents are seen as future stumbling blocks in commercialization efforts and need to be addressed. Finally, both sides suggest that the University would benefit by having some exposure to an internal or external office that can identify research on campus which has commercial possibilities. This last point would be difficult to implement, both technically and politically.

7.2 Conclusions

Commercialization of university research is of widespread interest to both university personnel and to industry. The objectives of this study were to develop a framework for assessing university-industry relationships, apply that framework to the various institutional structures for commercializing research at



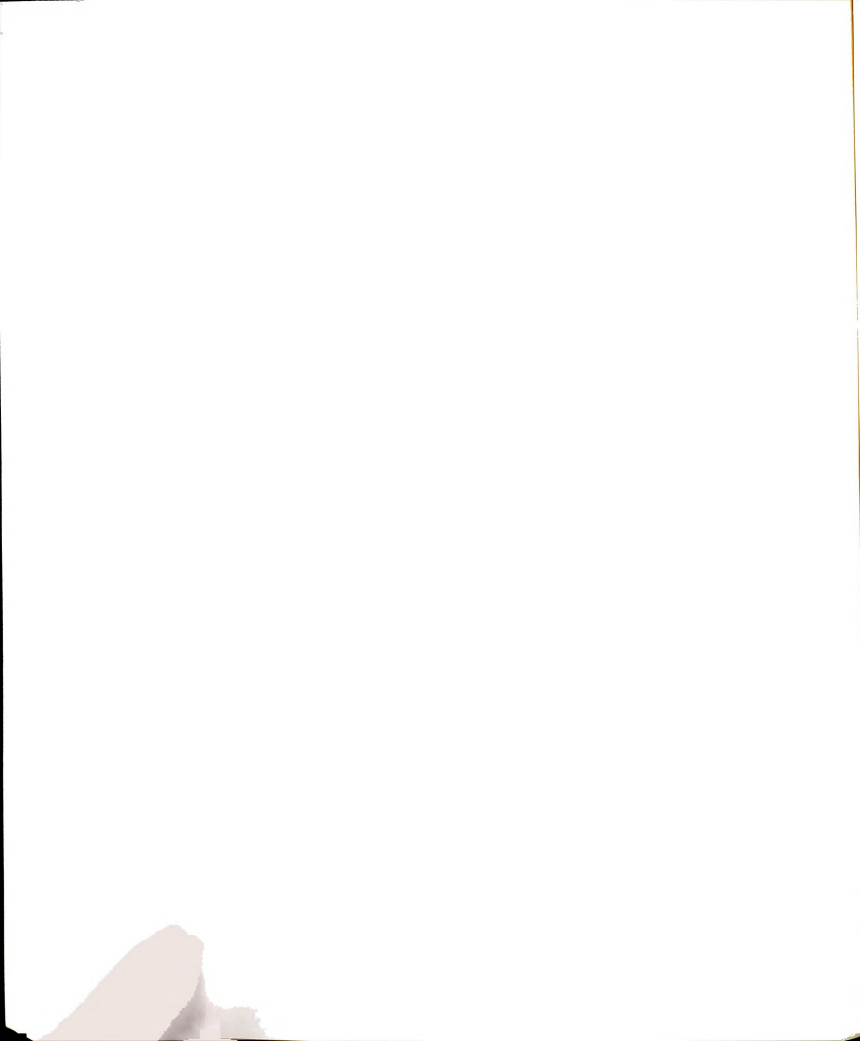
Michigan State University, and draw implications from the study results for the future agenda of research commercialization in the Department of Forestry.

The public choice model of situation, structure, conduct, and performance was used in developing a framework for the study. The problem was to identify the potential influence of institutional structure on financial performance by firms which commercialize University research. Performance measures chosen for the study included the capture of rents (value of user cost savings) by the firm, and the direct return of rents to the University.

User cost savings represented by a new technology are difficult to estimate but may provide a way to measure financial performance across industries and institutions. Performance can be measured for the firm that transfers technology (percentage of available rents captured by the firm), for the interchange (percentage of captured rents returned to the university), and for the system (percentage of available rents returned to the university).

When investment and transaction costs are borne by the firm they may lead to more efficient capture of rents but detract from the return of rents. When information costs are borne by the University they may lead to both more efficient capture and return of rents. Public controls, maintenance of quality, and University investment may provide more efficient capture and return of rents but do not necessarily lead to the largest markets or absolute returns.

Private firms with growth/profit objectives may be in a more competitive position where prices are dictated by market conditions



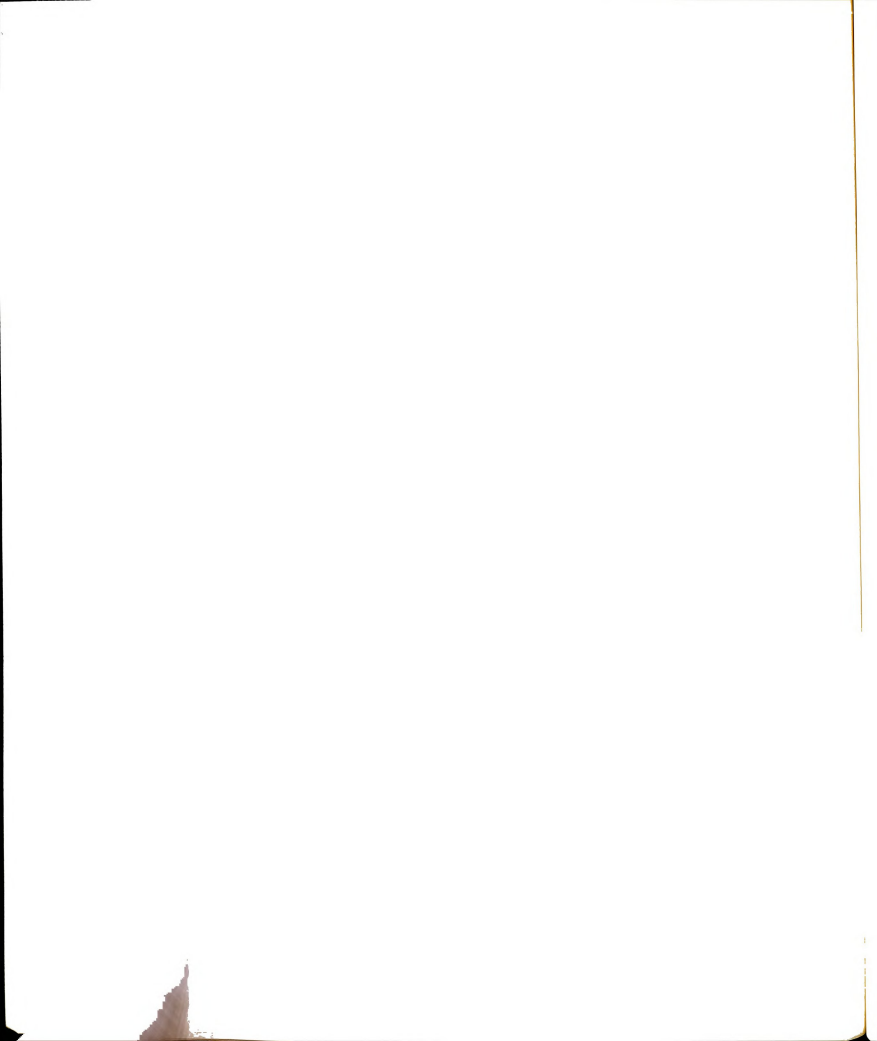
rather than system efficiencies. System efficiencies may be reduced but this would not prevent the University from realizing large returns on large volumes of a small margin item.

Private ownership or exclusive licensing may also provide more efficient capture of rents. Property ownership possibilities need to be expanded by the university and the rights and distribution of benefits from subsequent positions need to be better understood.

It appears that cost issues which lead to more efficient capture of rents by the firm do not lead to more efficient returns to the University while non-cost issues that lead to more efficient capture of rents by the firm lead to more efficient returns to the University. This is a striking difference.

University policy has been stated which demonstrates a desire for better University-industry relationships, a more attractive environment for faculty, and protection of the Land Grant philosophy. If efficiency (not absolute dollars) of the capture and return of rents from research commercialization is one policy goal, the results of this study imply there may be several program considerations which could enhance that effort.

Better internal and external relationships for University-industry interactions are consistent with University policy statements and departmental and firm needs. Stronger commitment of University resources to pre- and post-development stages of research with commercial potential is of primary importance. These resources should focus on both non-cost and cost aspects of structured relationships. Equity participation is only one possibility.



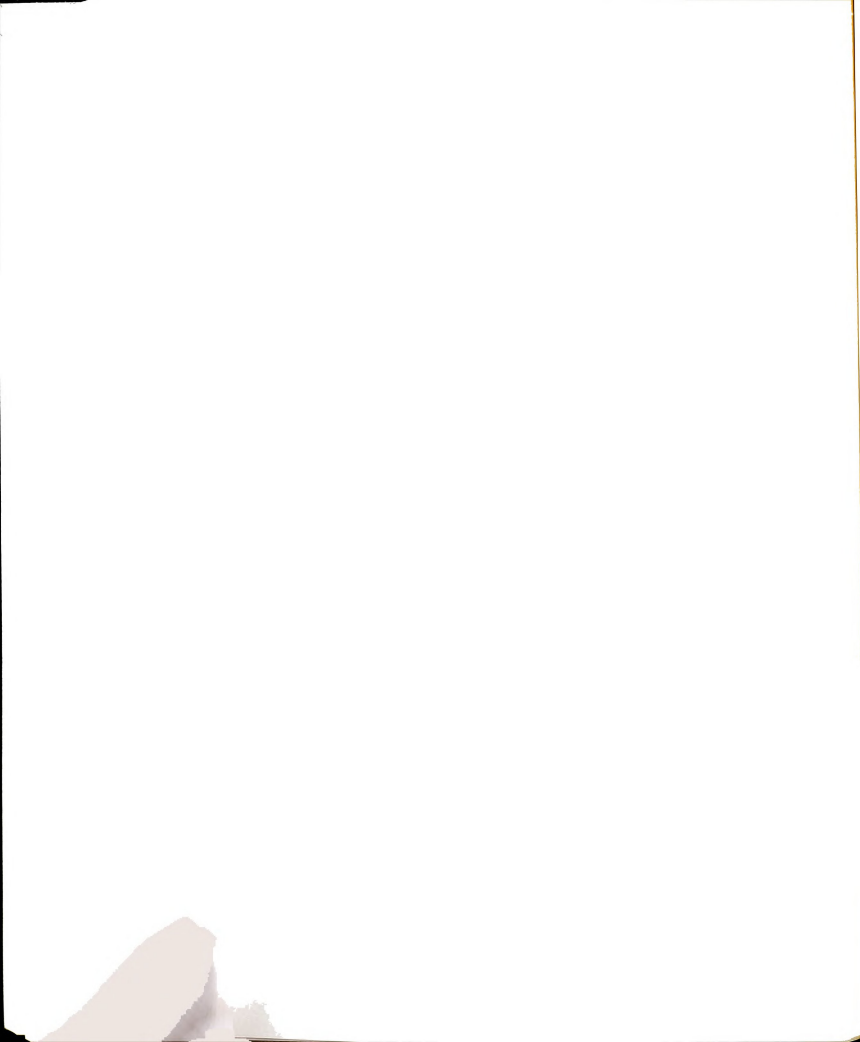
An emphasis on quality should enhance the efficiency of the transfer system and protect the Land Grant philosophy. Quality may be maintained through contractual controls or public administrative controls on a firm.

Use of the University name might be developed to have much more marketing power than it does. Automatic association of the University name with quality and a commitment to development should enhance commercialization efforts and lead to greater system efficiencies. This does not necessitate direct use of the name in advertising.

The University should realize the value of exclusive rights. Release of materials via an exclusive system may be more in the long-term public interest than simply giving materials away. Encouraging scientists to document their research and delay information exchange on ideas with commercial merit would enhance commercialization potential.

Two policies might encourage scientists to delay information exchange. Altering the merit system to value development efforts and successes would relieve the pressure to publish. And a University effort to identify early-stage research with commercial potential would allow scientists to make this choice.

The administration might consider allowing direct flow of contract funds for research with commercial potential back to the research program bypassing University overhead. They might also consider allowing direct flow of sales returns back to the program



circumventing the current University distribution policy. The inventor might find the latter acceptable if the former is in place.

Allowing private ownership of patents or non-patented technologies with a continued commitment to technology flows, might allow the University to receive credits for much of the technology that is developed on campus but has been exploited by industry in the past without giving up any returns.

Finally, a commitment to increased communication by the Administration, both inside and outside of the University, would be extremely beneficial to further commercialization efforts.

Interest and cooperation by most department chairpersons and all firm representatives in this study was outstanding. There was a call for increased activity, commitment, and understanding of current alternatives and future possibilities for the commercial development of University research. The problem seems to be who will take the initiative.

7.3 Implications for Forestry

The Department of Forestry has interests in commercializing genetic stock, silvichemicals, wood composites, and other technologies. Several points from this study may be applied to policy considerations by the Department when initiating these projects.

Commercializing genetic stock from the Department can be considered as both a short-term interest and a long-term potential. The results of this study seem to indicate that University-imposed

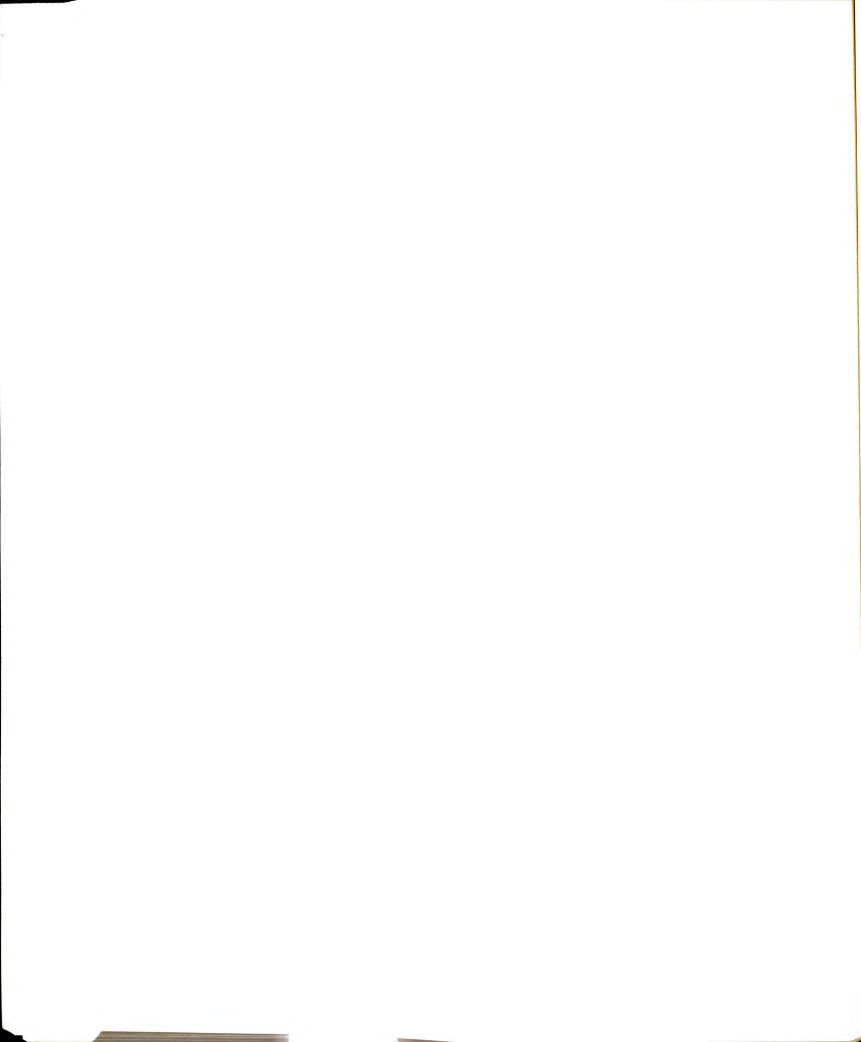


quality controls, an absolute must for the success of continued tree breeding research, may lead to more efficient capture and return of rents.

One consideration for the Department in the case of genetic stock is the possibility of licensing through a firm with public controls. The results of the study indicate that a firm with public controls and a quality/research objective may capture rents more efficiently and return a greater portion of those rents to the University. This does not imply that they will provide larger volume sales and larger total dollar amounts.

Long-term interests of the Department in commercializing genetic stock and supporting the research program may be enhanced through several factors. An open commitment to establishing proven quality and interacting at all levels with industry would be the precursor to increasing public control of commercialization efforts. Along with such a commitment should come a mechanism to provide direct returns to the research program and a fee structure that makes markets aware of that return. Maintaining exclusive distribution rights would help keep the efficiency of the system on a par with, or above, the potential of the private alternative. These are policy decisions for the Department, not the choice of a single researcher, and the Department may not want to make such commitments. In addition, the financial interests of the University, and perhaps of the individual, may be sacrificed.

Implications for silvichemical production, wood composites, and other technologies can also be made. The first comes from



unreported results. Potential markets must be determined and they must be sufficiently attractive to capture the interest of the private sector. While the technological possibilities may be forthcoming, a Departmental understanding of the industrial preservative market and the specialty chemical market is not well advanced at this time. University-based analysis of these markets would help focus the research program and enhance the possibilities for research commercialization. And a commitment of University resources before and during commercialization would help enhance potential returns to the University.

Structuring that commitment so that it does not replace private investment on cost characteristics will lead to both increased efficiency in capturing rents and returning rents. If the University commitment only takes place in cost characteristics there may be decreased efficiency by the firm in capturing rents. And finally, a long-term commitment by the program to the continued flow of technology for development is needed for the economic viability of a commercialization relationship to be upheld.

7.4 Suggested Work

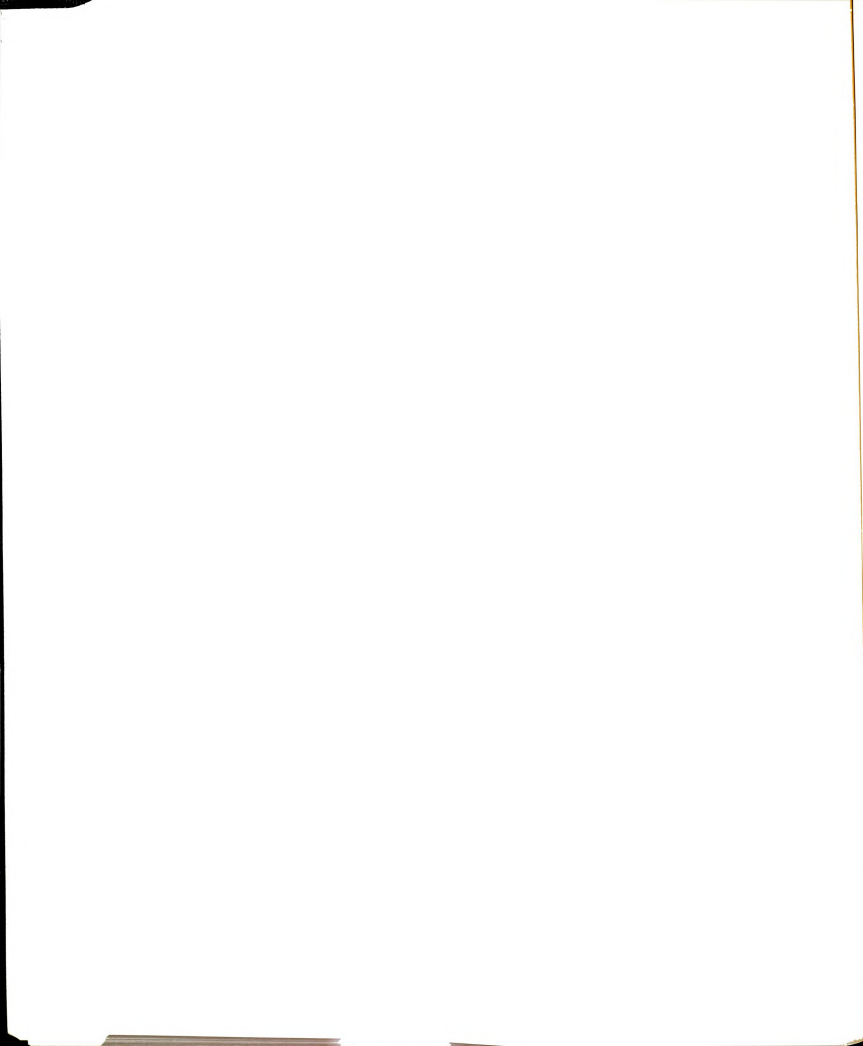
This study is unusual in its attempt to make a quantitative assessment of the influence of structural characteristics on the financial performance of firms commercializing university research. Progress has been made but there are many aspects of the research which require further work.

Some unexpected results were obtained in this study. One reason might be that the framework did not account for the stage of development or the stage of a product life cycle in which firms were involved. Another might be that the public influence on building system efficiencies was discounted. They may, in fact, have added value for the performance measures used. Other considerations lead to several suggestions.

The first and most obvious need is for a larger sample size so that statistical inference and ranking of structural characteristics can be made. The range of variation is sufficient in this study and could be expanded only slightly by going outside the study population. One difficulty with increasing the sample size is measuring performance. Cost savings estimates are costly in terms of time, and may be difficult to obtain in a survey (written) format, but will cut across industries and institutions.

More quantitative data on dollar flows for whole projects are needed, not just on the capture and returns of rents. Expenditures by universities and firms need to be tracked from basic research, through sales, and back to the program and inventor. This would answer questions about firm efficiencies, relative costs, and distribution systems.

Given the proliferation of new types of joint university-industry relationships, performance measures could be expanded to include pre- and post-development returns and indirect monetary returns. One question that demands comprehensive treatment is whether total returns to the university are equal no matter what the



structure of the firm. When direct returns are high are indirect returns low, and when direct returns are low are indirect returns high? In other words, when returns of rents from a project represent a small portion of available rents, do the remainder of those rents come back through the legislature and through public support? While this complicates the problems of measuring rents it may shed light on the importance of alternative payback arrangements.

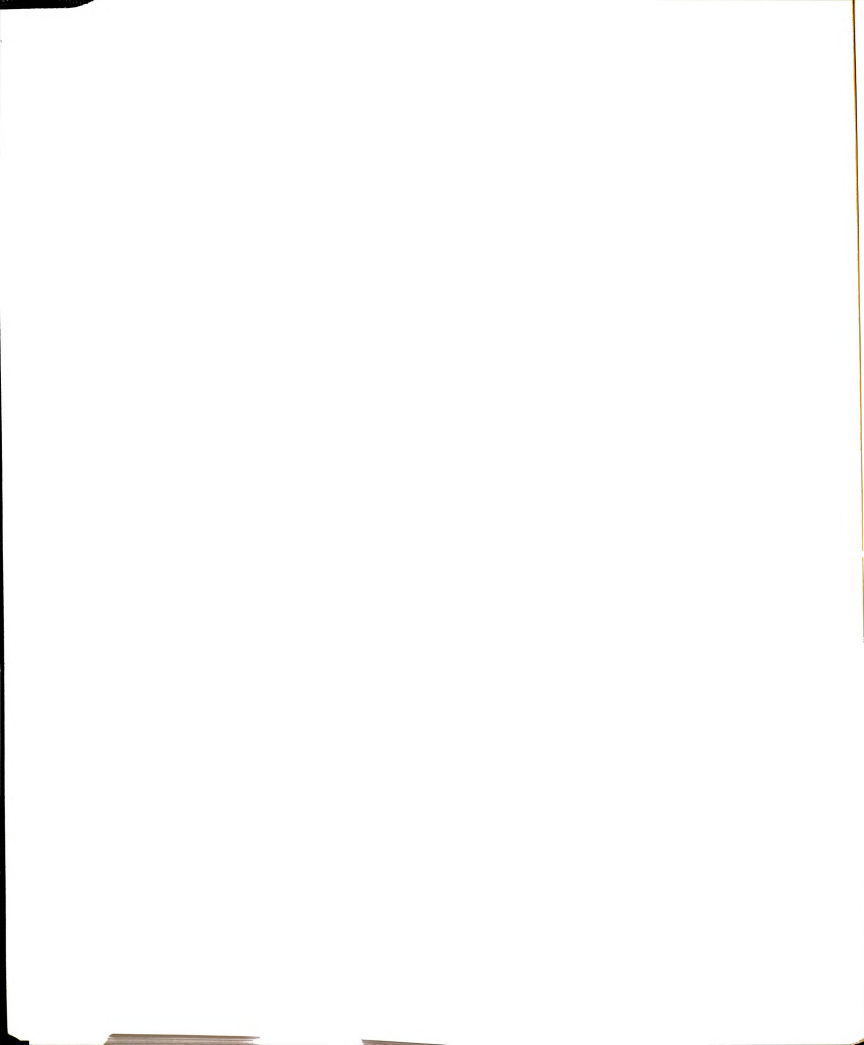
Attempting to measure market efficiencies rather than system efficiencies would also be helpful. One of the basic questions this study does not answer is the issue of total returns to the university. While a system may be relatively inefficient in capturing or returning rents on a per unit basis, it may be remarkably efficient at capturing markets and escalating total returns. The university administration that is interested in total returns should be aware of this when making development choices.

An attempt to measure the potential payoff to university equity involvement is fundamental to the university's commitment of capital resources in product development. Equity involvement suggests that the University can participate in sharing the net revenues of the firm. This study did not look at net returns because we could not get at costs. Equity involvement may be an incentive for the firm to seek lowest cost alternatives rather than attempt to capture rents through price maximization. Such work might be done at an institution where there is a history of university involvement financing firm start-ups or financing product commercialization.

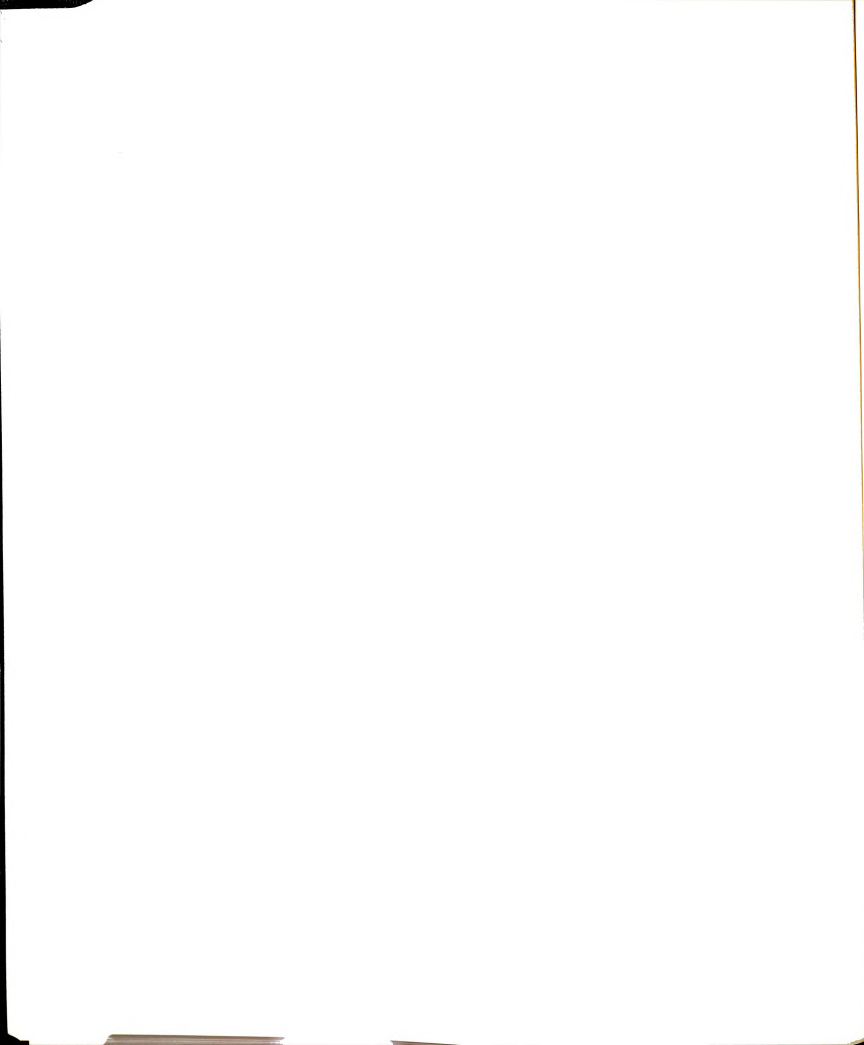
More work needs to be completed on how structure influences performance for systems with private patent ownership and non-patent proprietary rights. These may be the biggest questions facing the university administrator in the relatively near future. Research at commercialization centers may or may not lead to university patents or center patents, and the consequences of returns to the university as a tradeoff for ownership in these structures are not well understood. In fact, the consequences of ownership as a tradeoff for initial co-financing are not well understood.

Finally, work that expands the analysis to portions of the framework not covered by this study would be most enlightening. Quantitative measures must be maintained. All firms might maximize rents by adopting to sector differences and uncertainties (this study assumed that rents were known and quantifiable). Different institutional structures might evolve for different types of products and they may all be efficient at capturing rents. That says little about system efficiencies for returning rents to the University. Exploration of this idea might be helpful in resolving structural characteristics that are important to system efficiencies.

Commercialization of university research has its payoffs and its tradeoffs. Quantifying them and optimizing them through the selection of alternative institutional structures is the challenge. Hopefully this study represents one small step in that direction.



APPENDICES



APPENDIX A

Letter for Interview I

Michigan State University
E. Lansing, Michigan 48824
(517) 355-0090

Department of Forestry

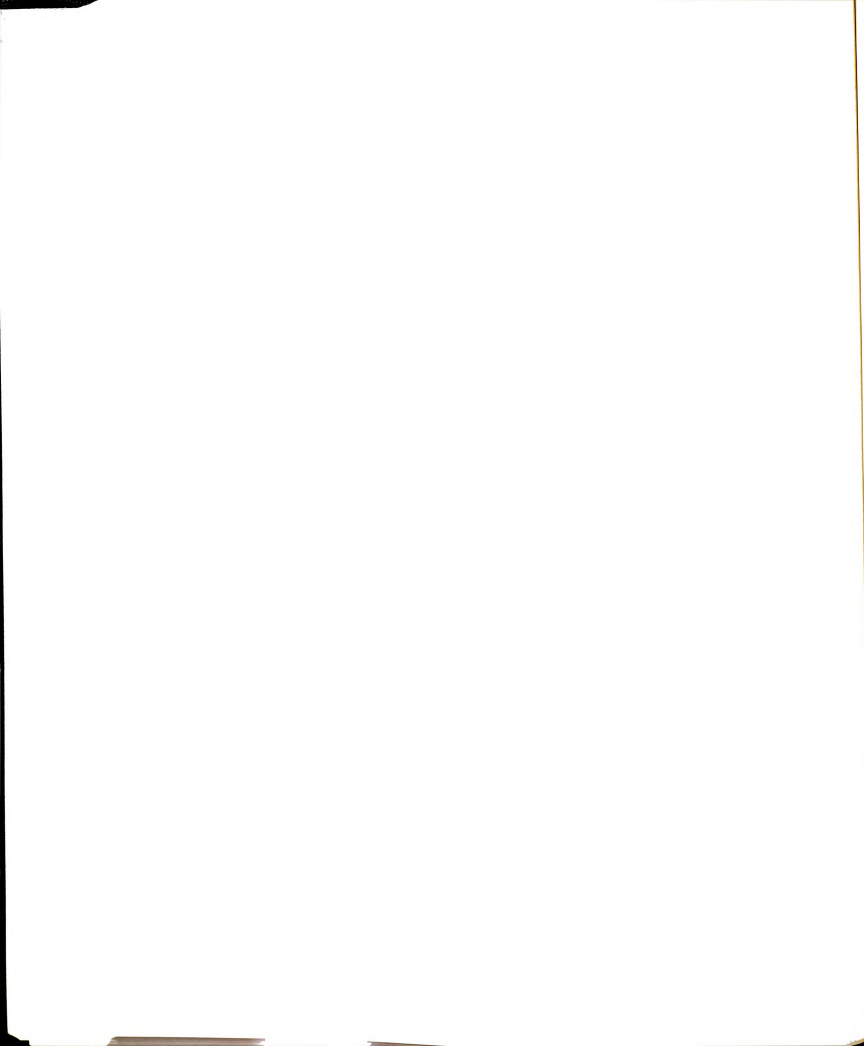
September , 1987

Dear Dr. :

The Department of Forestry is sponsoring a study of technology transfer at Michigan State University. This study focuses on the transfer of research products with commercial potential which move from the University to the private sector. It does not incorporate elements of service or training oriented university/industry relationships. The focus on product transfer is particularly important to forestry which is just beginning to develop patentable materials and initiate private sector ties. Economic development may be, or become, important to your department.

The purpose of this interview is to explore the full range of variability in the mechanisms which exist at MSU for the transfer of research products from the university to the private sector. Your participation in this University-wide study will give you the opportunity to share an understanding of the variety of techniques used across campus for product transfers. This may help you evaluate and select techniques for future product transfers. A number of preselected department chairmen will be interviewed in establishing a baseline inventory of mechanisms. Because the sample size is limited your full participation is vitally important to the successful completion of this study.

The results of the interview will be greatly enhanced if you could spend a few minutes prior to the interview reviewing the different research products with commercial potential which have been transferred from your department to the private sector since 1980. These might include market products, commercially transferred technology, products which have been given away, software, and books. In addition, please review the principal investigator, the type of mechanism used to transfer each product, and the name of the firm, association, or institution which was the transfer mechanism. A separate sheet is provided for your use in this review.

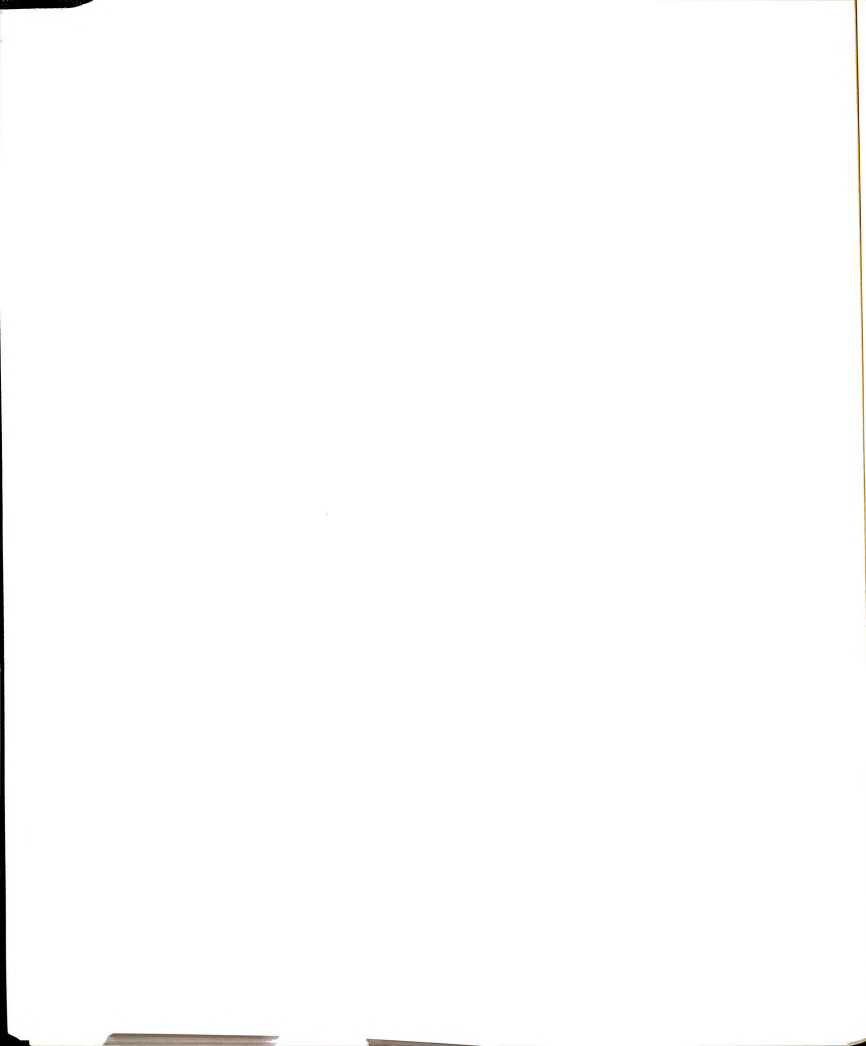


The inventory material will open the interview. Then we will select one particular product/firm combination from the list with which you are familiar and which represents the transfer activities in your Department. I will ask for information about this one product/firm combination regarding its technology and economics, private funding, property rights, contracts, control and selection of the firm or association, and returns to the University. Some general questions will conclude the interview.

Thank you very much for your time and cooperation and I look forward to meeting with you. Questions may be directed to myself or Professor James Hanover, the advisor for this study.

Sincerely,

Dikran Kashkashian



Consent for interview with Dikran Kashkashian

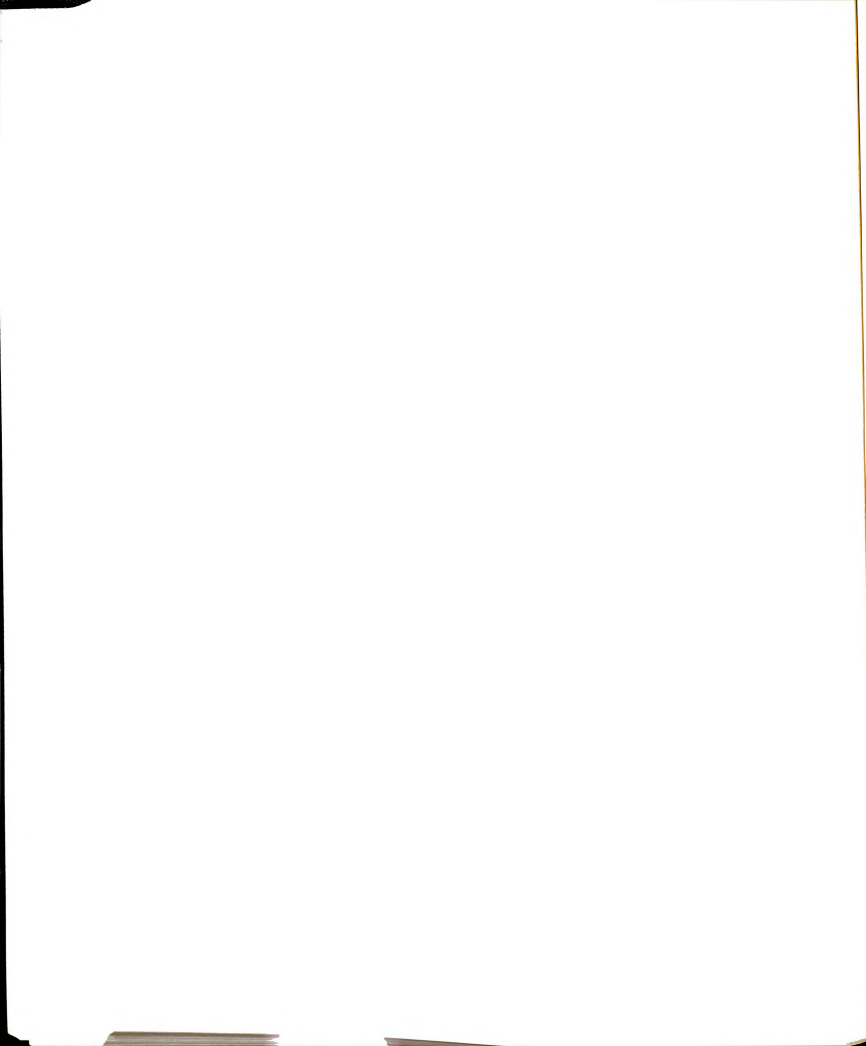
You have explained the nature and purpose of this study to me and have answered any questions which I may have about the study to the best of your ability. At this time I understand both the study and any perceived risks. To minimize any possible risk I have been asked not to release any legally confidential information to you. I have freely consented to participate in the interview and understand that I may discontinue that participation at any time.

I understand that information obtained through this interview will remain confidential and that the results will be reported in non-identifying, summary format only. I also understand that in completing this study you may contact investigators, firms, or the MSU administration for further information to develop several in-depth profiles of particular transfer mechanisms. I recognize that these profiles may contain identifying types of information and anonymity cannot be guaranteed at this level.

I will sign and date this form and return it to you at the time of our interview.

Name _____

Date _____



List for interview with Dikran Kashkashian: _____ to _____ on _____

<u>Product or Technology</u>	<u>Investigator</u>	<u>Mechanism¹</u>	<u>Firm</u>
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

Number of books _____ (typical) _____

¹Mechanism

- A. Given away to anyone that was interested.
- B. Given away to a single for-profit firm.
- C. Given away to a single non-profit firm or association.
- D. Protected by MSU and licensed to anyone that was interested.
- E. Protected by MSU and licensed to a single for-profit firm.
- F. Protected by MSU and licensed to a single non-profit firm or association.
- G. Protected by MSU and developed through Research Corporation.
- H. Private development by the investigator.
- I. Other (please specify).

APPENDIX B

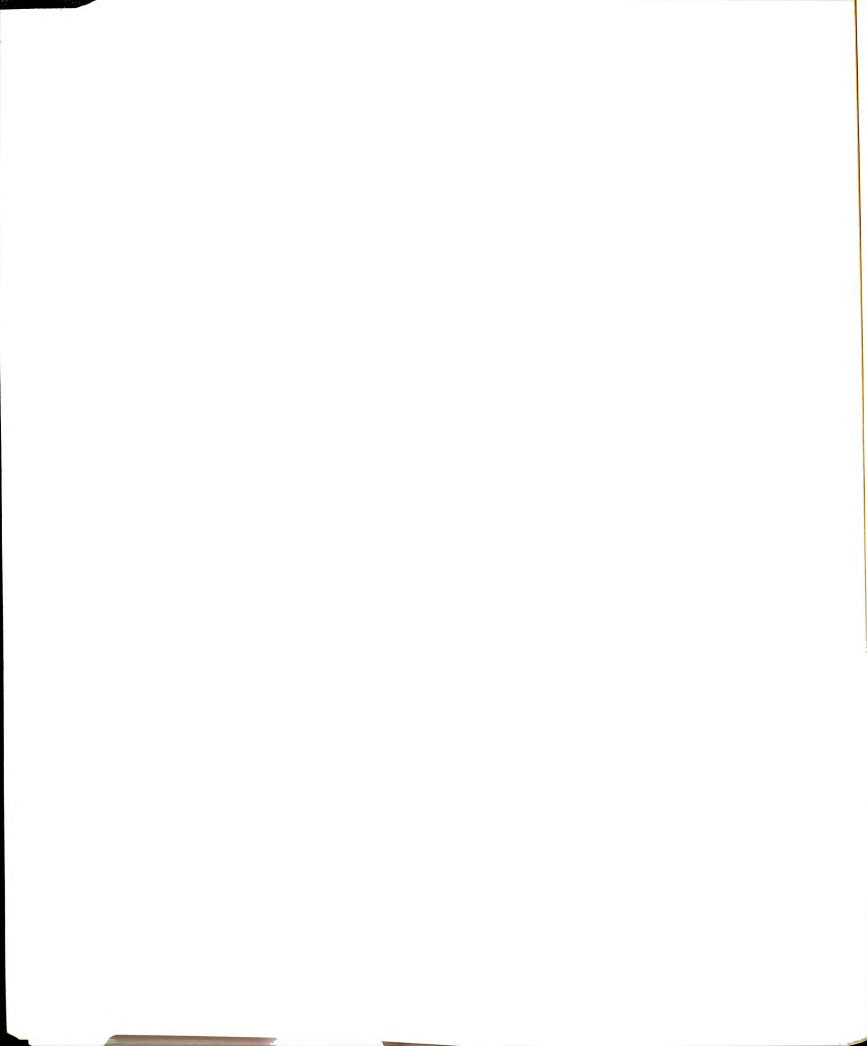
Instrument for Interview I

MICHIGAN STATE UNIVERSITY
COMMERCIAL PRODUCTS TRANSFER SURVEY

Department _____

Name _____

Date _____



I sent you a letter explaining this study and outlining the purpose of the interview. As you know I would like to focus on what happens in your department when research leads to a commercial product which the investigator transfers to the private sector. This study examines how institutional arrangements influence the portion of economic benefits captured by the transfer mechanism and returned to the university. Even though most academic effort goes toward free information flow without consideration for commercial development there are several reasons for the particular focus of this study:

- A national trend emphasizing university/industry technology transfer has surfaced in a variety of public and private institutions.

- The State of Michigan has recently focused on regional economic development through university based centers for commercial applications.

- The Department of Forestry is just beginning to develop patentable materials and initiate private sector ties for commercial development.

- I am interested in pursuing this line of work and have spent time at both Neogen and MBI since starting graduate school here.

- The selection of a research topic for my dissertation forced me to focus on one aspect of university/industry relationships.

Do you have any questions for me right now?

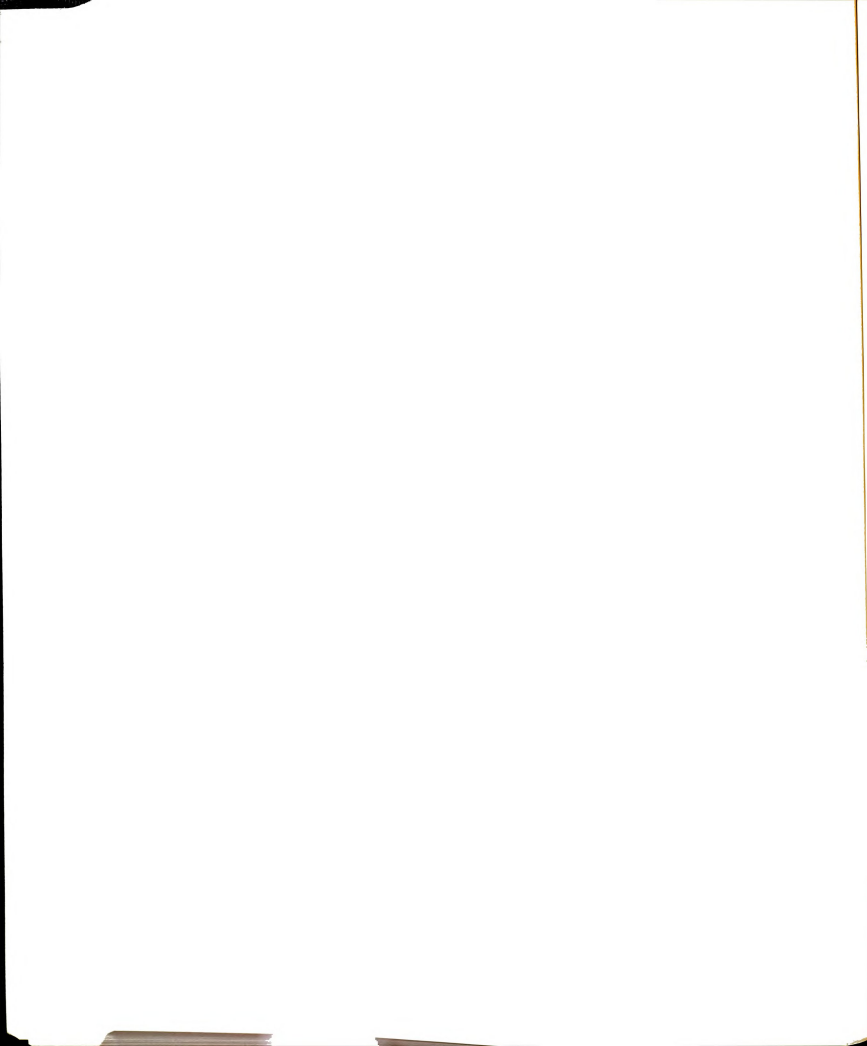
Some of the interview questions will require the use of an answer card which I will hand to you before reading the question. Please read the answers to me from the card and feel free to select more than one option when appropriate.

I apologize but the consent form was required by university policies. May I have that back?

First, lets cover the material which I requested you review. Did you get a chance to complete the list that was enclosed with the letter?

Lets go over the sheet now.

What about (generic) _____?



Lets select one product/firm combination for further discussion. Give some thought as to how familiar you are with the various options, the relevance it has to your department and field, and how representative it may be of past and future transfer activities in your department. There will be a number of questions regarding the technology and economics of the product, contracts with the firm, and other aspects of this particular university/firm relationship. Much of the interview will center around this one product. If you have several can I help make a choice?

Which product and firm would be good to talk about?

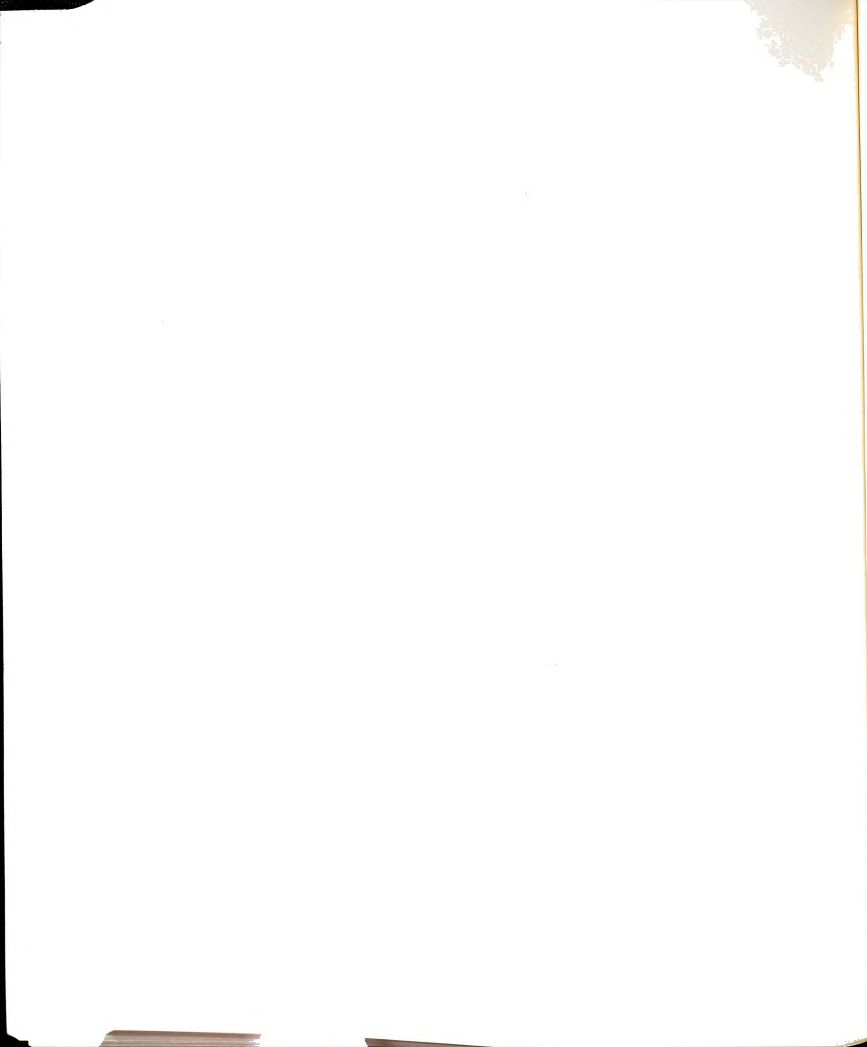
Where is the firm located?

What technology or innovation does the product represent?

Who was the principal investigator on the project?

Is he/she still in your department?

Where can I contact them?



Now I d like to ask a few questions about private sector funding which might have contributed to the resources used for completing this research. Then I'll ask a few questions about the property rights which have been arranged for the final product.

Here is card #1.

The mechanism used to transfer a product may be in part a function of the funding structure. Please estimate the portion of funding for this project received from the following sources.

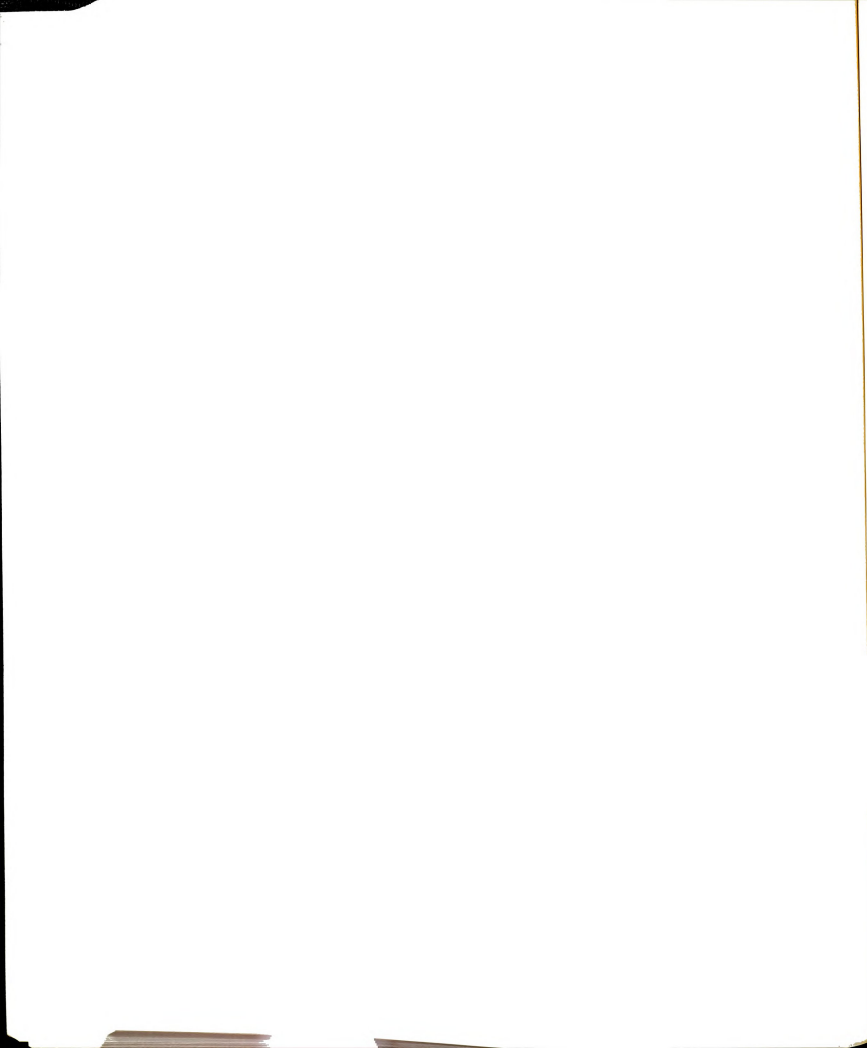
- A. Federal
- B. State
- C. Industry
- D. Other (please specify)

Here is card #2.

What form did the private sector funding come in?

- A. Research contract
- B. Grant
- C. Designated gift
- D. Other (please specify)

From whom was it received?



Here is card #3.

What type of legal protection exists for this product?

- A. Patent
- B. Copyright
- C. Trademark
- D. Plant Variety Protection Act Certificate
- E. Other (please specify)

Here is card #4.

Who owns these legal rights?

- A. University
- B. Department
- C. Investigator
- D. The transfer firm
- E. Other (please specify)

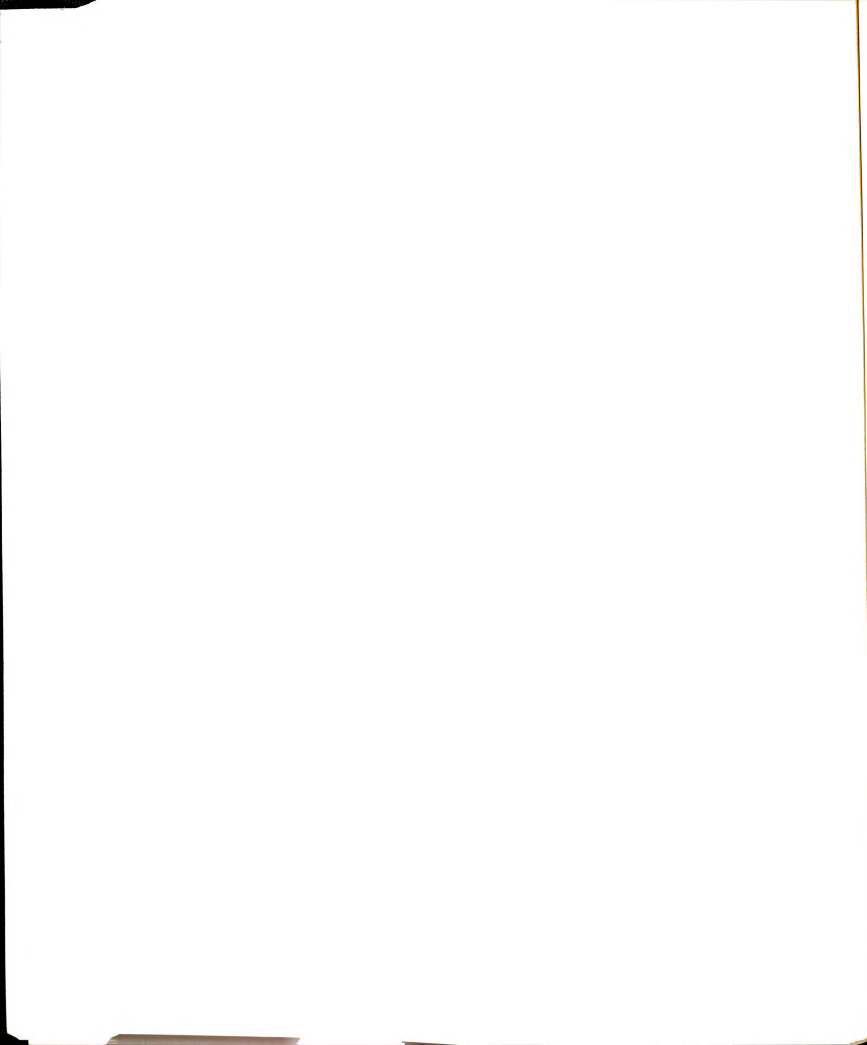
Using card #4 again, who paid to process these legal rights?

- A. University
- B. Department
- C. Investigator
- D. The transfer firm
- E. Other (please specify)

Using card #4 a third time, who is responsible for enforcing them?

- A. University
- B. Department
- C. Investigator
- D. The transfer firm
- E. Other (please specify)

Does the product have the MSU name or Spartan trademark associated with it?



In addition to property rights there may be some formal arrangements between the university and the firm or association used to transfer the product to the private sector. I d like to identify the source of this arrangement, get an idea of its contents, and see if there are any public controls on the firm or association which might influence this arrangement.

Here is card #5.

What type of formal performance agreement is there between the university and the firm?

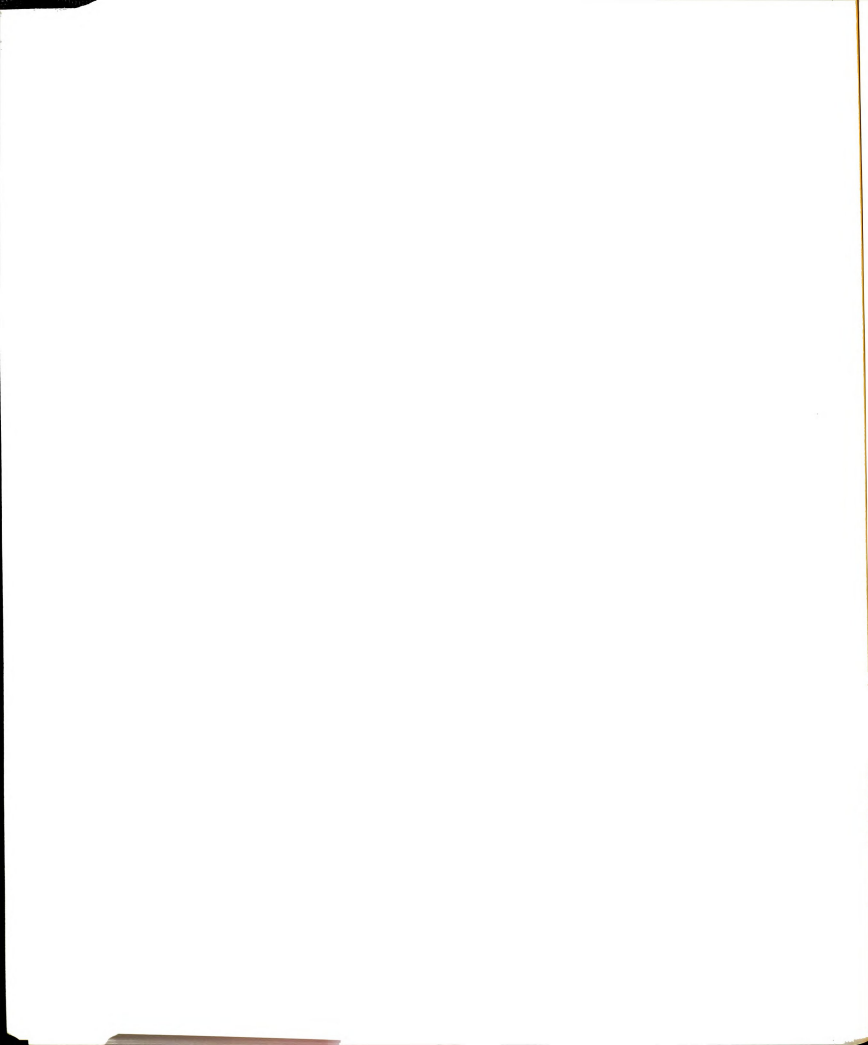
- A. Licensing agreement
- B. Memorandum of agreement
- C. Informal letter
- D. Other (please specify)

Here is card #6.

What university unit entered into and holds the agreement?

- A. University Contracts and Grants
- B. College
- C. Agricultural Experiment Station
- D. Department
- E. Investigator
- F. Other (please specify)

Could you briefly describe the agreement for me?



Here is card #7.

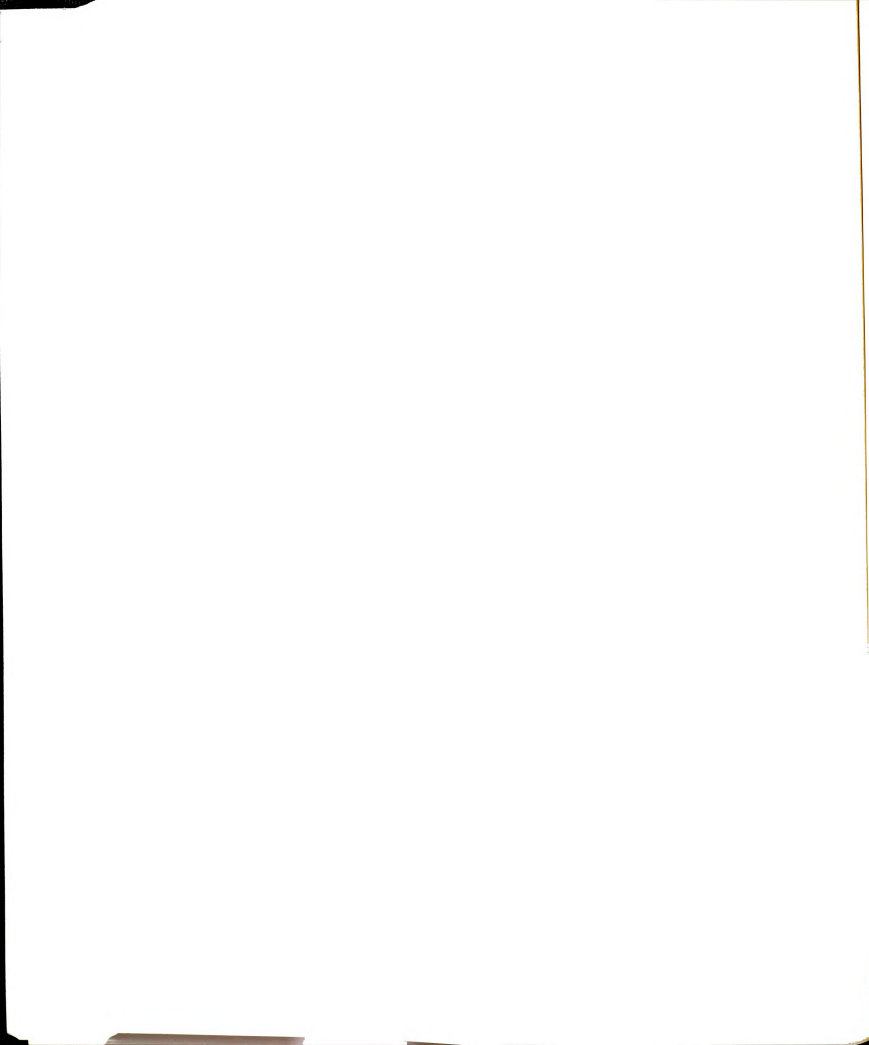
I d like you to help characterize the influence Michigan State University might have on the firm by telling me which of the following apply to its structure.

- A. Michigan State University equity in the firm
- B. Other public equity in the firm
- C. MSU employees on the firm s board of directors
- D. MSU employees on the firm s science advisory board
- E. MSU alumni hold top executive positions in the firm
- F. MSU employees used as consultants by the firm
- G. Other (please specify)

How was the firm selected?

What other firms or mechanisms were considered and why were they rejected?

Would you use a similar arrangement again for the transfer of another product to the private sector? Why or why not?



Financial returns to the university and the distribution of these returns are of interest to certain university administrators yet they remain a point of contention among academic peers. Without judging these issues I d like to ask a few questions regarding the institutional arrangements for returns to the university and some follow-up questions regarding the technology and economics of the product. Again, this is because this study examines how institutional arrangements influence the portion of economic benefits captured by the transfer mechanism and returned to the university.

Here is card #8.

What is the nature of receipts from the firm to the university for the transfer of this product?

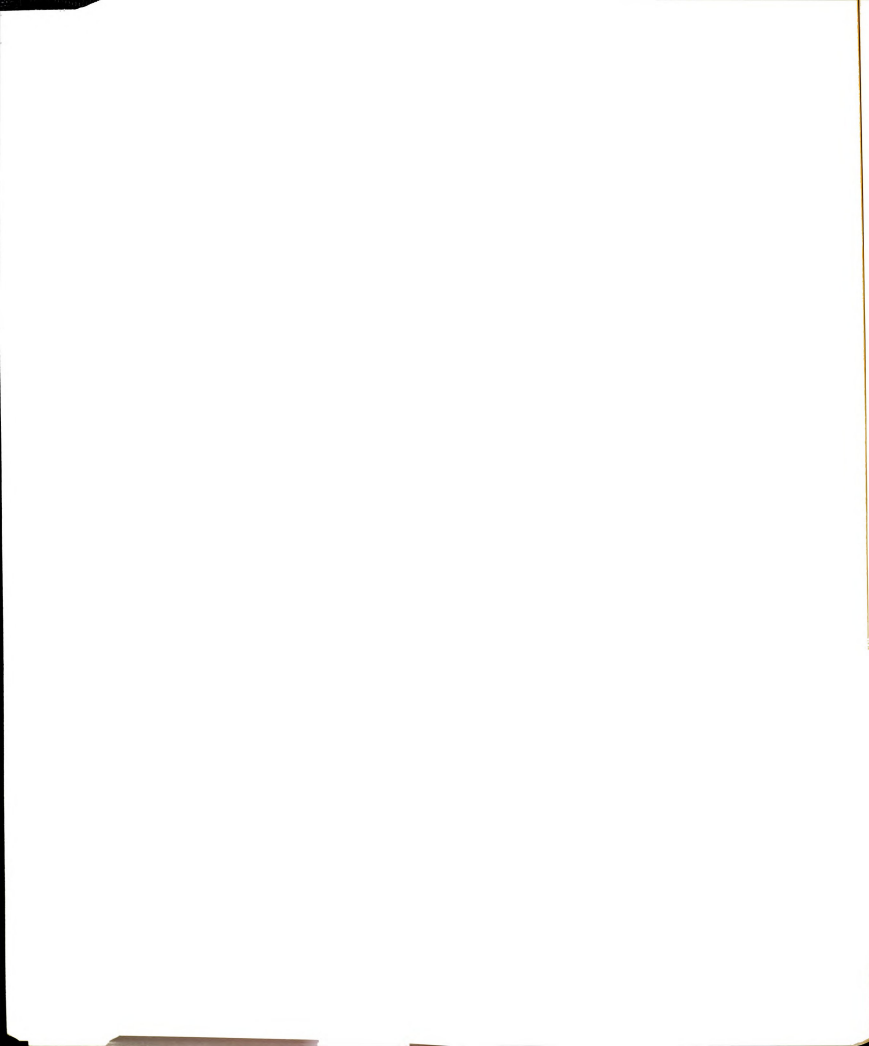
- A. Licensing fee
- B. Royalty payments
- C. Designated gifts
- D. Donations
- E. Revolving account
- F. Other (please specify)

Here is the last card.

Please tell me the final distribution of these funds by percentage?

- A. University
- B. College
- C. Department
- D. Project
- E. Investigator
- F. Other (please specify)

What other contributions does the university receive from the firm?



The next series of questions may be a little difficult to answer but I would like your help in trying to estimate the value of the end product.

Is the product one input into a production process or is it a final product for the consumer?

What is the closest substitute for the product?

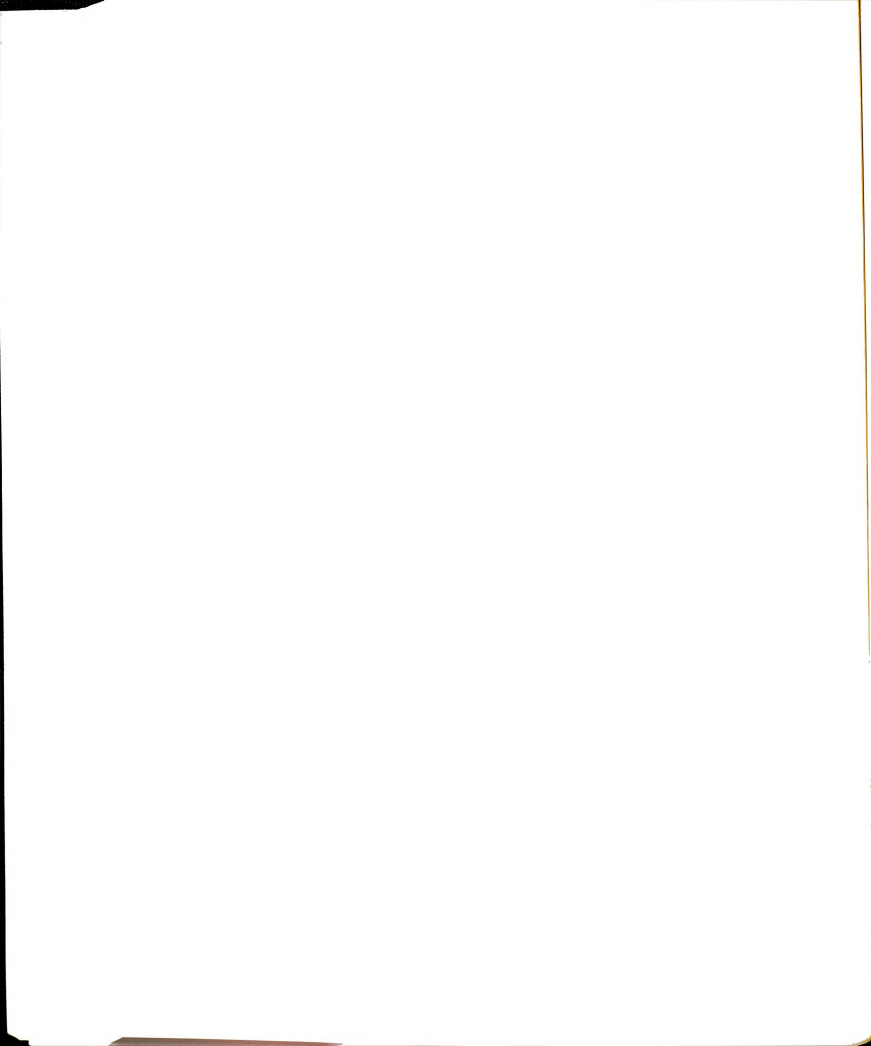
Does the product sell for a premium or a discount to that substitute?

How much is the premium or discount? This can be a ballpark figure as other estimates may be obtained later.

What is the actual cost savings which the technology represents to the producer or consumer? In other words, if it is a producer good how much does the technology represent as a cost savings in the production process or if it is a consumer good what is the consumer willing to pay for it.

What percentage of the actual discount or premium is returned to the university by the transfer firm? This too can be a ballpark figure.

In general, what factor do you feel most influences the percentage of funds returned to the university by the transfer firm?



I would like to ask you a few general questions about commercial product transfers in your field. These no longer apply to just the one product we have been discussing.

Which type of transfer mechanism do you feel is most important to past and future development activities in your department and why do you feel this way?

What university do you feel does the best job of getting research products with commercial potential in your field out into the private sector and what do they do?

This is not the most common mode of interaction between academics and user groups.

Should we do more or less of it?

What have we learned from what has been done?

Is it important that MSU be recognized as the source of a new design or technology which has gone out to industry? Why or why not?

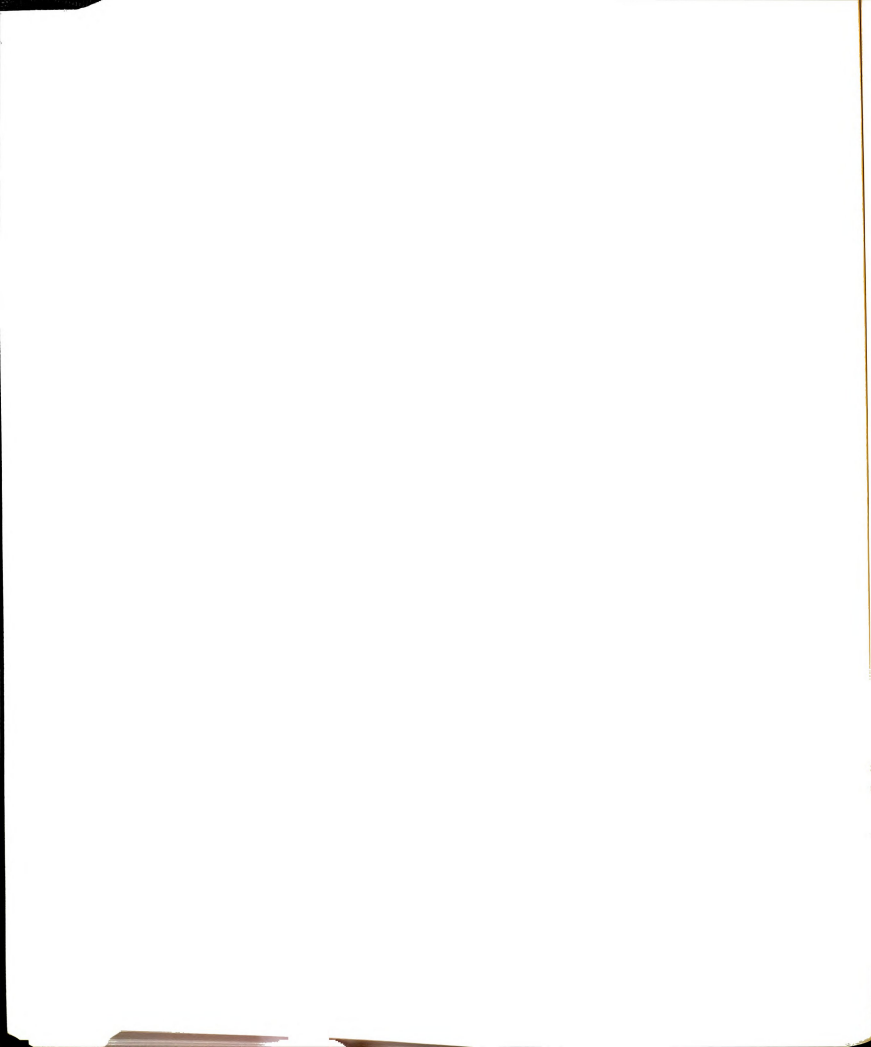
Please name three products or technologies from other departments at MSU which have been transferred to the private sector. The PI and transfer mechanism or firm name would be helpful if you know it.

What are the current needs for product or technology transfer which are not being met at MSU?

What institutional arrangements promote or inhibit the return of economic benefits to the university by a technology or product transfer mechanism?

What do you feel are the major conflicts between academic goals and private marketing?

As a follow-up to the last question, what do you feel are the most important issues regarding the broader area of university/industry relationships?



This was a short time I got to spend with you. May I call on you for help on a few last items if I happen to hear of something that was developed in your department which we did not cover today?

Would you mind telling me how long you have been in this department and how long you have been department chair?

Can you suggest another source from your department whom I might talk to if necessary?

Where can I contact them now?

Do you have any questions for me?

Thank you very much for your time and cooperation. This is an exploratory study and your understanding has been most appreciated.

APPENDIX C

Letter for Interview II

Department of Forestry
Michigan State University
E. Lansing, Michigan 48824

December , 1987

Dear :

The Department of Forestry is sponsoring a study of technology transfer at Michigan State University. This study focuses on the transfer of research products with commercial potential which move from the University to the private sector. It does not incorporate elements of service or training oriented university/industry relationships. The focus on product transfer is particularly important to forestry which is just beginning to develop patentable materials and initiate private sector ties.

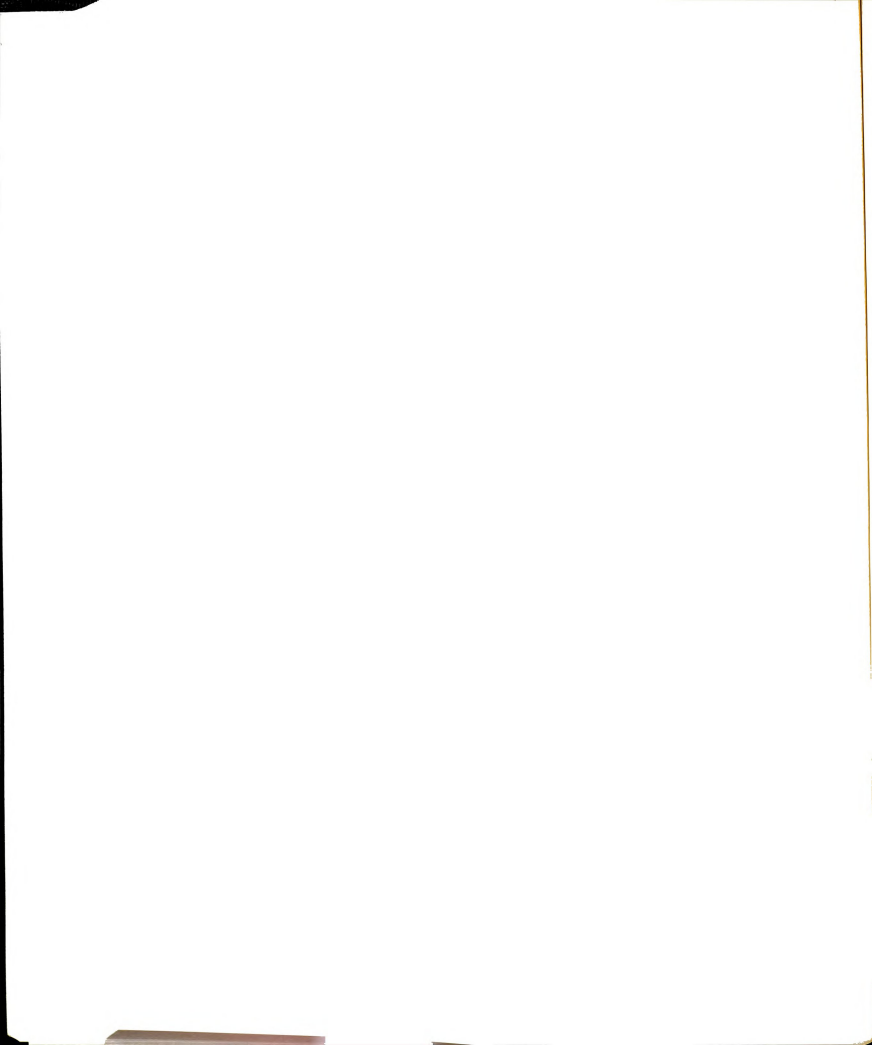
One part of this study consisted of interviews with twenty-one department chairmen. The purpose of those interviews was to inventory most of the research commercialization mechanisms used at Michigan State University since 1980 and assess some current policy issues and needs.

Several firms identified from that inventory are now being interviewed for detailed profiles of certain structural and pricing variables which fit into an economic model. The purpose of this interview is threefold: 1) To confirm certain structural characteristics of your firm and its licensing or development agreement for XYZ with the University. 2) To understand the specific user cost savings which XYZ represents, its pricing, and its payback to the University. 3) To discuss how you price a new product and where the University fits in with your firm's objectives. Because the sample size is limited your full participation is vitally important to the successful completion of this study.

A consent form is attached which I will get back from you during our interview on JZK . Thank you very much for your time and cooperation. Questions may be directed to myself or Professor James Hanover, the advisor for this study.

Sincerely,

Dikran Kashkashian



Department of Forestry
Michigan State University
E. Lansing, Michigan 48824
(517) 355-0090

Consent for interview with Dikran Kashkashian

Dikran Kashkashian has explained the nature and purpose of this study to me and has answered any questions which I may have about the study to the best of his ability. To minimize any possible risk I have been asked not to release any legally confidential information. I have freely consented to participate in the interview and understand that I may discontinue that participation at any time without penalty. I may also choose not to answer any specific questions during the interview. The interview should last not more than two hours but Dikran Kashkashian may phone me for additional clarification on specific points.

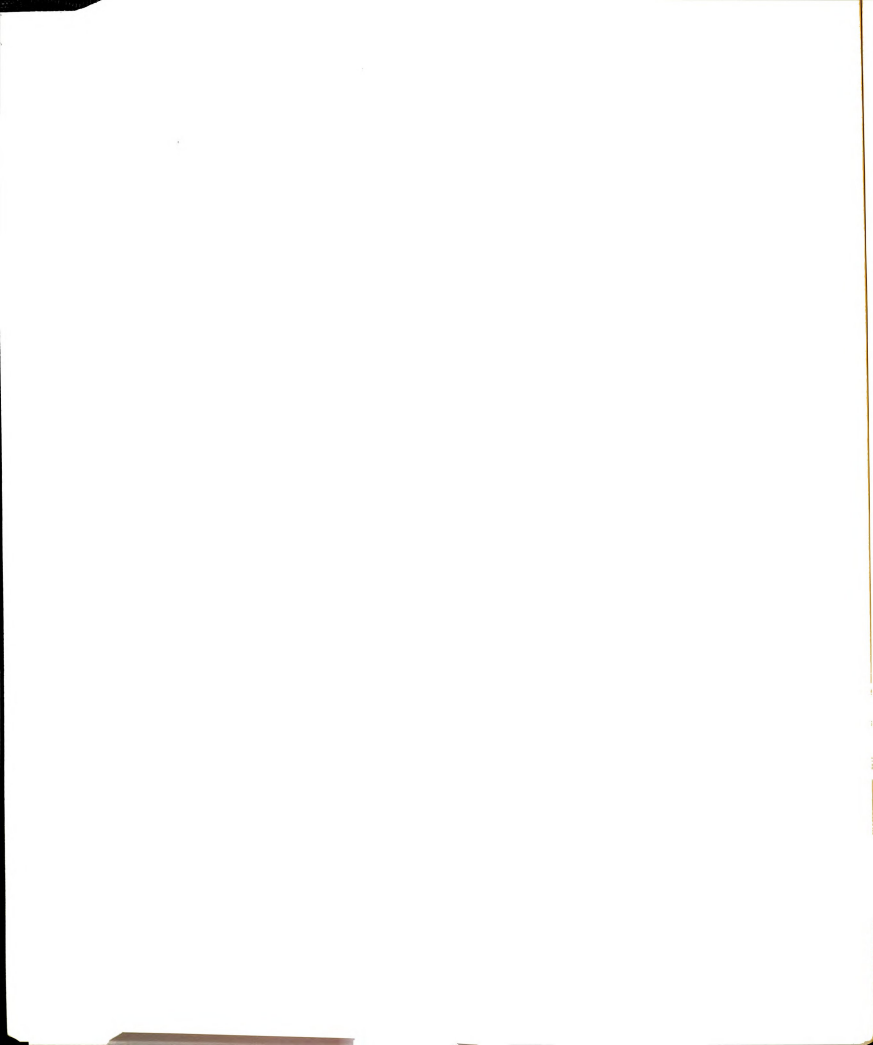
I understand that in completing this study other investigators, firms, or the MSU administration may be contacted by Dikran Kashkashian for additional information in order to develop profiles of commercialized research products and their transfer mechanisms. I recognize that these profiles may contain identifying types of information and anonymity cannot be guaranteed at this level. The final work will not contain my name, the firm name, or the product name. The final work will contain the information we discuss as related to the following classification:

- University facilities
- Faculty initiated private firm
- External brokerage firm
- University co-sponsored commercialization center
- University licensee

Name _____

Firm _____

Date _____



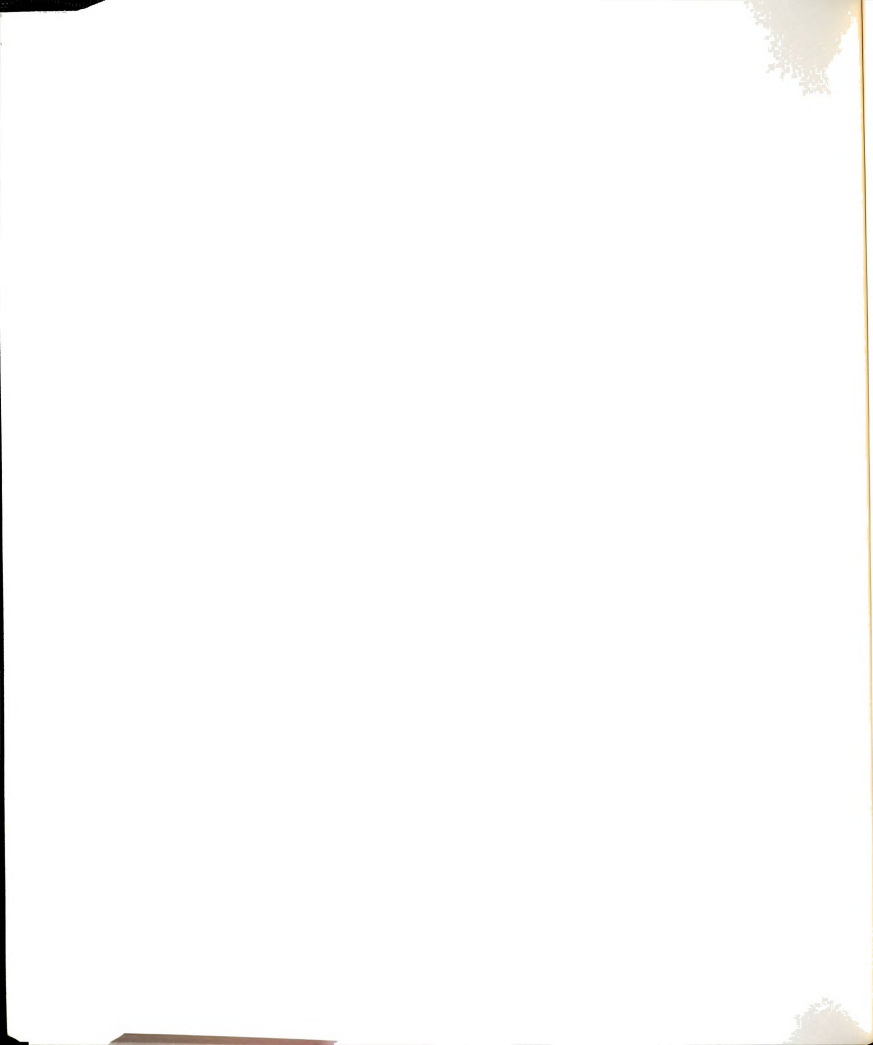
APPENDIX D

Instrument for Interview II

MICHIGAN STATE UNIVERSITY
COMMERCIAL PRODUCTS TRANSFER SURVEY

Name _____

Date _____

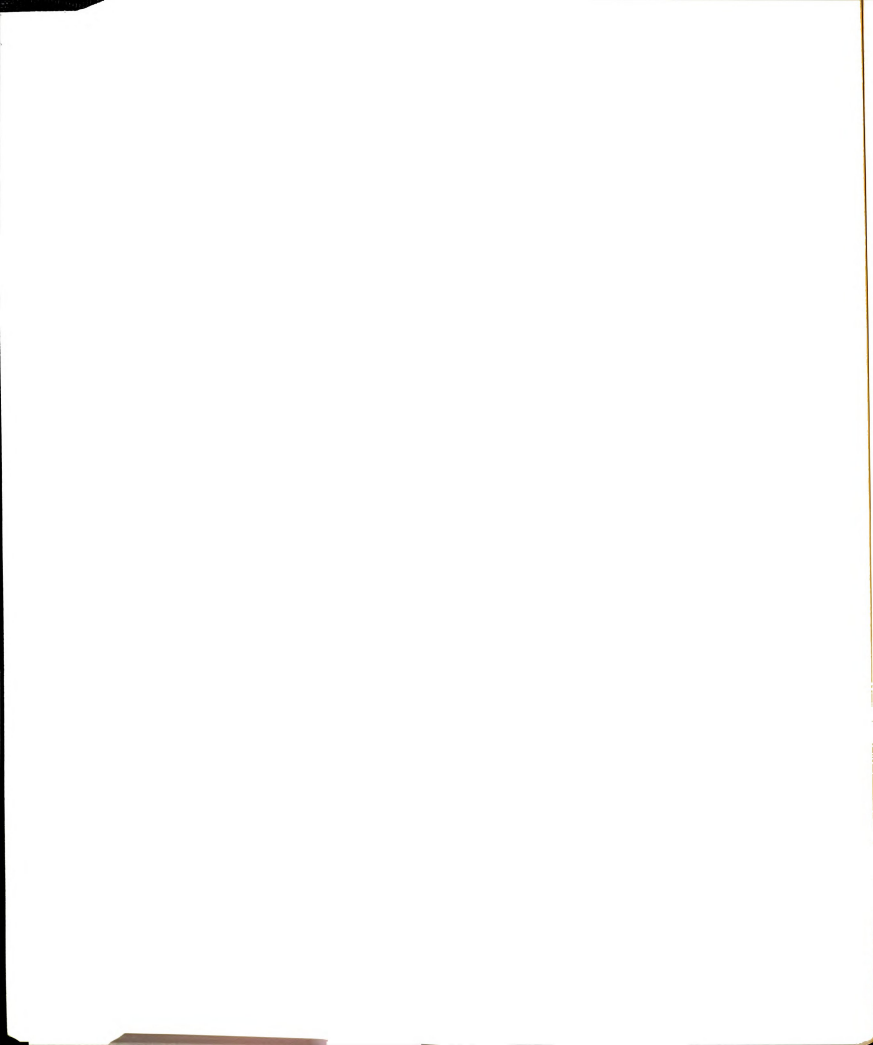


This study examines how institutional arrangements influence the portion of economic benefits which are captured by a technology transfer mechanism and returned to the university. Even though most academic effort goes toward free information flow without consideration for commercial development there are several reasons for this particular focus:

- A national trend emphasizing university/industry technology transfer has surfaced in a variety of public and private institutions.
- The State of Michigan has recently focused on regional economic development through university based centers for commercial applications.
- The Department of Forestry is beginning to develop patentable materials and initiate private sector ties for commercial development.
- I am interested in pursuing this line of work and have spent time at both Neogen and MBI since starting graduate school here.

Do you have any questions for me before we start?

I apologize but a consent form would be helpful to me. I sent one with the explanatory letter but if its not available I brought an extra copy.



Please give me a brief idea of:

- How your firm got started?
- How you initiated ties with Michigan State University?

I'd like to confirm certain structural characteristics which may apply to your firm and its relationship with Michigan State. These are important because they may effect performance measures in the model for the study.

Public controls can influence the way a firm acts. Did any of the money for starting the firm or for operating the firm come from federal, state, or university resources?

What about faculty equity in the firm?

What public figures are on your firm's board of directors? These might include university administrators or faculty.

What public figures are on your firm's scientific advisory board?

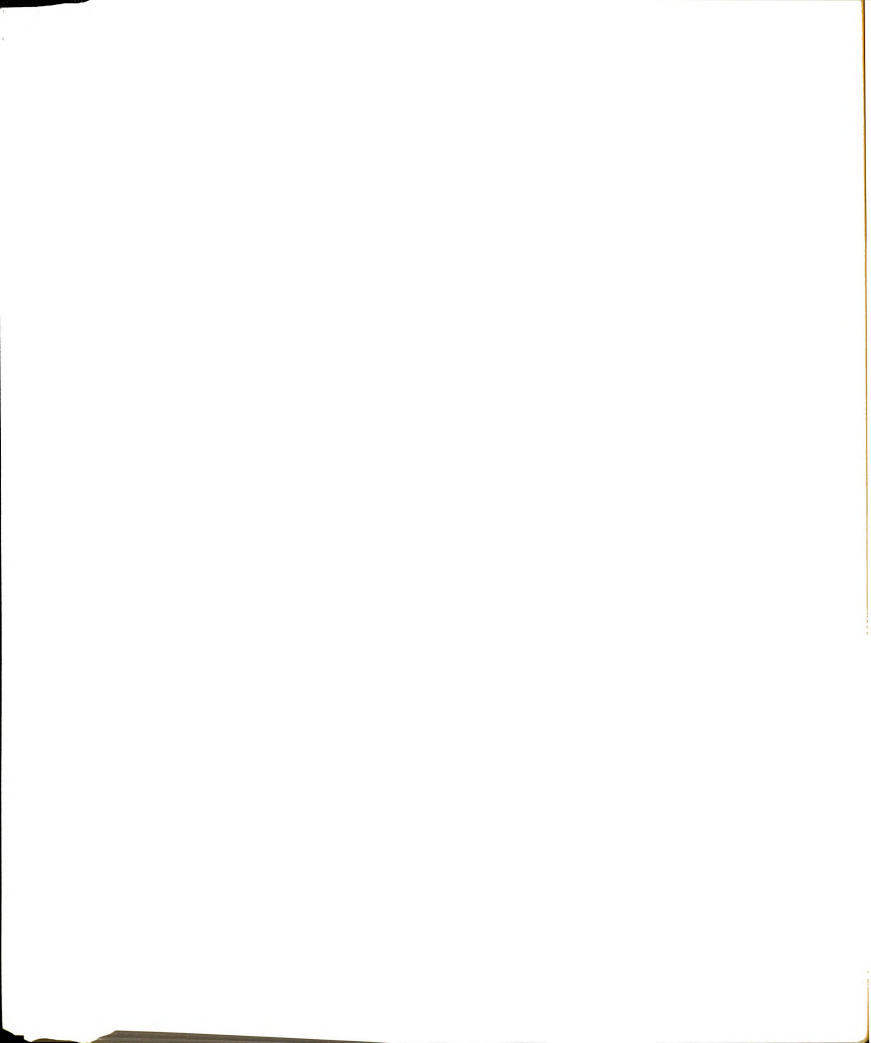
What top executives also hold a public administration or faculty position?

Have any of these public controls played a role in changing policies which your firm might not otherwise have taken?

How would you spell out the economic objective of your firm?

Where do the following items fit in with this economic objective?

- Profit maximization
- Quality of the product
- Quantity of the product available to the public
- Satisfying the research interest of executives



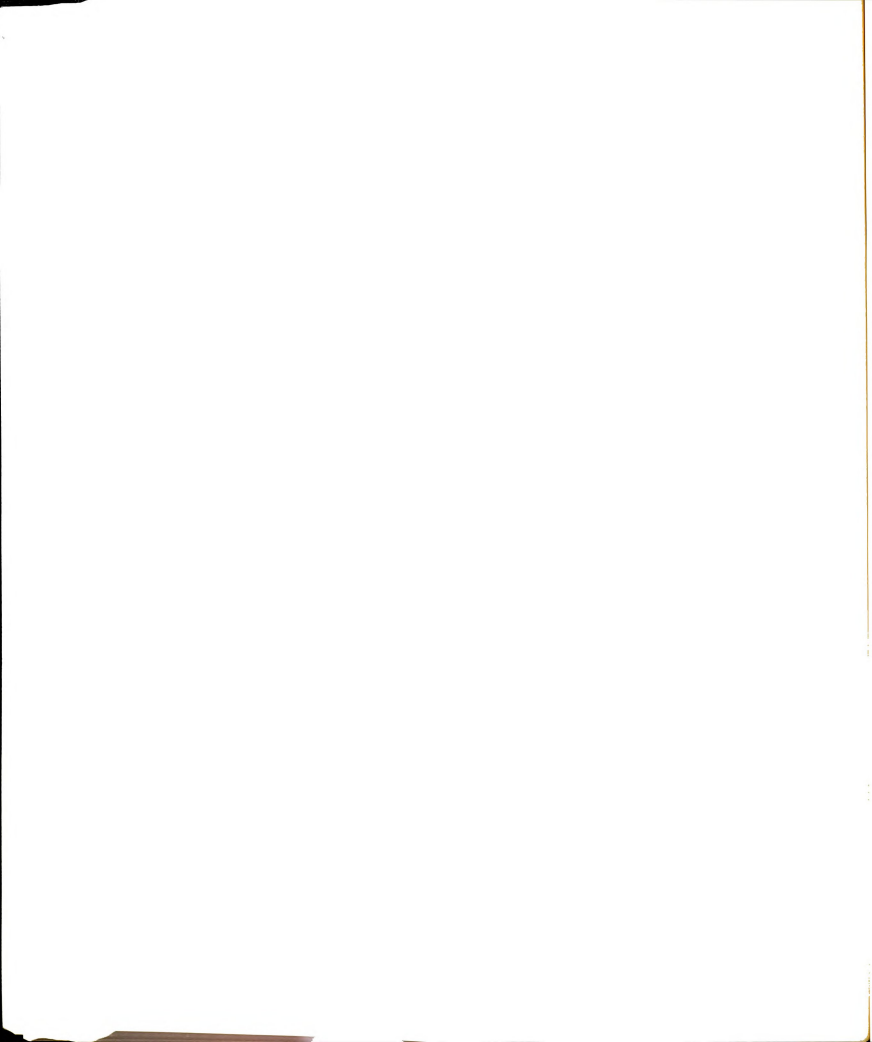
Certain contractual issues between the firm and Michigan State may also have an effect on performance measures in the model for the study. I'd like to clarify some of these details for a particular product: _____.

Who owns the patent for _____?

If the firm owns the patent what was the reasoning which led to this outcome?

If the university owns the patent is your license exclusive or non-exclusive?

Did non-exclusive licensing or public agency rights lead to any concessions in negotiations with the University?

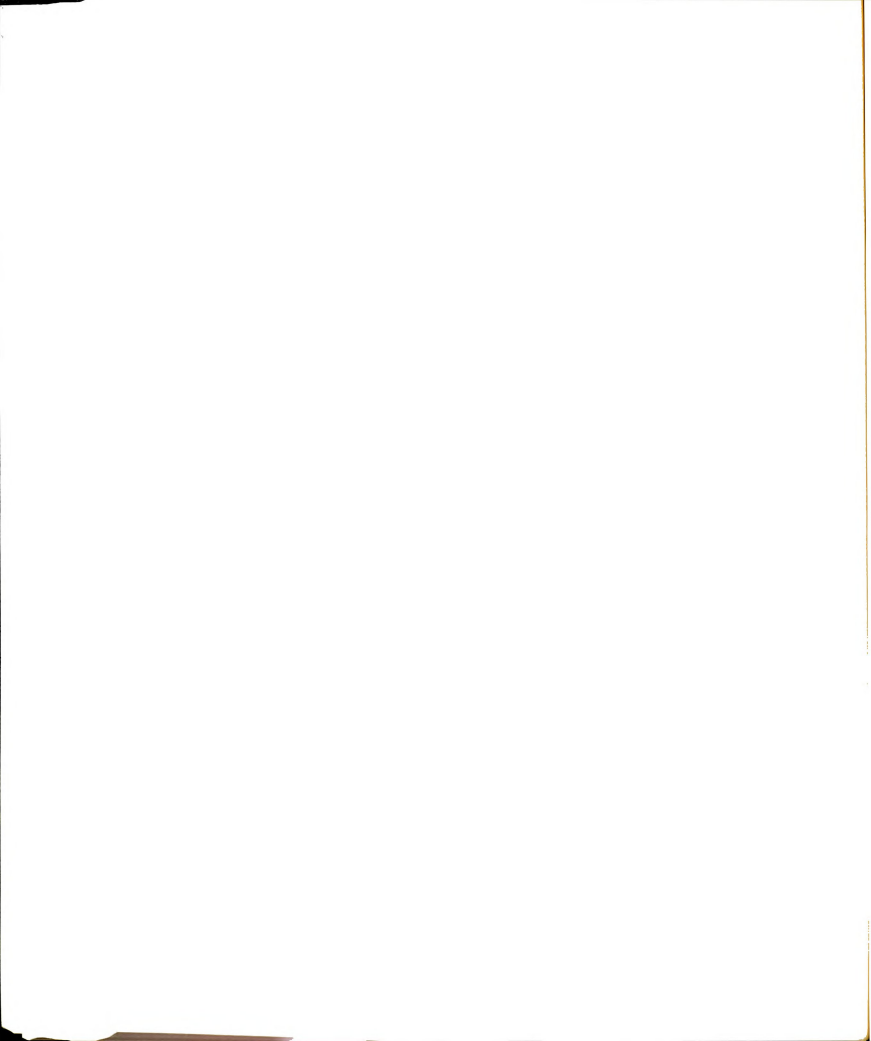


Does the licensing agreement allow the University to:

- Police the patent?
- Rescind the patent?
- Set performance standards for the firm in quality or quantity?

Who retains the rights to proceed with further developments and licensing of unidentified uses of the patent?

Were publication delays granted by the University or the investigator?

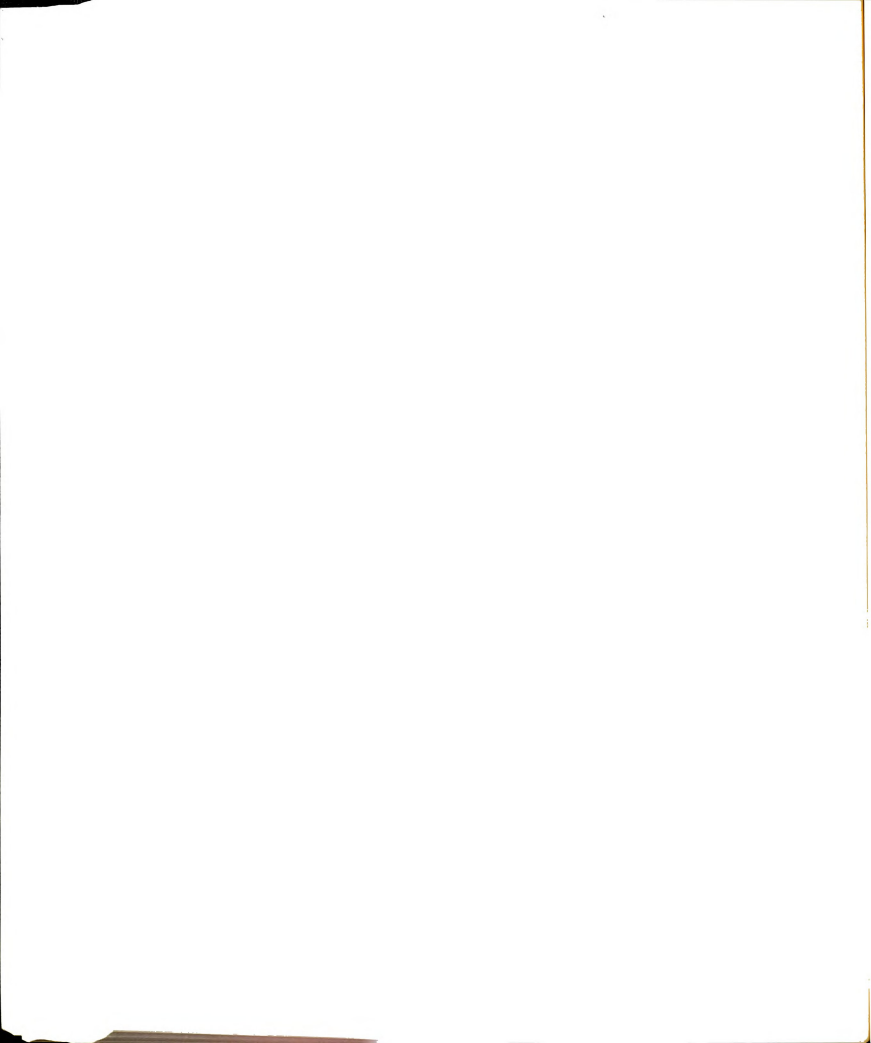


Costs can also have an effect on the performance measures of the study.

Does the University help with advertising costs by pushing
 _____ through the Extension Service?

Does the University allow the use of the Michigan State name to
 accompany _____ in the marketplace?

How much of an asset to commercialization are these last two items?



Did your firm pay any basic, applied, or development research costs for the product to the University?

Did you pay overhead to the University on any research contracts or grants?

Did your firm have to complete any basic, applied, or development research for the product outside the University?

Who paid the cost of filing the patent? How much?

Do you police the patent? What does this cost?



Now I'd like your help in understanding the technology and the cost savings to the user which _____ represents.

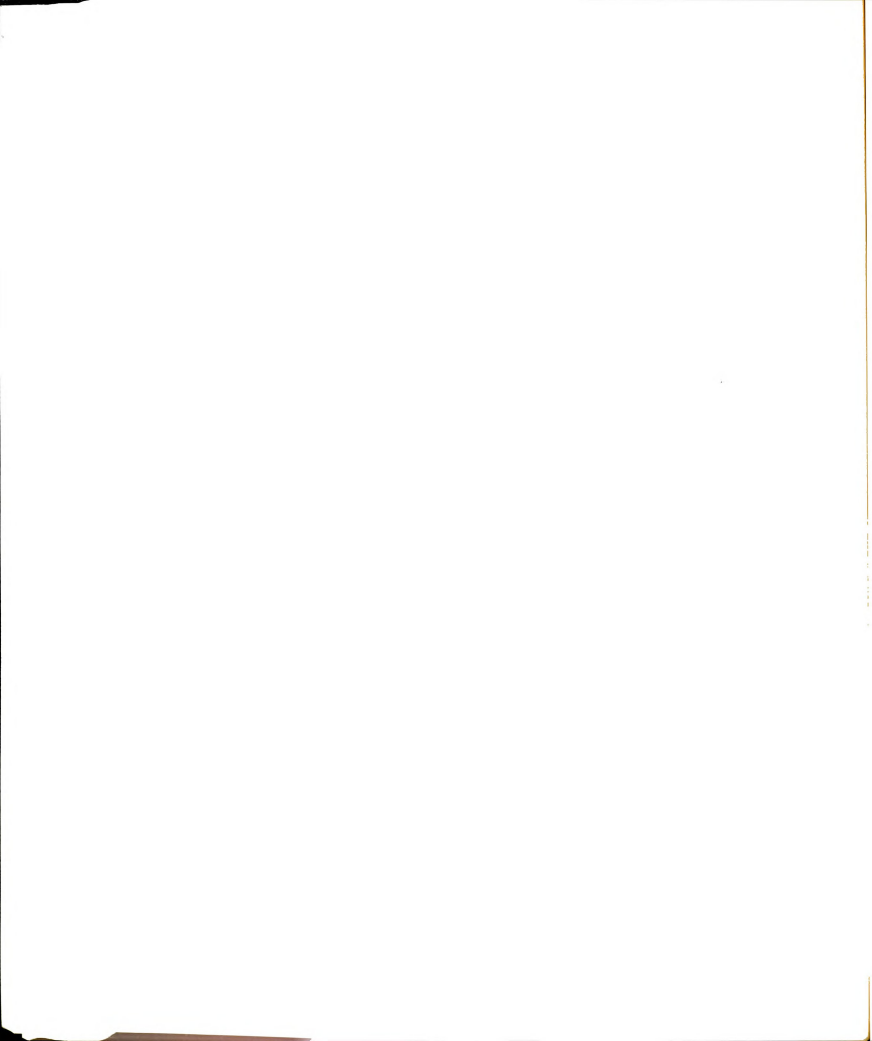
Please describe the technology or product?

What is the closest substitute? Are there publications or documentation which compare the two?

What does the substitute cost?

What does the _____ cost?

How did you arrive at this price?

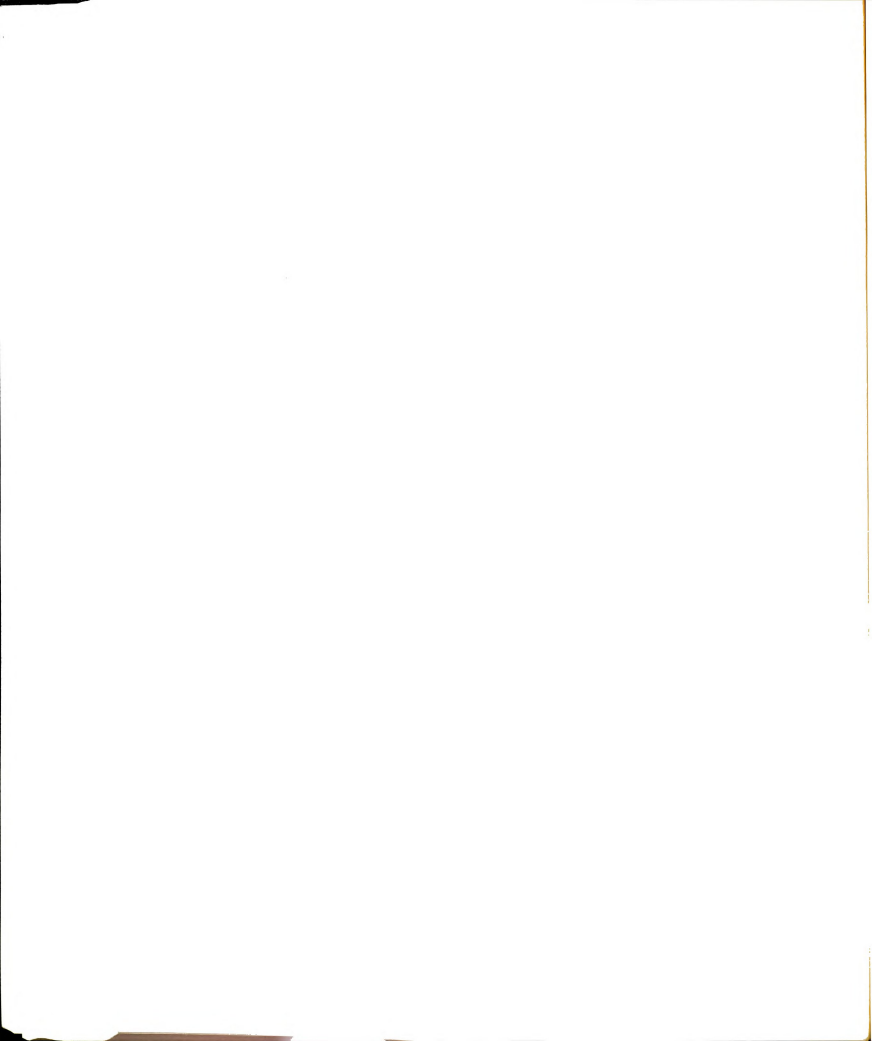


What are the productivity changes for the user?

What are the labor savings for the user?

What are the efficiency or accuracy savings for the user?

Are there other savings to the user?



How much money is returned to the University for this product as a:

- licensing fee
- royalty
- gift
- further contract or grant
- other

How many _____ are sold annually? I need this number to calculate returns on a per unit basis.

Please name the layers in the income stream between the sales of the product and the University.

There are many factors which go into a pricing decision by the firm. A few last questions would be helpful.

How can university research commercialization efforts be structured so there is an incentive for firms to share profits rather than view returns to the University as a cost item on the balance sheet?

How can university commercialization relationships be structured so there is an incentive for the firm to minimize its costs and maximize cooperative product development with the University?

Does the firm try to understand the user costs savings we just discussed and use that as part of a pricing guide?

What is your pricing decision rule for new products (elasticities, market share, firm cost plus, other)?

What are the current policy needs at Michigan State that would enhance research commercialization?

What has worked well with Michigan State in your experience and what has not?

BIBLIOGRAPHY

BIBLIOGRAPHY

- Abelson, P.H., 1986. Evolving State-University-Industry Relations. Science. V 231. pp. 317.
- Adler, R.G., 1984. Biotechnology as intellectual property. Science. V 224. pp. 357-62.
- , 1986. Can patents coexist with breeder's rights? Developments in US and international biotechnology law. IIC. V 17(2) pp. 195-227.
- Baba, M.L., 1985. University Innovation To Promote Economic Growth And University/Industry Relations. Draft. NSF Conference on Science and Technological Innovation. Albany, N.Y.
- Barnes, D.M., 1985. New University-Industry Pact Signed. Science. V 230. pp. 1255-56.
- Bengston, D.M., 1984. Economic impact of structural particle board research. Forest Science. V 30. pp. 685-97.
- , 1985a. Economic evaluation of agricultural research. Evaluation Review. V 9(3). pp.243-62.
- , 1985b. Aggregate returns to lumber and wood products research: An index number approach. IN: Forestry Research Evaluation: Current progress, future directions. St. Paul, Minn.: N.C. Forest Experiment Station.
- Benson, R.H., 1986. Biotechnology patent pitfalls. BioTechnology. V 4. pp. 118-20.
- Biggart, W.A., 1981. Patentability in the United States on microorganisms, processes using microorganisms, products produced by microorganisms, and microorganism mutational and genetic modification techniques. Idea. V 22(2). pp. 113-35.
- Blanchard, T., 1986. U-M's patented faculty. Michigan Today. V 18(3) pp. 14.
- Bloch, E., 1986. Basic research and economic health: The coming challenge. Science. V 232. pp. 595-99.

Blumenthal, D., Gluck, M., Louis, K.S., and Wise, D., 1986a. Industrial Support of University Research in Biotechnology. Science. V 231. pp. 242-46.

-----, Stoto, M.A., 1986b. University-Industry Relationships in Biotechnology: Implications for the University. Science. V 232. pp. 1361-1366.

Bound, J., Cummins, C., Griliches, Z., Bronwyn, H.H. and Jaffe, A., 1984. Who does R&D and who patents? IN; Z. Griliches, Ed., R&D, Patents, and Productivity. Chicago: Chicago U Press.

Bredeck, H., 1986/87. Personal Communication. Office of Research and Graduate Studies. Michigan State University. E. Lansing, MI.

Byrne, N.J., 1985. Plants, animals, and industrial patents. IIC. V 16(1). pp. 1-18.

Cadman, D.L.T., 1985. The protection of microorganisms under European patent law. IIC. V 16(3). pp.311-17.

Cantlon, J., 1986/87. Personal Communication. Office of Research and Graduate Studies. Michigan State University. E. Lansing, MI.

Chermiside, H.B., 1985a. Some ethical conflicts affecting university patent administration; part I. J of the Society of Research Administrators. V 16(3). pp. 23-34.

-----, 1985b. Some ethical conflicts affecting university patent administration; part II. J of the Society of Research Administrators. V 16(4). pp. 11-17.

Clark, E., 1985. Passing the Buck in R & D Financing. Business Week. 12/2/85. pp. 34.

Comanor, W.S., 1964. Research and competitive product differentiation in the pharmaceutical industry in the US. Economica N.S.. V 31(124). pp. 372-84.

-----, 1965. Research and technical change in the pharmaceutical industry. Review of Economics and Statistics. V 47(2). pp. 182-90.

Converse, J.M. and Presser, S., 1986. Survey Questions: Handcrafting the Standardized Questionnaire. Sage University Publications. Beverley Hills, CA.

Culbertson, J.D. and Mueller, W.F., 1985. The influence of market structure on technological performance in the food manufacturing industries. Review of Industrial Organization. V 2(1). pp. 40-54.

Dasgputa, P. and Stiglitz, J., 1980a. Industrial structure and the nature of innovative activity. The Economics Journal. V 90. pp. 266-93.

-----, 1980b. Uncertainty, industrial structure, and the speed of R&D. The Bell Journal of Economics. V 11(1). pp. 1-28.

David, E.E., 1982/84. The university-academic connection in research: Corporate purposes and responsibilities. Idea. V 24(3). pp. 157-66.

Dickson, D. 1987. Europe Agrees To EUREKA Projects. Science. V 237. pp. 1563.

Doyle, J., 1985. Altered Harvest. New York: Viking Press.

Doyle, P.H. and Brisson, C. 1985. Partners in Growth: Business-Higher Education Development Strategies. Northeast-Midwest Institute: The Center for Regional Policy. Washington, D.C..

Eddleman, B.R., Teigen, L.D. and Purcell, J.C., 1982. Productivity in US food and agricultural: Implications for research and education. Southern Journal of Agricultural Economics. pp.1-7.

Ellis, J.E., 1986. Monsanto: Meet the big company on campus. Business Week. 6/23/86. pp. 136.

Engel, F., 1984. Protection of personal rights in scientific discoveries. IIC. V 15(3). pp. 302-21.

Ettlie, J.E., 1982. The commercialization of federally sponsored technological innovations. Research Policy. V 11. pp. 173-92.

Evenson, R.E., Waggoner, P.E. and Ruttan, V.W., 1979. Economic benefits from research: An example from agriculture. Science. V 205. pp. 1101-07.

Fishel, W.L., Ed., 1971. Resource Allocation in Agricultural Research. Minneapolis: U of Minnesota Press.

Freedom of Information Act. 1967. Michigan Compiled Laws Annotated. 15.218 - 12.246.

Galbraith, J.K., American Capitalism. 1952. Boston: Houghton Mifflin.

Gast, R., Ed. 1987. Proceedings of The State Agricultural Experiment Station Plant Variety Release Workshop. Lansing, MI.

Genetic Technology News. 1987. 11/87. pp. 6a.

Gershman, A.P. and Scafetti, J. Jr., 1980. Patents on microorganisms. *Idea*. V 21(1). pp. 1-35.

Gibbons, H., 1981a. The relationship between law and science. *Idea*. V 22(1). pp. 43-61.

-----, 1981b. The relationship between law and science: Six representatives of the law/science relationship. *Idea*. V 22(2). pp. 159-88.

-----, 1981c. The relationship between law and science: Points of contact between law and science - A taxonomy. *Idea*. V 22(3). pp. 227-41.

-----, 1981d. The relationship between law and science: Deciding about technology - Solutions to the law/science problem. *Idea*. V 22(4). pp. 283-308.

Goldhor, R.S. and Lund, R.T., 1983. University-to industry advanced technology transfer. *Research Policy*. V 12. pp. 121-52.

Gollop, F.M., 1985. Analysis of the productivity slowdown: Evidence for a sector-biased or sector-neutral industrial strategy. IN; W.J. Baumol and K. McLennan, Eds., *Productivity Growth and US Competitiveness*. New York: Oxford U Press.

Griliches, Z., 1957. Hybrid corn: An exploration in the economics of technological change. *Econometrica*. V 25(4). pp. 501-22.

-----, 1964. Research expenditures, education, and the aggregate agricultural production function. *American Economic Review*. V 54(6). pp. 961-74.

-----, 1973. Research expenditures and growth accounting. IN; B.R. Williams, Ed., *Science and Technology in Economic Growth*. London: MacMillan.

-----, 1980. R&D and the productivity slowdown. *American Economic Review*. V 70(2). pp. 343-48.

-----, 1986. Productivity, R&D, and basic research at the firm level in the 1970's. *American Economic Review*. V 76(1). pp. 141-54.

----- and Lichtenberg, T., 1984. R&D and productivity growth at industry level: Is there still a relationship? IN; Z. Griliches, Ed., *R&D, Patents, and Productivity*. Chicago: U of Chicago Press.

Hamper, B., 1985. Patenting of recombinant DNA technology: The deposit requirement. *J of the Patent and Trademark Office Society*. V 67(1). pp. 569-613.

- Haygreen, J., H. Gregerson, I. Holland and R. Stone. 1986. The economic impact of timber utilization research. *Forest Products Journal*. V 36. pp. 12-20.
- Huffman, W.E. and Miranowski, J.A., 1981. An economic analysis of expenditures on agricultural experiment station research. *American J of Agricultural Economics*. V 63(1). pp. 104-18.
- James, F.E., 1986. Chicago University, National lab sees profit from ideas. *The Wall Street Journal*. 10/16/86 pp.24.
- Kamien, M.J. and Schwartz, N.L., 1975. Market structure and innovation: A survey. *Journal of Economic Literature*. V 13(1). pp.1-37.
- , 1982. *Market Structure and Innovation*. Cambridge: Cambridge University Press.
- Kashkashian, D., 1986a. Letter to the Provost: Michigan State University. E. Lansing, MI.
- , 1986b. *Innovation, Markets, and Academia*. Department of Forestry, Michigan State University. E. Lansing, MI. Draft.
- Kashkashian, D. and Hanover, J., 1986. *Bibliography on University and Patents or Industry: 1980-1986*. Michigan State University. E. Lansing, Michigan.
- Kelly, F.M., 1970. The influence of firm size and market structure on the research efforts of large multi-product firms. Ph.D. Dissertation. Oklahoma State University.
- Kelly, J.F. and Schmid, A.A., 1986. *Varietal Release and Royalty Allocation Policy Survey*. MSU Agr. Econ. Staff Paper 86-5.
- Kendrick, J.W., 1961. *Productivity trends in the United States*. NBER General Series No. 71. Princeton, NJ: Princeton U Press.
- , 1983. *Interindustry differences in productivity growth*. Washington, DC: American Enterprise Institute for Public Policy Research.
- Kennedy, C. and Thirwall, A.P., 1972. *Surveys in applied economics: Technical progress*. *The Economics Journal*. 4/72. pp. 11-72.
- Koenig, H.E., 1986. *Executive Summary: The Michigan Project on Industry-University Cooperation*. Draft report to the National Science Foundation. Michigan State University. E. Lansing, Michigan.

- , 1987. Economic Competitiveness and the Research University. Draft. MSU News Makers. E. Lansing, Michigan.
- Kitch, E.W., 1980. The law and economics of rights in valuable information. *J of Legal Studies*. V 9(4). pp. 683-726.
- Kitti, C. and Trozzo, C.L., 1977. The Effects of Patent and Antitrust Laws, Regulations and Practices on Innovation. 3 vols. National Technical Information Service.
- Krosin, K.E., 1985. Are plants patentable under the Utility Patent Act? *J of the Patent and Trademark Office Society*. V 67(5). pp. 220-38.
- Kruytbosch, C. 1982. Annotated Bibliography on University/Industry Research Relationships. In: *University/Industry Research Relationships*. National Science Foundation. pp.269-95.
- Kurtz, M., 1987. Personal Communication. Michigan State University, E. Lansing, Michigan.
- Lapping, M.B., 1987. University/Industry Cooperation To Promote Economic Development In Sweden. *Working Life In Sweden*. No. 33. Swedish Consulate General. New York.
- Lederberg, J., 1983/84. Professor as consultant: Conflict of interest? *Idea*. V 24 (3). pp. 149-55.
- Lehnert, D., 1986. It s more than just a matter of mushrooms. *Michigan Farmer*. 8/2/86. pp. 38.
- Levin, R.C., Cohen, W.M. and Mowery, D.C., 1985. R&D appropriability, opportunity, and market structure: New evidence on some Schumpeterian hypotheses. *American Economic Review*. V 75(2). pp. 20-24.
- Linck, N.J., 1985. Patentable subject matter under section 101 - Are plants included? *J of the Patent and Trademark Office Society*. V 67(9). pp. 489-506.
- Lubove, S.H., 1986. The old college tie. *The Wall Street Journal*. 11/10/86. pp. 10d-11d.
- Machlup, F., 1958. An economic review of the patent system. Senate Subcommittee on Patents, Trademarks and Copyrights. Study No. 15.
- Mansfield, E., Rapaport, J., Schnee, J., Wagner, S., and Hamburger, M., 1971. Research and Innovation in the Modern Corporation. New York: Norton.
- Maurer, J.E., 1984/85. Toward economic recovery: University/industry cooperation. *Idea*. V 25(2). pp.63-69.

- McEowan, J., 1987. Personal Communication. Department of Agricultural Economics. Michigan State University. E. Lansing, MI.
- Melman, S., 1958. The impact of the patent system on research. Senate Subcommittee on Patents, Trademarks and Copyrights. Study No. 11.
- Milliken, W.G., 1982. Draft Release. Executive Office for the Governor of the State of Michigan, 10/13/82. Lansing, MI.
- Minassian, J.R., 1962. The economics of research and development. IN; R.R. Nelson, Ed., The Rate and Direction of Inventive Activity: Economic and Social Factors. Universities NBER Conference Series No. 13. Princeton, NJ: Princeton U Press.
- Muller, S., 1983/84. Academic responsibilities and dependencies. Idea. V 24(3). pp. 141-48.
- Murray, D.J. and O'Connor, P.J., 1983. A Guide to Corporate Sponsored University Research In Biotechnology. Genetic Sciences International. Millbrook, New York.
- National Science Foundation. 1982. 14'th Annual Report of the National Science Board. University/Industry Research Relationships: Myths, Realities and Potentials. Washington, DC.
- Nelson, R.R., 1982. The role of knowledge in R&D efficiency. Quarterly Journal of Economics. V 97. pp. 453-71.
- Nelson, R.R., 1959. The simple economics of basic scientific research. Journal of Political Economy. V 67(1). pp. 297-306.
- Newman, P., 1984/85. Toward economic recovery: University/industry cooperation. Idea. V 25(2). pp. 77-80.
- Nordhaus, W.D., 1972. The recent productivity slowdown. Brookings Papers on Economic Activities. V 3. pp. 493-545.
- O Boyle, E.J., 1984. On the university research as entrepreneur. International Journal of Social Economics. V 11(3/4). pp. 114-23.
- Palmer, A.M., 1957. Patents and nonprofit research. Senate Subcommittee on Patents, Trademarks and Copyrights. Study No. 6.
- Peters, L. and Fusfeld, H., 1982. Current U.S. University/Industry Research Connections. In: University/Industry Research Relationships. National Science Foundation. pp. 1-162.
- Peterson, I., 1987. Funding facilities: Who's getting what. Science News. V 131. pp. 246.

Picot, A., 1985. Intellectual property rights in biotechnology and computer technology: Comment. Zeitschrift für die gesamte Staatswissenschaft. V 141(1). pp. 142-45.

Pings, C.J., 1986. A Time for Steadiness. Science. V 232. pp. 437.

Plant, A., 1934. The economic theory concerning patents for inventions. Economica N.S.. V 1(1). pp. 30-51.

Report to the President, 1984. White House Conference on Productivity Growth. Washington, DC: National Technical Information Service PB84-159144.

Roberts, E.B. and Peters, D.H., 1981. Commercial innovation from university faculty. Research Policy. V 10. pp. 108-26.

Ruttan, V.W., 1982. Bureaucratic productivity: The case of agricultural research - A rejoinder. Public Choice. V 39. pp. 319-29.

Sah, K.R., and J.E. Stiglitz. 1986. The architecture of economic systems: Hierarchies and polyarchies. The American Economic Review. V 76(4). pp. 716-27

Scherer, F.M., 1980a. Industrial Market Structure and Economic Performance. Chicago: Rand McNally, 2'nd ed..

-----, 1980b. The economics of the patent system. IN; Industrial Market Structure and Economic Performance. Chicago: Rand McNally. 2'nd ed.. pp.439-58.

-----, 1965. Firm size, market structure, opportunity, and the output of patented inventions. American Economic Review. V 55(5). pp. 1097-1125.

Schmid, A.A., 1985a. The political Economy of Public Investment. Michigan State University. E. Lansing, MI.

-----, 1985b. Biotechnology, plant variety protection, and changing property institutions in agriculture. North Central J of Agricultural Economics. V 7(2). pp. 129-38.

-----, 1985c. Property Rights in Seeds and Microorganisms. IN; Public Policy and the Natural Environment. JAI Press.

-----, 1985d. Intellectual property rights in biotechnology and computer technology. Zeitschrift für die gesamte Staatswissenschaft. V 141(1). pp. 127-41.

Schmookler, J., 1955. Invention and Economic Growth. Cambridge, Mass: Harvard University Press.

- Schuman, M.D., 1984. Patent protection for microbiological processes: Has "In Re Argoudelis" been Mutated? Wisconsin Law Review. V 6. pp. 1679-1709.
- Schumpeter, J.A., 1950. Capitalism, Socialism and Democracy. New York: Harper and Row. 3rd ed..
- Seldon, B.J., 1985. The marginal productivity of public research in the softwood plywood industry. Ohio Economic Studies Working Paper #85-15. Ohio University.
- Sheldon, A. W., 1986. Making the campus-corporate connection: The role of linking units. The Michigan Project on Industry-University Cooperation. Wayne State University. Detroit, MI. 158 pp..
- Smith, E.J., 1986. Where a venture capitalist is big man on campus. Business Week. 7/28/86. pp. 49.
- and Clark, E., 1986. Now, R&D is corporate America's answer to Japan Inc.. Business Week. 6/23/86, pp.134-38.
- Solow, R.M., 1957. Technical change and the aggregate production function. Review of Economics and Statistics. V 39. pp. 312-20.
- Stallman, J., 1986. Impacts of the 1930 Plant Patent Act on Private Fruit Breeding Investment. Michigan State University. Ph.D. Dissertation. E. Lansing, MI.
- Steinberg, R., 1986. The revealed objective function of nonprofit firms. Rand Journal of Economics. V 17(4). pp.508-26.
- Straus, J., 1984. Patent protection for new varieties of plants produced by genetic engineering - Should "double protection" be prohibited? IIC. V 15(4). pp. 426-42.
- , 1985. Patent protection for biotechnological inventions. IIC. V 16(4). pp. 445-48.
- Sun, M., 1985. Plants can be patented now. Science. 10/18/85. pp. 303.
- Tornatzky, L.G. et.al., 1983. The Process of Technological Innovation: Reviewing the Literature. National Science Foundation. Washington, DC.
- Ullmann, J.E., Ed., 1980. The Improvement of Productivity: Myths and Realities. New York: Praeger Publishers.
- Usher, D., 1964. The welfare economics of invention. Economica N.S.. V 31(123). pp. 279-87.

Varin, D.R. and D.S. Kukich. 1985. Guidelines for industry-sponsored research at universities. Science. V 227. pp. 385-388.

Valavanis-Vail, S., 1955. An econometric model of growth in the USA: 1869-1953. American Economic Review. Papers. 5/55. 45 pp..

Warwick, D.P. and Linninger, C.A., 1975. The Sample Survey: Theory and Practice. New York: McGraw Hill.

Westgate, R.A., 1984. Indexed Bibliography on the Research Management Process. Staff Paper Series No. 40. St. Paul: U of Minnesota.

-----, 1985. Returns to investment in forestry research: The case of containerized forest tree seedlings. IN: Forestry Research Evaluation: Current Progress, Future Directions. St. Paul, Minn.: N.C. Forest Experiment Station.

Williams, S.B., 1984. Protection of plant varieties and parts as intellectual property. Science. V 225. pp. 18-23.

Williamson, O.E., 1979. Transaction cost economics: The governance of contractual relations. Journal of Law and Economics. V 22(2). pp. 233-61.

-----, 1980. The organization of work: A comparative institutional assessment. Journal of Economic Behavior and Organization. V 1. pp.5-38.

Wink, L., 1986. AgroForestry Comes of Age. Futures 4(3). Michigan Agr. Exp. Stat.. Spring, 1986. pp. 12-15.

Wright, B.D., 1983. The economics of invention incentives: Patents, prizes, and research contracts. American Economic Review. V 73(4). pp. 691-707.

Wright, D.E., 1986. The Michigan Project on Industry/University Cooperation: An Historical Analysis. Draft report to National Science Foundation. Lyman Briggs School. Michigan State University. E. Lansing, Michigan.

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