1980

The agricultural scientist: his role as an entrepreneur in the research process

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by

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A Thesis Submitted to the

Graduate Faculty in Partial Fulfillment of the

Requirements for the Degree of

MASTER OF SCIENCE

Department: Economics
Major: Agricultural Economics

Signatures have been redacted for privacy

Iowa State University
Ames, Iowa

1980

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CHAPTER I. INTRODUCTION

An agricultural experiment station faces the significant and uncertain task of developing a research package that will generate the greatest social value. Since agricultural research impacts several segments of society, the station must be sensitive to a widening variety of research demands. Farmers, households, private industry, granting agencies, federal and state legislators, extension workers, citizen groups, and scientists have intensified their vocalization of the research results they desire. A growing skepticism of the station's ability to equitably and efficiently allocate its resources has accompanied these demands. Therefore, an urgent need to examine the experiment station's research decision-making process has surfaced.

The experiment stations are members of a vast research institution. The amount of scientist time allocated to agricultural research is considerable. During fiscal year 1976, 10,808.9 science years [3] were allocated to public-supported agricultural research. In the past few years station expenditures have totaled approximately $500 to $600 million per year.

Experiment station expenditures, because they have a large potential impact and are appropriated by a political process, are controlled and scrutinized as a part of public policy. The press, the public, budget examiners, and politicians seem to direct a large amount of attention to the allocation of agri-research funds.

Each year research budget examiners and program reviews seem to grow in number and intensity. Many, on behalf of the public, are intensely interested in the services and information they are purchasing with these relatively small, tax-supported experiment station research expenditures.

Controversy has arisen over whether the agricultural research establishment has responded to current human resource, income distribution, and environmental concerns. For example, the land grant complex received scathing criticism of misconduct in the 1968 book Hard Tomatoes Hard Times in which Jim Hightower begins with the statement, "Although the land grant complex was created to be the people's university, to reach out and serve the various needs of a broad rural constituency, the system has, in fact, become the sidekick and frequent servant of agriculture's industrialized elite" [10, p. 3]. He questions whether the public interest is adequately served by the current allocation of agricultural research resources. He concludes this research has not benefited and may have actually harmed small producers, farm laborers, and rural communities. Hightower implies that these clients are of secondary importance to the land grant science community.

New clients groups concerned with nutrition, the environment, and rural development seek priority in research allocations. American consumer groups have also expressed dissatisfaction with the cost, quality, and safety of food. The popularity and financial success of alternative rural lifestyle publications like Mother Earth News and Organic Farming may indicate that significant numbers of rural residents do not feel adquately served by the experiment stations and land grant colleges. Books such as Diet for a Small Plant and Small is Beautiful, while international in focus, are popular in the United States and may reflect a desire by part of the American public for research directed toward less natural resource-intensive products and more low-energy, small-scale, and nonindustrialized production techniques.

Experiment station directors and scientists also have felt a need to examine agricultural research. Howard Ottoson, in a presentation made to the scientists associated with NC-148, called attention to the situation that "administrators are faced with the need to examine the productivity of the investments which they make in various areas of research in the interests of: (a) better decisions in making resource allocations, (b) accountability to those who supply resources, and (c) in justifying the program to clientele and supporters [21, p. 5]." Ottoson reflects a widespread internal interest in improving the use of agricultural research funds.

These uncertainties over the optimality of the current allocation of agricultural research funds has prompted several internal studies, congressional hearings, and state legislative meetings. Each year science administrators say they are asked more penetrating questions when they justify and explain their research programs and resource requests. They must defend their experiment station programs by providing the public acceptable answers to such questions as: "Who do you serve?"; "To whom do you listen?"

Experiment Station Decision-Making Structure

A description of the multi-leveled decision-making structure in the management of research resources in the experiment stations may help to understand how program decisions are made and how they could be influenced to meet these criticisms, concerns, and questions. Paulsen and Kaldor [14] described the agricultural experiment station decision-making structure as consisting of both internal and external decision-makers. The external decision-makers are the public through the United States Congress, federal executive agencies, the state legislatures, state agencies, and several private corporations and foundations. They allocate funds between the station and other claimants, and consequently decide the size of the station. The internal decision-makers, the station director, the department chairmen, and the research scientists decide which research activities to undertake and also which research methods to use. Simply, "the internal decision-makers decide the program and the external decision-makers appraise the program and decide how much support to give it" [14, p. 10].

A need for research on the decision-making processes within the agricultural experiment station was formally expressed by the North Central Region directors in regional project NC-148. To complete this research will require an explicit focus on the internal decision-makers. Each decision-maker has a different role in the production of station research. For example, station administrators and DEO's define staff positions, hire scientists, determine salaries, request and supervise the construction of new facilities, and allocate the budget among departments. In contrast the scientists select the research topics to propose and design research methods. In the process of these many decisions, the administrators and scientists collectively determine the station's research output mix and resource efficiency. All internal decision-makers contribute to the success of the external competition for funds with other agencies. As they exercise their individual capacity to self-determine their research contributions they collectively fix the station's program attractiveness. Each, however, possesses a limited amount of information and power in the experiment station decision hierarchy and allocation process.

Station administration

The station director and assistant directors are assigned the most comprehensive responsibility for the research program. They perform a market information function. The directors cannot know as much about any specific research possibility as a specialized scientist. Because they are in direct contact with university officials, the regents, the state legislature, and the federal congress, they are in a better position than an individual scientist to perceive the relative value to client groups of alternative research programs that are feasible given the station's available resources.

The station directors' decisions in the research allocation process are primarily long-run and interdepartmental. The responsibility to decide which research program areas to expand at the expense of other research is borne by them. Their authority to deny or approve positions, select department administrators, and reallocate funds among departments are their major vehicles for obtaining research output they consider to have a high social value. The directors also exert a short-run influence on the mix of station research by fostering grants or contracts in high-value areas as well as directly discussing the relative value of research output with scientists, thereby indicating the type of projects they would like to see proposed.

Department heads or chairmen

The department heads and chairmen (Department Executive Officers, DEOs) are in the middle administrative position of the internal decision-making structure. Similar to the directors, though on a restricted level, they have the responsibility to influence the allocation of resources among individual research areas and scientists.

They also have the important long-run program influence of redefining vacant positions and proposing new staff members.

In the short run, the department head has the capacity to suggest high-value research ideas and to provide specific market signals to the research scientists. His most subtle and perhaps valuable contribution may be to promote a research environment which stimulates the scientists' personalities and creativities, and fosters the form and degree of intellectual interdependence conducive to the production of new knowledge.

The personality and management type of the department head is an important factor in the department's productivity. At extreme but descriptive ends of the spectrum of DEO management styles, the DEO can be characterized as a dictator or as a democratic coordinator. There is a wide variation among department heads in the extent to which they narrow research choices for individual scientists through job descriptions. When hiring new faculty, a rigid job description is used by some DEOs to restrict research possibilities. The degree of freedom in project proposal preparation is another reflection of a chairman's management style. Some help and closely supervise. Others keep hands off. Another management technique is through the use of seminars and subdepartmental groups. These may be used for voluntary colleague information exchange or may be used to allocate budget and facilities at the subdepartment level.

Objective function of the research administration

Bredahl, Bryant, and Ruttan [3] have identified several elements they believe enter into the objective function of science administrators (i.e. directors and department heads). They believe the typical research manager has a "service" view of the world which places a "heavy weight on the value of new knowledge and new technology and places a low weight on both the direct and indirect costs of research and technological change" [3, p. 20]. These authors also believe that because an administrator's recognition and standing among his colleagues is related to his ability to develop a quality research staff which receives awards and is recognized for its dramatic discoveries by clients and fund suppliers, an emphasis will be placed on obtaining and holding outstanding professional personnel. This is consistent with the utility function hypothesized for a bureau manager [20]. They assumed that the bureau manager's utility is a function of (a) the bureau's output and (b) the bureau's discretionary budget. Bredahl, Bryant, and Ruttan see that "in the case of the agricultural experiment station or the agricultural research institute, we can interpret bureau size in terms of research staff and the output of applied research that is valued by the research institution's clientele."

Scientists

The research scientists comprise the final level in the internal decision-making structure and are the largest group of decision-makers. They are the initiators of research proposals and thus have the most short-run influence on the station's output mix. Because they conduct the research, they control its productivity via work habits and research methods. The scientists have the implicit authority to screen possibilities before turning them into proposals. Only proposed research can reach department heads and station directors to be approved or rejected. The vigor, creativity, and efficiency of researching and reporting rests with the scientists.

Little is known about the inputs to and influences on the scientists' research idea identification and screening processes. Sources of research ideas, indications of social value, and the influence of each source on final project selection are yet to be identified. The individual scientist's research decision-making process is the focus of this study.

Purpose of Study

The purpose of this study is to identify and describe the research allocation process of the experiment station research scientists at Iowa State University. More specifically, this study will focus on the following two objectives:

(1) to conceptualize the stages, participants, and constraints on the project selection process of the research scientists,

(2) to identify and describe the criteria which scientists use in allocating research resources.

Positive economics will be used to accomplish this study's objectives. An examination of the current decision-making process will be made without prescribing how decisions should be made. We want to know how scientists decide. We do not intend to tell them which choices to make. The economic framework for this study is that the scientist is an entrepreneur who allocates his scarce resources and tries to obtain the highest possible output value in his production of new knowledge.

Potential Uses of Results

This study is the first stage in an effort to identify the interrelated allocation processes and objective functions of the three internal decision-makers: the station administrators, department heads, and scientists at the Iowa State University Experiment Station. The primary aim of the results is to improve the capacity to plan the allocation of resources to research. The information gathered from the analysis could be a valuable input in efforts by management to design allocation mechanisms more responsive to society's needs. An identification of the goals and objectives of scientists will allow tests for consistency with the goals of other decision-makers. An allocation evaluation tool may result.

This Iowa State University study is an exploratory study which will hopefully produce a survey technique that can be adapted by other experiment stations interested in information about scientists' decision-making. A potential methodological use of the research will be to improve the effectiveness of the survey instrument designed for this study.

Kaldor [13] repeatedly pointed to the lack of systematic knowledge about the decision-making processes within the experiment station. The writing about science decision-making currently available is primarily based on introspection, hypothesizing, casual observations, and inferences made by scholars. This beginning study, it is hoped, may expand a neglected area in the research on research.

CHAPTER II: THE RESEARCH ENTREPRENEUR

The research scientist is an extremely vital performer and decision-maker in the production of information at the agricultural experiment station. He is the entrepreneur, the catalytic agent in the venturesome process of producing research. His abilities are to attract highly competent and creative assistants, secure research funds, and to employ both effectively on high-value topics. He must assimilate demand and supply information pertaining to research whose end product is usually far in the future and thus not well-specified. The development of a large and respected agricultural research program requires a high level of entrepreneurial skill.

Typically the entrepreneurial skills must sharpen as a scientist's research program grows. At first the program is a small enterprise involving only the scientist, minimal laboratory space, and one or two graduate students. It may grow into a complex hierarchical organization using over a million dollars per year which requires major capital investments for specialized facilities and equipment and which employs twenty or more graduate students and technicians. Research entrepreneurship of this scope is very rare.

Several scientists who have studied the allocation process within the experiment station view the scientist as a research entrepreneur [3], but they have provided only preliminary descriptions of his entrepreneurial function in the allocation of scarce research resources. Evenson writes [8, p. 166], "In the research process, the researcher acts in some ways like the entrepreneur who is making a decision." Evenson, however, does not elaborate further. Schultz includes science administrators and other individuals in his definition of research entrepreneurs. Every person who enters into the experiment station's decision-making process, especially founders of institutes, but including scientists, Schultz says is an entrepreneur. Efforts by Ruttan to model the behavior of scientists under various research funding strategies also point to associated entrepreneurial characteristics [25, p. 7].

This chapter will explore several concepts and elements of the scientist's role as a research entrepreneur. The qualities and functions traditionally associated with the entrepreneur in economic literature will first be discussed. New theoretical approaches which have extended the entrepreneurial role will then be identified. Finally, the scientist and his function as a research entrepreneur will be clarified.

The Entrepreneur

Even the words used to describe the entrepreneur in 1803 and translated from French seem to apply to ISU scientists. Jean-Baptiste Say wrote that the entrepreneur was the economic agent who:

> . . . unites all means of production -- the labor of one (a graduate student?), the capital (a $50,000 grant?) or the land (laboratory?) of the others -- and who finds in the value of the products which result (information?) from their employment the reconstitution of the entire . . . [5 , p. 183].

For the extollers of entrepreneurship this economic agent is a separately distinguishable element of production and very critical to the success of the endeavor. It is more than labor, even more than knowledge and management. An entrepreneur is a synthesizer, an agent of change, a bearer of technological improvement who innovates when the adoption is still very uncertain to others. He correctly anticipates the need for information and has the creativity to see how to produce it. This person, this entrepreneur, whether in business or research must have special personal qualities. According to Say the entrepreneur must have:

> . . . judgment, perserverance, and a knowledge of the world (literature?) as well as of business (methodology?). He is called upon to estimate, with tolerable accuracy, the importance of the specific product (technology?), the probable amount of the demand (extent and rate of adaptation?), and the means of its production (R & D?): at one time, he must employ a great number of hands (field experiments or survey?); at another, buy or order raw materials (write grant proposals?), collect laborers (recruit graduate students?), find consumers (contribute papers or make presentations?), and give at all times a rigid attention to order and economy; in a word, he must possess the art of superintendence and administration . . . . In the course of such complex operations, there are an abundance of obstacles to be surmounted, of anxieties to be repressed, of misfortunes to be repaired, and of expedients to be devised [5 , p. 183].

This description seems to make the entrepreneur of research or business a rare individual and thus by the law of scarcity, a valuable one. However, the social valuation of the entrepreneur may rise and wane according to twentieth century Edwin F. Gay:

> The self-centered, active individual is a disruptive force, and there are periods in the rhythm of history (a department or industry?) when the cake of custom must be broken, when the disruptive, innovative energy (or new technology and products?) is socially advantageous and must be given freer opportunity. But the social or group motive is even then latently powerful, while for normally longer periods of the rhythm the motive of social stability and order enjoys the more marked social approval [5 , p. 181].

Entrepreneurship in research creates the opportunity for growth through innovations, but entrepreneurship also helps the system adapt and adjust to the disequilibria caused by the innovations according to T. W. Schultz [30].

The entrepreneur, early recognized for his important role in change, the behavior of the firm, and growth cycles in the free enterprise system has usually been neglected in neoclassical equilibrium literature. In the writings of classical economists of England the entrepreneur was not given a large role. He was an actor in securing profit for the firm, but his equilibrium function was not well-defined. Even today, the entrepreneur remains virtually unrecognized in general equilibrium theory.

The entrepreneurial concept is usually restricted to a special breed of businessmen with a sharpened perception of disequilibrium and profit opportunity, the capacity to lead rather than follow, and the willingness to accept risk and uncertainty in the marketplace. Profits from accurately perceiving situations where demand exceeds supply provide motivation for entrepreneurial activity. Yet on average, general equilibrium theory implies a zero profit for this role. Economic science, in its preoccupation with equilibrium, averages, and normal distribution has eloquently designed mathematical models of firm behavior which conveniently omit the entrepreneurial function.

Schumpeter wrote that the "creative and innovative responses" of the entrepreneur have often rescued a developing economy from stagnation [31]. Empirical studies by Schultz [29] on the nature of output growth in agriculture concluded that capital accumulation and labor force expansion alone could not totally explain the historical growth in the output of the United States. Perhaps this additionally indicates a hidden entrepreneurial function. Entrepreneurs who generate innovations through research may be very important to scientific growth.

Definitions

In an effort to capture the nature of this elusive economic actor, various economists have composed definitions for the entrepreneur. Baumol describes the entrepreneurial function as, "It is his job to locate new ideas and put them into effect. He must lead, perhaps even inspire, he cannot allow things to get into a rut . . . [1 , p. 65]".

Leff writes, "Entrepreneurship clearly refers to the capacity for innovation, investment, and activist expansion in new markets, products, and techniques [17, p. 47]." He emphasizes that because the entrepreneur possesses superior information and a productive imagination, the risks and uncertainties associated with opportunities others would normally overlook or avoid are reduced to an acceptable level. The opportunity set of production possibilities is enlarged as a result of these entrepreneurial traits.

McConnell, in his extensively used beginning economics textbook, assigns four traditional functions to the entrepreneur. Defined as a scarce human resource, the entrepreneur is first associated with the function of combining other economic resources (land, labor, and capital) in the production of goods and services. Secondly, he is assigned the task of making nonroutine business policy decisions. The entrepreneur is, as previously indicated, an innovator, not only in the introduction of new products to the competitive marketplace, but also the imaginative force behind new forms of business organization and production techniques. Finally, McConnell defines the entrepreneur as a risk bearer, perhaps the most readily identifiable entrepreneurial characteristic [18, p. 23]. At risk is his time, effort, business reputation, and invested funds.

In most descriptions, entrepreneurship is ascribed a distinction beyond managerial functions. Baumol defines a manager to be "the individual who oversees the ongoing efficiency of continuing processes [1, p. 64]." This important, yet rather routine role of managing a production process does not capture the innovative, creative, leadership qualities of the entrepreneur. The manager belongs more to the labor category, whereas enterpreneurship has been exalted into what by some has been called the "fourth factor of production."

The Scientific Entrepreneur

Throughout the preceding definitions and descriptions of entrepreneurship several traditional concepts have tended to prevent an expansion of this resource into other areas. The entrepreneurial function has usually been restricted to businessmen involved in traditional production activities, governed in microeconomic theory by cost minimization and profit maximization. It would therefore be considered a questionable theoretical leap to include a scientist involved in the nonprofit activity of conducting research for the production of new knowledge as an entrepreneur. Gary Becker [2] and others, by their introduction of the human capital approach in analyzing the economically useful abilities of people, have provided the long-needed technique necessary to make this leap into the previously neglected nonmarket sector.

Schultz writes, "At various points over the life cycle every person is an entrepreneur. No one of us is spared by the test of making adjustments in the allocation of our own time to changing circumstances [28, p. 1]." This all-inclusive treatment of entrepreneurship hinges on Schultz's identification of "allocative abilities," a broader and more flexible concept than entrepreneurship. This new concept represents the ability of persons "to perceive a given disequilibrium and to evaluate its attributes properly in determining whether it is worthwile to act" by reallocating their resources [30, p. 834]. Therefore, the ability to reallocate resources, to innovate, to lead amidst economic disequilibria is no longer only the domain of the businessman.

This broadened view has already facilitated pioneering studies in many areas. Students are seen to reflect allocative (entrepreneurial) abilities as they combine their time and purchased educational services in response to changes in earnings and personal satisfactions they expect to receive from their education. Workers, in allocating their services between work for hire or self-employment, are also exhibiting allocative abilities.

The productive household model provides an excellent method of describing the allocative abilities of family members. Pollak and Wachter [23] and others provide a strong theoretical background for this model. The household is viewed as an economic enterprise that combines time with purchased goods and services to produce commodities that yield utility to its members. Commodities in this context have included "seeing a play," "sleeping," and "quality of children." The entrepreneurial skills of the household members would have a direct bearing on the production of these "commodities" and consequently on the household's level of satisfaction.

This broadened view of entreprenership, therefore, can now be applied to the production of research by the scientist, the research entrepreneur. The scientist under study is the agricultural scientist, an entrepreneur faced with inexhaustible research possibilities, yet constrained by the availability of resources and the state of knowledge. His task may require perhaps the most sharpened of entrepreneurial skills.

The Research Entrepreneur

The experiment station scientist is a research entrepreneur. He possesses a scarce ability, one that is hard to identify, and one whose reward, it has been argued, is haphazardly administered in the university research organization. He continues, however, to exhibit leadership, creativity, and the ability to bear risk in the dynamic production of research. The research entrepreneur, therefore, shares all of the characteristics associated with this factor of production.

The scientist must exhibit leadership in order to effectively mobilize the economic factors unique to the production of information. Large capital outlays, both in terms of funds and research facilities and equipment, must be attracted to the scientist's research program. The scientist finds it necessary to confer with farm leaders, granting agencies, private industry, and experiment station administrators in order to attract funds to support or expand his research program. Schultz clarified this leadership function when he wrote, "Scientists at the experiment stations were the ones who could see the possible impact of certain research efforts, demonstrated some of these to farm producers, and thereby created a desire on the part of the farm sector that such research be done [27, p. 104]."

Equally important is the ability to exhibit leadership in the mobilization of specialized labor. The research scientist utilizes the skills of a large number of high trained individuals.

His ability to direct and stimulate their output is an important entrepreneurial function. Requiring a great amount of leadership time are the graduate students working for the scientist. Because they are in the training stage (and acquiring the skills to possibly become future entrepreneurs), the scientist must try to foresee the areas in which their productivity will be greatest. Technicians, clerical help, and publications officers are additional individuals of importance to a research program. The entrepreneur may seek collaborative or joint projects with other scientists. In order to establish an association between scientists with differing personalities, research methods, objectives, and backgrounds as well as to coordinate a project that involves interdepartmental cooperation requires a strong leader. Involvement with regional and national committees requires the same leadership capabilities.

The research scientist exhibits a high affinity for creative and innovative tasks. He gains utility from being the first to introduce a new idea, method, or device . The methodology most often used by scientists is the scientific method of hypothesis formulation and vertification by experimental or statistical methods. Both fomulation and verification by experimental or statistical methods. research" that is extolled as the fundamental, dynamic agent of long-term economic growth. The scientific establishment, therefore, fosters this type of activity. The career of a researcher hinges on his ability to recognize new lines of scientific inquiry and to develop creative research procedures. In a "think tank," those who are most productively creative have the greatest chance to advance.

The research entrepreneur is the possessor of superior information. This information is embodied in the scientist's human (or intellectual) capital. He approaches a problem by using his present stock of knowledge as well as knowledge he acquires in his search for and interpretation of other information. The scientist who has invested much time in this capital accumulation activity expects this high rate of personal investment to produce high returns. Schultz explains that scientists "are assumed to have a high level of education which gives them, in general, a comparative advantage over persons with less education in evaluating new information with regard to changes in demand and supply conditions and in responding and adjusting to those conditions - a decision-making advantage in terms of allocative ability which is similar to that of entrepreneurs with a high level of education in other economic activities [27, p. 99]."

Nelson also emphasized that the greater a scientist's knowledge of the fields relevant to his research, the fewer will be the alternatives he must consider before finding one that is satisfactory. "Thus, the greater the underlying knowledge, the lower the expected cost of making any particular invention [19, p. 300]." Nelson also postulated that if a scientist finds that the state of knowledge is not advanced enough to undertake a particular project, he will not pursue it even if a great demand exists for the results. These observations point to an increasing trend and necessity for agricultural researchers to specialize in order to realize the benefits of the entrepreneurial knowledge advantage. Specialization arises out of the realization that in order to keep up with the rapid advances in science, to stay on top of their fields, scientists must consciously narrow the research possibilities they consider.

A major feature of the scientific entrepreneur is his ability to bear the risk and uncertainty of undertaking a research project. The research effort inherently includes the element of uncertainty. A scientist can never be certain that the research project he selects and allocates his time to will produce a product of value.

Risk is an important consideration for the researcher on the university staff. Job promotions, the ability to attract funds, peer approval, and prestige all hinge on evidence of the scientist's productivity, most usually evidenced by the number and quality of journal publications. An extremely risky project, therefore, will often be given longer consideration before a scientist decides to invest his scarce resources to it. (It should be noted, however, that a risky project does not necessarily entail one the scientist believes will yield results contrary to his original hypothesis. Rather, it is a project that has a high probability of yielding results that are not usable.)

These qualities of leadership, creativity, superior information, and willingness to bear risk that are often associated with scientists therefore qualifies them for research entrepreneur status.

CHAPTER III. THE RESEARCH FIRM

The research entrepreneur leads a unique organization. In the following discussion it will be referred to as a "research firm" and the research process will be treated as a production process. Conventional economic components such as inputs, outputs, demand and supply can then be specified. As Evenson notes however, the research process involves a number of dimensions not ordinarily important in a conventional production process [8 , p. 164]. Unlike the firm in microeconomic theory, its objective is not profit maximization nor does it always produce marketable outputs. These dimensions, while creating theoretical difficulties which should not be overlooked, at the same time give the research firm its unique nature.

The activity the scientist's firm engages in is research. Schultz writes that research "is a specialized activity requiring special skills and facilities that are employed to discover and develop special forms of new information [27, p 91]." As Schultz explains, research qualifies as an economic activity because it utilizes scarce resources (human skills and time, facilities) in the production of something of value (knowledge, new information).

Research Output

The end product of the research process is new information or knowledge. For evaluative and descriptive purposes information is usually divided into two categories: (1) information which can be appropriated; and (2) information which is not appropriable [27, p. 91]. The categorization of agricultural research output into final and intermediate products draws a similar distinction.

Appropriable information can be transferred into products demanded by households, firms, government agencies, and farms. The demand for these products gives rise to their economic value. This type of information is usually associated with applied research. The second category of information, the intermediate or nonappropriable products, consists of new ideas, new scientific and technical concepts, models, and theories. Because this information often appears in scientific and technical journals, its use cannot be controlled (hence its unappropriable nature) and is usually not specific enough to be patented. A majority of the research effort in the experiment station is exerted in the production of this type of information.

The two subsets of information are interrelated. Intermediate research products are often used in the production of higher level intermediate products which are then incorporated into the production of final products. This process has been called the chain of knowledge production. The lowest link in the chain is described as general knowledge. Each higher stage in the process represents a greater degree of specialization in the information produced. The value of an intermediate research product relies on the extent to which it can be incorporated into research processes whose end result is a final research product. For, as Schultz [27] emphasized, appropriable (final) products have economic value due to the demand for them from other sectors in the economy.

Demand for research output

The demand for final or intermediate research products comes from many different sources. For both products demand is derived demand because the information is used either as an input in a traditional production process or in the case of intermediate products as an input in the production of additional research.

Demanders of final products The chief demanders of final research products are industries, farmers, and households. According to Schultz, this demand depends on the profitability of the new skills and materials that are produced. Industries that supply farm families and others with producer and consumer goods are anxious to utilize related research information. They may take an aggressive role by supplying experiment station researchers with funds to conduct research they specifically request. Farmers, naturally, are demanders of agricultural research. The importance of this subset of demanders is exemplified by the establishment of the university extension system which was specifically designed to transmit the information generated by experiment station research directly to farmers in order to reduce the "adoption lag." Demand for information also comes from households. Particularly when the household's "production activities" are examined do these demands become more evident.

As the prices of purchased inputs, the value of the time of housewives, and the techniques of household production have changed, strong economic incentives have arisen to alter the resources used by the household.

Demanders of intermediate products The demanders of intermediate products are not easy to identify. Intermediate products have many uses, hence the demand signals associated with these products are necessarily more ambiguous than those for final goods. Because the experiment station produces a high proportion of intermediate goods, there is a need for further examination of these demands.

The research scientist who produces an intermediate good often will envision how the intermediate good produced might eventually be incorporated into a final product. For example, a scientist studying intestinal metabolism of free fatty acids might emphasize the importance his research will have on nutrition in the household. In this way the demanders of final products receive indirect consideration. These demanders, however, usually receive less immediate importance than those directly demanding the intermediate research products.

A large majority of the demanders of intermediate products are the scientist's professional colleagues, particularly those working in the same research area. These scientists know best what information is needed for production to successfully continue in their research firms. Researchers working on similar topics of investigation exchange demand signals through their participation in special conferences, on regional and national research committees and task forces, and through articles published in professional journals. This interaction not only allows for the dissemination of information but it also produces indications of research areas in which there exists a demand for further knowledge. The priorities assigned by these committees and conferences to various research needs serve as indications of value. Publication of research results also causes scientists to infer (perhaps subconsciously) which intermediate research outputs are most highly regarded by the scientists' professional community.

Contact with scientists within departments as well as inter-departmental contacts are a second source of demand information. Colleagues producing final products could provide an indirect link to the final demanders of research output. Additionally, colleagues may be producing intermediate products which the scientist can use in his research firm or which the scientist believes he can improve. This interchange is evidenced, for example, in team projects involving scientists from several departments. When the team includes scientists whose work is characterized as basic research and researchers whose work is more applied-oriented, this demand interchange becomes most apparent.

This contact can increase the efficiency with which demand signals are transmitted down the chain of knowledge production.

Industries, private granting agencies, and government agencies are also demanders of intermediate research output. The National Science Foundation is a major demander in this group. The competitive grant system provides clear indications of the research wanted. These desires are transmitted to research scientists through personal contacts, granting agency announcements, and contract offers.

The research entrepreneur, therefore, finds it necessary to examine the myriad of demand signals he receives in order to determine which feasible research outputs have the greatest demand. As indicated in Chapter II, a successful entrepreneur is adept at this task. The size and output of his research firm reflects this skill.

The Research Production Process

The research entrepreneur faces the same tasks as the business entrepreneur who produces marketable outputs for a profit. He combines his available inputs in a production process that in the majority of cases yields more than one output. From these production possibilities, the research entrepreneur must determine which output or combination of outputs will be most beneficial to the life of his research firm. This decision is extremely complex, particularly since the nonprofit nature of the research firm restricts the allocative role of the market price system.

The research entrepreneur attempts to maximize the output (rather than profits) of his firm subject to various constraints. These constraints include the amount of funds allocated or awarded to the research firm and the proportion of the scientist's time budgeted to research. There exists, therefore, a production function which relates research inputs to research outputs. As Evenson [8] has noted an "engineering" production function is not particularly applicable because some research firms may produce products of no immediate value. The relationship that does exist between research inputs and output will be described in the following discussion.

Inputs

The survey designed for this study attempts to identify the major inputs used by research firms in the experiment station and to indicate the importance of each in determining the set of possible outputs. (A description of these inputs will be made in this section. The importance attached to them by the scientists interviewed will be presented in the following chapter.)

The important inputs of the scientist's intellectual (human) capital and his entrepreneurial skills have already been discussed. The production of research also requires the input of skilled workers. Specifically, the human capital of graduate students, technicians, interdepartmental consultors (i.e. statisticians), as well as other research scientists significantly contributes to research output.

The skills and abilities of these individuals determine to some extent the types of research products that can be produced as well as the quality of the output. The number of skilled individuals attracted to the research firm and the method in which they are managed has a direct bearing on the firm's output.

The research firm combines this skilled labor with a variety of capital goods. The amount and availability of physical facilities are important inputs. Office space and equipment, greenhouse space, electronic computers, libraries, well-equipped laboratories, experimental plots and farms, and experimental plants and animals are only a small sampling of the capital goods necessary for production of research. As in any firm, considerable expenditures must be made for maintenance and replacement of these inputs as well as for investment in new inputs.

Environmental variables

Other important factors in the production of research can be classified as environmental variables. These variables surround the research process and effect the efficiency of production in the research firm. Unlike traditional inputs, environmental variables cannot be used up in the production process. Environmental variables of interest to the research firm include the age, experience, and academic status of the researcher, the geographic location of the experiment station, and the departmental organizational structure in which the researcher works.

Constraints

The research firm is constrained by the availability of funds and the state of the research art. The amount and type of funding the firm receives obviously limits the quantity and quality of inputs that can be purchased. The research entrepreneur must allocate and invest these funds to inputs that will be most productive or generate a high return. For example, the research scientist may have to choose between hiring a graduate student or a technician or purchasing a new piece of equipment. He must therefore know the potential affect of each on his research program. The scientist is also constrained by the state of the research art. This consideration is vital to a static analysis in that it ultimately puts a limit on the research possibilities available to the scientist when he is deciding how to allocate his firm's scarce resources.

Output characteristics

Additional factors influencing the quantity, quality, and type of research produced are output characteristics that appeal to or provide motivation for the scientific entrepreneur. These factors are difficult to quantify in that they are a source of utility to the scientist. As indicated by the survey results in Chapter IV, they do play a large role in the research allocation and production process.

Important considerations are whether a research possibility provides intellectual stimulation or is problem-solving in nature, whether it is a satisfying, interesting activity, and whether it produces socially needed products or outputs that match the scientist's personal, humanitarian objectives. Practical considerations also are taken into account. The research entrepreneur may select a project because he believes the research is valued by the experiment station or his professional colleagues as "good science." He believes this research will lead to job security, promotions to administrative positions, and salary increases. The research entrepreneur will direct his research firm to produce output that will build his professional prestige among his peers.

CHAPTER IV: SURVEY RESULTS

The purpose of this study is to identify and describe the process by which the research entrepreneurs (the scientists) in the Iowa State Experiment Station allocate research resources. Little is known about the framework of and the influences on their research production decisions. As was emphasized at the outset of this study, the intent is not to determine the socially optimal combination of research for the Iowa State Station. Rather, we want to know how scientists decide.

The Sample

A representative one-third sample of 64 scientists from the 198 Iowa State scientists with some time budgeted in the experiment station was selected. All scientists were first placed into three broad categories: animal scientists, plant scientists, and social scientists. Within each category the scientists' names were arranged by academic rank. Then, within each rank the names were listed in decreasing order of percent of time budgeted in the experiment station. Every third name was drawn for the sample. The one-third sample was therefore randomly, but systematically drawn.

Thirty-four plant scientists, 16 animal scientists, and 14 social scientists were selected (Table 4.1). The sample included 4 distinguished professors, 32 professors, 12 associate professors, and 16 assistant professors (Table 4.2). A classification was also

Table 4.1. Sample composition by department

	Number of scientists
Plant Sciences	
Agricultural engineering	3
Agronomy	12
Entomology	4
Food technology	4
Forestry	3
Genetics	0
Horticulture	6
Plant pathology	2
Subtotal	34
Animal Sciences	
Animal ecology	2
Animal science	7
Biochemistry	4
Dairy science	2
Poultry science	1
Subtotal	16
Social Sciences	
Agricultural education	1
Economics	3
Home economics	5
Sociology	3
Statistics	2
Subtotal	14
Total	64

made according to the amount of time scientists were budgeted in the experiment station. Those scientists budgeted 25 percent or less were classified minor time; scientists budgeted 26 to 60 percent were classified medium time, and scientists budgeted more than 60 percent were classified major time. The sample included 15 minor time, 22 medium time, and 27 major time scientists (Table 4.3). The sample composition closely corresponds to the composition of the Iowa State University research staff.

This systematic drawing of the sample provides observations disbursed among fields or departments, rank, and budgeted research time, and allows an examination of the importance these variables have on the scientist's research decision-making process. We hypothesize that a scientist will have more entrepreneurial flexibility if he possesses a higher academic rank and if a majority of his time is budgeted to research. A scientist with fewer constraints may be more of a risk-taker and may operate a larger research program. The department or field of science may reflect characteristic choice patterns of research unique to the plant, animal, or social sciences. The similarities and differences found between decisions by rank, field, and percent of time may have important implications for the management of research programs via allocations.

Table 4.2. Sample composition by academic rank

Department	Distinguished professor	Full professor	Associate professor	Assistant professor
Animal sciences	1	9	3	3
Plant sciences	1	17	7	9
Social sciences	2	6	2	4
Total	4	32	12	16
Sample percent	6%	50%	19%	25%
Population percent	7%	50%	19%	24%

Table 4.3. Sample composition by percent of time on the experiment station budget

	Percent of Budgeted Research Time									
Department	0-9	10	20	30	40	50	60	70	80	90-100
Animal sciences	-	-	3	-	3	2	3	1	1	3
Plant sciences	-	2	6	2	2	4	2	4	6	6
Social sciences	-	-	4	3	1	3	1	2	-	-
Total	0	2	13	5	6	9	6	7	7	9
Sample percent	0%	3%	20%	8%	9%	14%	9%	11%	11%	14%
Population percent	1%	4%	25%	9%	8%	13%	9%	11%	9%	11%

The Survey Instrument

The survey instrument (Appendix A) was designed to be administered and completed during a personal interview with each of the scientists. It was believed this method would provide the best data, obtain good cooperation, and save scientist time. Personal interview made it possible to ask more open-ended questions and to take a more flexible approach in order to perceive the unique personality of each entrepreneur.

Before the interviews were started in a department, a meeting was held with the DEO. The DEO was informed which scientists had been selected to participate in the survey and the content and manner of the interview were described. The DEO discussions were also used to gather job descriptions, information on internal or subdepartment structure, delegation of decision-making, and other descriptive information the DEO believed would assist the survey. The interviews with the scientists were then arranged through personal telephone contact. The time required to complete the survey varied between forty-five minutes to one and one-half hours per scientist.

The data on the first page of the survey were compiled from experiment station records. Only projects in which the scientist was listed as co-leader or leader were available from these records. Therefore, it was necessary to have each scientist examine this information and correct or extend it as necessary. Time was saved and rapport established by completing as much background information from records as possible prior to the interview.

Question two of the survey was included to determine what role outside funds played in the scientist's research program. Together with the experiment station records a complete picture of the size and composition of the scientist's research program was available. During the interview the scientist's attention was therefore directed to his total program, a necessary requirement for obtaining accurate responses to the remaining questions in the survey.

Research Decision-Making Process

The research production process and its components which were described in Chapter III have been incorporated into a flow diagram (Figure 4.1). This hypothetical diagram, divided into three decision-making stages, will provide an orderly structure for presenting the results of the survey.

To test for significant associations between the strata (department, academic rank, and research time) and the variables in the diagram, chi-square tests were computed. The null hypothesis is the hypothesis of independence. If the null hypothesis is rejected, a statistical association between the two attributes is indicated. An alpha value of 0.10 was used. (The results of all chi-square tests are listed in Appendix B.)

Many open-ended responses were also recorded during the personal interviews. Because these comments provide useful insights into the complex entrepreneurial process under study, they will be included with the numerical results.

STAGE I

Perceived area(s) of professional specialization	Job description

*Scientist narrows set of research possibilities

↓

STAGE II

Demand factors:	Supply Factors:
A. Chief demanders of intermediate products	A. Resource constraints to the production of research
1. Departmental colleagues	1. Graduate students
2. Other university scientists	2. Technicians
3. Friends 4. Journals	3. Scientist's research interests
	4. Facilities
B. Chief demanders of intermediate & final products	5. Scientist's research skills
1. Department Exec. Officer	6. Time
2. Experiment Station Administrator	7. Research funds
3. Adopters	B. The state of the research art
4. Media	
5. Extension	
6. Research committees	
7. Granting agencies	
8. Government contract offers	
9. Private industry contract offers	

*Scientist assesses supply & demand conditions & narrows research possibilities further

↓

STAGE III

Research characteristics:
1. Probability of research success
2. Intellectually intriguing research problem
3. Publishability of results
4. Social significance of the research problem
5. Research methods that could be used
6. Team or solo research

↓

*Scientist chooses project(s) for formal proposal that gives him highest utility

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*Signifies sequential narrowing of research project possibilities.

FIGURE 4.1. The research entreprenuer's project selection process

Stage I

The manner in which a scientist defines his area of professional specialization and the job description under which he is hired are two variables that initially determine the scope of research possibilities a scientist will consider when making production decisions. For example, a scientist who describes his professional specialty in a general manner and who was hired under a broadly written job description can realistically consider a broad set of research possibilities.

Professional specialization   When asked to define their area(s) of professional specialization, the scientists provided an indication of how broadly they perceived the field(s) in which they were competent to do research. For example, a scientist who described his area of research expertise as the "breeding and genetics of forage crops" had perceived a well-defined niche for himself in the experiment station community. All scientists interviewed indicated they were actively conducting research in their areas of specialization (Question 1b). Probably all scientists self-limited or considerably narrowed their research possibilities as they described their fields of expertise and hence research preferences.

The areas of professional specialization were post-classified similar to the scheme outlined in the Manual of Classification of Agricultural and Forestry Research. Responses were classified either as: (1) field of science only; (2) field of science and subdiscipline; or

(3) field of science, subdiscipline and commodity, resource, or technology. The field of science, the discipline employed in doing the research, is the classification used by the National Science Foundation for various government-wide reports. Commodity, resource, or technology not commodity oriented describes the objective of the research or "what is being improved or protected [34, p. 2]."

For illustrative purposes, a respondent who considered himself a plant pathologist would be classified under field of science only. A scientist who identified his area of specialization as disease physiology would fit into the classification field of science and subdiscipline. Finally, the response corn disease physiology would be classified as field of science, subdiscipline, and commodity.

The results in Table 4.4 show that the survey sample is fairly evenly divided between categories 2 and 3, the medium and narrow fields of specialization. Department and academic rank show no statistically significant association with degree of specialization. There is a positive and significant association between research time and degree of specialization (Table B.1). Sixty-two percent of the major time scientists provided a very specific description of their professional specialization. Medium and minor time scientists, however, were more likely to describe their specialty in broader terms.

Table 4.4. Classification of professional areas of specialization (in percent)

Stratum	Field of science only	Field of science & subdiscipline	Field of science subdiscipline & commodity resource, or technology
Department			
Animal sciences	0	43.8	56.2
Plant sciences	0	58.8	41.2
Social sciences	0	46.2	53.8
Academic Rank			
Full professor	0	51.4	48.6
Associate professor	0	58.3	41.7
Assistant professor	0	50.0	50.0
Research Time[a]			
Major time	0	37.9	62.1
Medium time	0	65.0	35.0
Minor time	0	64.3	35.7
Sample Total	0	52.4	47.6

[a]Significant chi-square at 90 percent confidence level.

Most major time scientists seem to have found it advantageous to concentrate their research in a narrow area of study. One major time animal scientist verbalized this tendency when he defined a "successful scientist" as one who concentrates his efforts in only one area of research.

Job descriptions The scientist's area of specialization is often an extension of the job description under which he was hired. This is particularly true for new scientists. The department heads are the persons chiefly responsible for hiring new staff members. Therefore, they play a major role in the initial narrowing of research possibilities.

During our interviews, most DEOs indicated that a new scientist is hired to fill a position in a specific area. Although job descriptions may not be highly formalized, there is usually a "general understanding" or "implied contract" over job expectations when the scientist is hired. Once the scientist joins the department he then has considerable leeway in determining the thrust of his research program within his specified area. Job candidates are most often selected to fill positions that fit into a department's prestructured program. Only one DEO favored the philosophy of "hiring good people and turning them loose."

The experiment station scientist begins the research decision-making or selection process with the alternatives narrowed in his job description. A soil physicist would not develop and lead a research project on crop breeding. Not only is he unqualified, he feels unauthorized. Further, a corn breeder would be reluctant to propose research in soybean breeding. Hence, a scientist enters stage II of the selection process with a narrowed set of research possibilities.

Stage II

The research entrepreneur, we hypothesize, receives messages that indicate to him which research results will be most highly valued. Once he identifies these demands and assesses their plausibility as research his firm can produce, he can narrow his production possibilities even further.

Demand for information   A skilled entrepreneur is very sensitive to messages he receives from a diverse group of demanders. This study hypothesized fourteen groups might comprise major demanders of experiment station research. Each scientist was asked to identify those sources from which he could recall receiving a demand signal or message (Question 6). Once the demanders relevant to the particular scientist had been identified, he was then asked to give a relative weight (on a scale of 100) to the actual influence each demander had exerted on his research selection (Question 7).

Demand signals   The survey results indicate that the major sources of research value are fellow scientists and researchers, demanders most often of intermediate research products (Table 4.5).

Table 4.5. Percent of scientists receiving demand signals from each source

Source	Percent
Departmental colleagues	79
Friends who are non-ISU scientists	71
Professionals through journals or conventions	65
DEO	65
ISU professors outside the scientist's department	59
Adopters of research results	59
Extension	50
Granting agencies	47
ISU Experiment Station administration	41
Regional research committees	41
General public, legislators	35
Private industry contract offers	29
Government contract offers	26
Mass media	15

Departmental colleagues play the major role in transmitting demand signals. Friends who are not associated with Iowa State University, information obtained through journal articles and at conventions, and DEOs provided Iowa State scientists with more demand signals than interdepartmental contacts. These researchers, therefore, look to scientists with similar research interests and academic backgrounds for information on the value of alternative research.

The mass media was reported least effective among the fourteen sources in signaling research demands. Contract offers from both private industry and the government are transmitting signals to a minority of experiment station scientists. The desires of the general public and legislators are received by only one-third of the scientists.

It is within these least effective demander categories that the widest variation between the strata occur, as illustrated by significant chi-square tests (Table B.1). The signals sent by the general public and legislators have been received by a significantly higher percentage of assistant and associate professors (56 percent and 58 percent respectively) than by full processors (29 percent) (Table 4.6). An even wider variation occurs between the three departments. Whereas 62 percent of the animal scientists surveyed indicated they had received research demand from this source, only 19 percent of the plant scientists reported the same (Table 4.7).

Table 4.6. Percent of scientists receiving demand signals by academic rank

Source	Assistant Professor	Associate Professor	Full Professor
Departmental colleagues	69	92	71
Interdepartmental colleagues	62	75	51
Friends who are non-ISU scientists	75	67	60
Professionals through journals or conventions	81	58	66
DEO	81	50	54
ISU Experiment Station administration	50	50	46
Adopters of research results	50	67	63
General public, legislators	56[a]	58[a]	29[a]
Mass media	19	25	9
Extension	50	58	49
Regional research committees	50	67	46
Granting agencies	69	50	49
Government contract offers	38	33	26
Private industry contract offers	25	42	46

[a]Significant chi-square at 90 percent confidence level.

A significant chi-square result in the mass media response resulted because no plant scientists reported receiving demand signals from this source. As expected, the social scientists reported the most interaction with the media, yet it was a low thirty percent of the respondents (Table 4.7).

Another category producing a significant chi-square test was the department executive officer (Table 4.7). All of the social scientists recorded that their DEO had indicated which research possibilities would be most valued. On the other hand, only fifty

Table 4.7. Percent of scientists receiving demand signals by department

Source	Animal Sciences	Plant Sciences	Social Sciences
Departmental colleagues	75	75	90
Interdepartmental colleagues	75	50	60
Friends who are non-ISU scientists	75	69	70
Professionals through journals or conventions	62	62	70
DEO	50[a]	50[a]	100[a]
ISU Experiment Station administration	38	38	50
Adopters of research results	75	56	50
General public, legislators	62[a]	19[a]	40[a]
Mass media	25[a]	0[a]	30[a]
Extension	50	50	50
Regional research committees	38	44	40
Granting agencies	38	44	60
Government contract offers	38	25	20
Private industry contract offers	25	44	10

[a]Significant chi-square at 90 percent confidence level.

percent of the animal and plant scientists identified their DEO as a signaler of research value. It can be seen that the social scientists also had the highest departmental colleague response, suggesting a tendency for the social sciences to have the most departmental interaction. This pattern may be the result of a field of science influence, the organization in these departments, or the DEOs' leadership styles. Because research projects among social scientists tend to be shorter term than among plant and animal scientists and because new projects entail administrative contact, more frequent DEO interaction may naturally result in the social sciences.

Other significant chi-square tests at the 90 percent confidence level occurred between scientists by research time. As we hypothesized, the results indicate that major time scientists are the chief recipients of contract offers from private industry (Table 4.8) Fifty-two percent of these scientists had made contact with this demand source in comparison to fourteen percent of minor time scientists. This may be due to private industry's perception that there is an advantage to approaching scientists with large research operations.

Table 4.8. Percent of scientists receiving demand signals by research time

Source	Minor Time	Medium Time	Major Time
Departmental colleagues	86	75	69
Interdepartmental colleagues	50	65	59
Friends who are non-ISU scientists	50[a]	85[a]	59[a]
Professionals through journals or conventions	57	70	72
DEO	71	60	55
ISU Experiment Station administration	43	40	55
Adopters of research results	50	65	62
General public, legislators	29	40	48
Mass media	7	20	14
Extension	50	50	52
Regional research committees	29	50	62
Granting agencies	43	50	62
Government contract offers	36	20	34
Private industry contract offers	14[a]	40[a]	52[a]

[a]Significant chi-square at 90 percent confidence level.

Another significant association occurred between percent of research time and the category "friends who are non-ISU scientists." Medium time scientists indicated that eighty-five percent had received indications from their non-ISU friends about which research possibilities they most highly valued. Fifty-nine percent of the major time and fifty percent of the minor time scientists responded they had heard from this category. This result seems to reflect a tendency for medium time scientists to have a high interaction with demanders in the majority of categories (Table 4.8).

Influence of the demanders To further assess the demand information, the scientists were asked to rate the relative influence each source had exerted on their research decisions (Question 7). Although a researcher may receive demand signals from a wide variety of sources, he may only give importance to a few when trying to determine which research possibilities will be most highly valued. The scientist was asked to give an approximation of the proportion of influence each source had on his decision-making on a scale of 0 to 100 (Table B.2).

From the results in Table 4.9 it can be seen that no demand source exerts a major influence on the research selection process. Demand information gained through journal articles and at conventions had the highest percent of influence (15.6 percent) over all the respondents.

Table 4.9. Average influence of each source on research selection[a]

Source	Percent
Professionals through journals or conventions	15.6
Departmental colleagues	14.6
Friends who are non-ISU scientists	8.9
Granting agencies	8.2
DEO	7.4
Other	6.5
Adopters of research results	6.3
ISU professors outside the scientist's department	6.1
Regional research committees	5.9
Extension	5.3
ISU Experiment Station administration	5.3
Government contract offers	4.3
Private industry contract offers	2.6
General public, legislators	2.0
Mass media	1.1

[a]The hypothesis H_T: $\mu = 0$ can be rejected for all values at $\alpha = 0.05$.

Departmental colleagues exerted the second highest amount of influence (14.6 percent). The mass media (1.1 percent) and the general public and legislators (2.0 percent) had the least affect on the research selection process.

As hypothesized, the scientists ranked the sources differently by frequency of demand signals transmitted and by average proportionate weight of influence on research decisions (Table 4.10). Most notable is the shift of professionals through journals and conventions to the top of the influence ranking from third position in frequency, and the inclusion of granting agencies among the four most influential signalers.

Table 4.10. Comparison of frequency and influence of the top four demanders

Source	Percent
Frequency of scientists reporting demand signals received by source	
Departmental colleagues	79
Friends who are non-ISU scientists	71
Professionals through journals, conventions	65
DEO	65
Average influence of demand signals by source	
Professionals through journals, conventions	15.6
Departmental colleagues	14.6
Friends who are non-ISU scientists	8.9
Granting agencies	8.2

These results may indicate a strong desire for professional prestige through future publication of research findings in respected journals and also a desire to expand the research firm through additional funds from granting agencies.

In order to test for significant mean differences among groups of scientists for each source, t-tests were computed (Tables B.3, B.4, B.5). The largest number of significant t-test results occurred between the research time divisions. The academic rank and department strata produced few significant mean differences. Only the scientists' budgeted research time seemed to play any major role in their interaction with demanders of research results.

Major time scientists gave professionals through journals the highest amount of influence (21.6 percent). Medium time scientists gave this source the second highest amount of influence (13.6 percent). Minor time scientists, on the other hand, assigned this source only moderate influence (5.7 percent). These results (Table 4.13) may reflect the opportunity or necessity for major time scientists to show to fellow professionals research productivity by publications in journals or through presentations at conventions. Here, the major time entrepreneur perhaps must better decipher from current journal publications the types of research that are worthy of future publication than the minor time researcher.

Animal and plant scientists assigned a significantly greater amount of influence (20.3 percent and 16.4 percent respectively) to journals or conventions than social scientists (7.5 percent). There was no significant difference between the three academic ranks (Table 4.11).

Significant differences were also observed for the second major source of influence, departmental colleagues. The tenured scientists (associate and full professors) assigned the highest influence to departmental colleagues (17.4 percent and 17.2 percent respectively). Medium influence (7.0 percent) was given by the assistant professors to departmental colleagues. Perhaps assistant professors have not developed strong working relationships with their colleagues. It appears that assistant professors rely more heavily on journals, their DEO, and scientists at other institutions (perhaps friends from their graduate training) for signals of research value. In any case, more of the peers of assistant professors seem to be outside the university (Table 4.12).

Minor time scientists give the highest amount of influence to departmental colleagues (26.8 percent). Maybe minor time scientists have heavy teaching loads, use their research time to supplement their teaching responsibilities and thereby depend more on colleagues to decipher the journals for priority research. Research which is more applied in nature supplements research conducted by major time scientists or feeds more directly to extension and teaching. These characteristics may explain the heavy reliance of minor time scientists on departmental contacts for indications of research value.

Major time scientists assigned a significantly larger amount of influence to granting agencies. They gave granting agencies the second highest amount of influence (12.7 percent) whereas medium and minor time scientists gave this source only moderate weights (5.2 percent and 3.3 percent respectively). Perhaps major time scientists interact more with granting agencies or have a greater opportunity or need to expand their funding base beyond experiment station funds. To increase their research efforts most scientists said that funds have to come from grants.

Table 4.11. Average influence of each source on research selection by department (in percent)

Source	Animal Sciences	Plant Sciences	Social Sciences
Departmental colleagues	18.7	13.3	13.2
Interdepartmental colleagues	4.4[a]	4.4[a]	12.7[a]
Friends who are non-ISU scientists	8.2	10.3	6.2
Professionals through journals or conventions	20.3[a]	16.4[a]	7.5[a]
DEO	3.1[a]	6.8[a]	14.6[a]
ISU Experiment Station administration	3.1	5.6	7.5
Adopters of research results	7.6	6.1	5.5
General public, legislators	2.6	1.7	1.8
Mass media	0.6	0.4	3.5
Extension	3.6	4.8	9.0
Regional research committees	4.4	6.4	6.4
Granting agencies	13.4	7.5	3.8
Government contract offers	5.6	4.2	3.1
Private industry contract offers	0.8[a]	4.2[a]	0.5[a]

[a]Significant mean difference between at least two of the three categories at the 90 percent confidence level.

Table 4.12. Average influence of each source on research selection by academic rank (in percent)

Source	Assistant Professor	Associate Professor	Full Professor
Departmental colleages	7.0[a]	17.4[a]	17.2[a]
Interdepartmental colleagues	4.8	5.8	6.8
Friends who are non-ISU scientists	7.5	5.8	10.7
Professionals through journals or conventions	18.3	10.4	16.1
DEO	9.1	8.7	6.3
ISU Experiment Station Administration	4.6	8.2	4.7
Adopters of research results	1.9[a]	3.1[a]	9.5[a]
General public, legislators	2.2	4.2	1.0
Mass media	1.9	1.4	0.7
Extension	5.9	4.8	5.2
Regional research committees	5.3	4.1	6.7
Granting agencies	9.7	5.9	8.4
Government contract offers	6.9	5.3	2.9
Private industry contract offers	1.6	1.9	3.2

[a]Significant mean difference between at least two of the three categories at the 90 percent confidence level.

Table 4.13. Average influence of each source on research selection by research time (in percent)

Source	Minor Time	Medium Time	Major Time
Departmental colleagues	26.8[a]	10.4[a]	11.7[a]
Interdepartmental colleagues	2.8[a]	10.4[a]	4.8[a]
Friends who are non-ISU scientists	5.4	10.8	9.4
Professionals through journals or conventions	5.7[a]	13.6[a]	21.6[a]
DEO	13.6	5.8	5.6
ISU Experiment Station administration	8.0	5.2	4.2
Adopters of research results	2.7[a]	11.8[a]	4.4[a]
General public, legislators	2.8	1.2	2.0
Mass media	0.8	1.2	1.2
Extension	8.6	5.0	4.0
Regional research committees	2.9	6.2	7.0
Granting agencies	3.3[a]	5.2[a]	12.7[a]
Government contract offers	8.6	3.8	2.7
Private industry contract offers	0.8[a]	3.0[a]	3.1[a]

[a]Significant mean difference between at least two of the three categories at the 90 percent confidence level.

Differences in the amount of influence the DEO exerts produced significant t-test results in the department and rank strata. Overall the DEO was given an average weight of 7.4 percent in influencing research decisions. Social scientists and minor time scientists, however, assigned a much higher weight (14.6 percent and 13.6 percent respectively) to this source.

Statistically significant differences between all three departments for the DEOs were found. The heavy weight of influence in the social sciences corresponds to the high frequency of signals received from the DEOs. The plant scientists interviewed responded they gave greater weight (6.8 percent) to their DEOs'signals of research value than did the animal scientists (3.1 percent). Once again, these results may indicate differences in management styles.

The high weight given the DEO by minor time scientists (13.6 percent) is further indication that they rely on departmental contacts for indications of where they should concentrate their research efforts. This weight is significantly greater than the weights assigned by major and medium time scientists (5.6 percent and 5.8 percent respectively).

Adopters of research results, with a sample average influence of 6.3 percent, was a source of significant t-test results. Full professors assigned a heavy weight to the demand signals from adopters (9.5 percent) as did medium time scientists (11.8 percent). This rapport with adopters has perhaps developed over the scientists' careers, hence the heavier weight given to them. Assistant professors gave adopters their second lowest weight (1.9 percent) indicating little interaction with them.

The remaining source that exhibited significant differences between means was contract offers from private industry. Scientists indicated that this source has very little influence on their research decisions. As with granting agencies, major time scientists assigned the greatest weight to contract offers (3.1 percent) further pointing to a desire for more research funds. Plant scientists were the only group that assigned a significant amount of influence to contract offers (4.2 percent).

These t-test results indicate that there are differences in the amount of influence each of the demanders has on the strata identified for this survey. Contrary to the opinion that experiment station research is very responsive to special interest groups, such as private industry and granting agencies, the results indicate instead that the scientists are more interested in what their fellow professionals perceive to be valuable research, particularly departmental colleagues and professionals through journals and conventions. Perhaps the research entrepreneurs are implying that in order to succeed in the academic work environment, they must first meet the research demands and expectations of their peers.

Production of information Once the entrepreneur assimilates the demand information pertinent to his research firm he next must determine which outputs can be feasibly produced with the available resources. For example, a scientist may determine that the results of a particular research project will be highly valued but to conduct it would require the purchase of very expensive equipment. He therefore faces a facilities constraint that may be too expensive to overcome.

In order to determine which resources are most constraining to research conducted in the Iowa State Experiment Station, the scientists were requested to assign a level of importance to the resources identified (Question 4). Although most scientists indicated that all of the resources were important to the research process, there were some resources that were more constraining when making a decision over which research inquiry to pursue. Considerable effort was exerted by the interviewers to make this distinction clear so that consistent responses were obtained.

The scientists indicated that their own human capital, embodied in their personal interests and research skills and abilities, were the resources they weighed most heavily when determining which research could be conducted. When summing over the "very important" and "important" categories in Table 4.14, it can be seen that 93.6 percent of the scientists indicated that personal interest was a major consideration. Personal skills and abilities (90.4 percent) and facilities (84.2 percent) were also rated of high importance. The resources rated of least importance as a constraint to research were time needed to complete a project (38.1 percent) and availability of technicians (27.0 percent).

Table 4.14. Scientists' ranking of the importance of resource constraints to research (in percent)

Resource	Very Important	Important	Not too Important	Not at all Important
Graduate students	25.4	25.4	33.3	15.9
Technicians	6.4	20.6	20.6	52.4
Personal interest	60.3	33.3	6.4	0.0
Facilities	55.6	28.6	7.9	7.9
Personal skills, abilities	46.0	44.4	7.9	1.6
Completion time	9.5	28.6	50.8	11.1
Experiment Station funds	17.5	34.9	39.7	7.9
Funds from outside sources	20.6	42.9	30.2	6.5

Graduate students The interests and abilities of graduate students were assigned only moderate importance (50.8 percent) as a research input. This result occurred due to a division of the scientist's responses. One group assigned a very high importance to graduate students as a constraint to the research they could produce. For example, one professor said, "A big problem in doing good research is getting motivated and able graduate students." Many scientists with heavy teaching loads emphasized their dependence on the interest and independence of graduate students, for without them these scientists said they do not have sufficient time to complete their projects. This group is perhaps more likely to allow graduate students "some say" in the research projects chosen.

On the other hand, another group of scientists believe there is no scarcity of graduate students. They stated that once their projects are funded, they can always find graduate students to assist in the research. Particularly scientists involved in long-term research projects view graduate students as resources that "come and go," therefore the availability of this input played no large role in the selection process. Most researchers agreed that graduate students are a source of ideas, that they "broaden and intensify" research, and that one of the roles of a research professor is "to train graduate students to do good research," but they disagreed on the importance this resource had on the research they selected.

This split was evidenced in the significant chi-square test (Table B.6) from the responses by academic rank (Table 4.15). Associate professors were evenly divided between very important and not too important. No associate professors responded that graduate students were "not at all important," whereas 22.9 percent of the full professors responded in this category. Most assistant professors emphasized that the availability of graduate students was an important factor in their research programs. The large percentage (56.2 percent) responding that graduate students were important arose, therefore, because assistant professors did not usually have a graduate student, but would like to attract one to their research programs.

Table 4.15. Scientists' ranking of the importance of graduate students in the research selection process (in percent)

Stratum	Very Important	Important	Not too Important	Not at all Important
Department				
Animal sciences	31.2	25.0	37.5	6.2
Plant sciences	17.6	26.5	35.3	20.6
Social sciences	38.5	23.1	23.1	15.4
Academic Rank[a]				
Assistant professor	0.0	56.2	31.2	12.5
Associate professor	50.0	0.0	50.0	0.0
Full professor	28.6	20.0	28.6	22.9
Research Time				
Minor time	35.7	28.6	28.6	7.1
Medium time	25.0	20.0	35.0	20.0
Major time	20.7	27.6	34.5	17.2

[a]Significant chi-square at 90 percent confidence level.

Technicians The results obtained from the technicians category do not adequately reflect the importance this resource could have for experiment station research. The scientists assigned technicians the lowest importance of the resources listed, primarily because they have resigned themselves to the fact that funds for technician help will not be increased in the near future. Therefore because most scientists do not have technicians and cannot afford to hire any, this resource is a permanent constraint. The scientists did not consider them to be a major consideration when they made their research decisions.

One scientist called this lack of funds for technicians a "glaring deficiency" and "a serious error that is getting to be a sore point."

Scientists believe that technician help would increase their research productivity and provide stability to their programs. One full professor, while agreeing with these prevailing opinions, offered a contrasting view of the importance of technicians when he commented, "I could do more work with good technicians, but our job is the training of students."

As hypothesized, the results produced a significant chi-square association between department and the importance of technician help (Table 4.16). One-half of the animal scientists responded that this resource is an important research constraint. Considerably fewer of the plant and social scientists (20.6 percent and 15.4 percent respectively) assigned an important ranking to technicians. Three-fourths of the social scientists said that technician help was not important at all as a constraint to the research they select. These results reflect the differing nature of the research conducted by the three departments.

Interest The interest of the researcher was the most important consideration when building a research program. Table 4.17 illustrates that the responses were approximately the same over all strata. One scientist said, "I can't imagine doing research I'm not interested in." Some scientists would take a cut in or not accept funds until they could work in areas where their interests lie. Productivity would be highest when a project matches their interests, most scientists concluded.

Table 4.16. Scientists' ranking of the importance of technicians in the research selection process (in percent)

Stratum	Very Important	Important	Not too Important	Not at all Important
Department[a]				
Animal sciences	6.2	43.8	31.2	18.8
Plant sciences	5.9	14.7	20.6	58.8
Social sciences	7.7	7.7	7.7	76.9
Academic Rank				
Assistant professor	0.0	12.5	25.0	62.5
Associate professor	16.7	33.3	25.0	25.0
Full professor	5.7	20.0	17.1	57.1
Research time				
Minor time	7.1	21.4	7.1	64.3
Medium time	0.0	25.0	15.0	60.0
Major time	10.3	17.2	31.0	41.4

[a]Significant chi-square at 90 percent confidence level.

Table 4.17. Scientists' ranking of the importance that the research under consideration matches their interests (in percent)

Stratum	Very Important	Important	Not too Important	Not at all Important
Department				
Animal sciences	62.5	31.2	6.2	0.0
Plant sciences	61.8	29.4	8.8	0.0
Social sciences	53.8	46.2	0.0	0.0
Academic Rank				
Assistant professor	62.5	31.2	6.2	0.0
Associate professor	66.7	33.3	0.0	0.0
Full professor	57.1	34.3	8.6	0.0
Research Time				
Minor time	78.6	21.4	0.0	0.0
Medium time	60.0	35.0	5.0	0.0
Major time	51.7	37.9	10.3	0.0

The scientists who stated that interest was not too important based their response on the fact that if there was a scarcity of people working in their research area, they would work on a project that "needs to be done" even if they were not interested in it. One full professor also observed that although interest was a major consideration at the beginning of his career, it had since diminished in importance. This remark may explain the slightly higher number of full professors (8.6 percent) responding that interest was not an important criterion when choosing among research possibilities.

Facilities Research facilities was the third most important resource. Specifically, computer facilities, sophisticated equipment greenhouse space, and laboratories were facilities considered vital by some scientists to conduct research.

Several scientists noted that if they have an idea for a project that requires too many facilities, they know that it will not be favorably reviewed and they will not "go after" it. They would also not start a project with hopes of later finding major facilities. As to whether Iowa State had adequate facilities, the scientists were somewhat divided. One scientist mentioned that he selected Iowa State because it had better facilities for his research. Another scientist said that his program is lacking specialized equipment and that he must usually rely on grants and funds from other sources to purchase the needed facilities. Most researchers agreed, however, that this resource is a vital consideration in determining which projects would be feasible.

As in the case of technicians, the nature of the research conducted in each of the departments produced responses showing a significant association with importance of facilities (Table 4.18). Ninety-four percent of the animal and plant scientists said that facilities were an important constraint to research compared to only 46 percent of the social scientists. As further illustration of the difference between departments, 38 percent of the social scientists said that the availability of facilities was of no importance. There was no significant association between importance of facilities and academic rank or research time.

Table 4.18. Scientists' ranking of the importance of facilities in the research selection process (in percent)

Stratum	Very Important	Important	Not too Important	Not at all Important
Department[a]				
Animal sciences	56.2	37.5	6.2	0.0
Plant sciences	61.8	32.4	5.9	0.0
Social sciences	38.5	7.7	15.4	38.5
Academic Rank				
Assistant professor	50.0	25.0	18.8	6.2
Associate professor	50.0	41.7	0.0	8.3
Full professor	60.0	25.7	5.7	8.6
Research Time				
Minor time	50.0	35.7	0.0	14.3
Medium time	60.0	25.0	5.0	10.0
Major time	55.2	27.6	13.8	3.4

[a]Significant chi-square at 90 percent confidence level.

Skills and research experience An important component of the research entrepreneur's human capital, his research skills and experience, was the second most important consideration in research selection (Table 4.19). Most scientists said they would be reluctant to enter a research area in which they do not feel competent. This experience and competency often corresponded with the scientists' graduate backgrounds.

The respondends explained that they must be adaptable and willing to develop traditional research skills. Although they can develop new skills, this requires a "tool up" time that must be a consideration when examining a research project that would require additional training. Therefore, skills are a limiting resource and a major factor in a scientist's research productivity.

Table 4.19. Scientists' ranking of the importance research skills have in the selection process (in percent)

Stratum	Very Important	Important	Not too Important	Not at all Important
Department				
Animal sciences	25.0	62.5	6.2	6.2
Plant sciences	50.0	41.2	8.8	0.0
Social sciences	61.5	30.8	7.7	0.0
Academic Rank				
Assistant professor	37.5	50.0	12.5	0.0
Associate professor	41.7	50.0	8.3	0.0
Full professor	51.4	40.0	5.7	2.9
Research Time				
Minor time	50.0	42.9	7.1	0.0
Medium time	40.0	60.0	0.0	0.0
Major time	48.3	34.5	13.8	3.4

Completion time The time required to complete a project (i.e., whether a project requires a short-term or a long-term research commitment) is a resource few scientists (38 percent) considered to be a major constraint. In some cases the scientists' research was inherently long-term in nature, such as plant breeding experimentation, so that the time factor was of no importance. Several scientists believed that more can be accomplished on long-term projects. On the other hand, one respondent said he would be uncomfortable working on a project that lasted less than one year or more than five years. A mix of short- and long-term projects appeared to be the most favored situation, with short-term projects permitting more opportunity to publish and long-term projects allowing for program continuity.

The statistical analyses (Table 4.20) show no significant associations. Of interest, however, is the large number of social scientists (62 percent) and minor time scientists (50 percent) that assigned a high importance to completion time. These strata are often involved with short-term projects which could explain these results.

Experiment station funds The role that experiment station funds play in research is a complicated one. Fifty-two percent of the scientists considered this resource to be an important research constraint. These scientists explained that experiment

Table 4.20. Scientists' ranking of the importance of completion time in the research selection process (in percent)

Stratum	Very Important	Important	Not too Important	Not at all Important
Department				
Animal sciences	0.0	31.2	50.0	18.8
Plant sciences	8.8	23.5	58.8	8.8
Social sciences	23.1	38.5	30.8	7.7
Academic Rank				
Assistant professor	6.2	25.0	68.8	0.0
Associate professor	8.3	25.0	66.7	0.0
Full professor	11.4	31.4	37.1	20.0
Research time				
Minor time	21.4	28.6	50.0	0.0
Medium time	10.0	35.0	50.0	0.0
Major time	3.4	24.1	51.7	20.7

station funds provide a foundation or "solid base" to their program because the experiment station is considered to be a "guaranteed funding source." Other adjectives applied to station funds were "constant," "steady," and "certain." Scientists also indicated they have used these funds for pilot scale experiments whose results were a major factor in whether they applied for larger, competitive grants from outside agencies. The importance of station funds was greater for scientists who have difficulty in attracting outside funds. One researcher stated he chooses projects that he "guesses will be funded," because his program would be severely constrained without station funds. This reliance was reiterated by another scientist when he explained that if he could not conduct a project on experiment station funds, he would give it lower priority.

On the other hand, 48 percent of the scientists assigned the resource low importance. This group tended to believe that the station provides them an "insignificant amount" of funds. For example, one scientist said that "if I had to rely on experiment station funds, I wouldn't be doing much work." He estimated that only 20 percent of his funding comes from this source. On the other hand, several scientists remarked that because they have never had a "hard time obtaining experiment station funds," they do not feel constrained by this resource. Some antagonism surfaced in several responses. Station funds have been a problem, several scientists indicated, "because the experiment station said they would provide background support, but haven't."

A significant chi-square association (Table 4.21) existed between station funds and research time. As reflected in the responses, minor and medium time scientists (64 percent and 55 percent, respectively) felt most contrained by this resource. A significantly greater number of major time scientists ranked station funds as not too important (52 percent). Among the department strata plant scientists (62 percent) assigned the highest importance to experiment station funds.

Funds from outside sources A larger number of scientists indicated that funding from outside sources is an important research constraint (63 percent). These funds they said are important sources of equipment and expanded facilities, are used to fund graduate students

Table 4.21. Scientists' ranking of the importance of experiment station funds in the research selection process (in percent)

Stratum	Very Important	Important	Not too Important	Not at all Important
Department				
Animal sciences	6.2	37.5	37.5	18.8
Plant sciences	20.6	41.2	35.3	2.9
Social sciences	23.1	15.4	53.8	7.7
Academic rank				
Assistant professor	25.0	25.0	50.0	0.0
Associate professor	8.3	41.7	50.0	0.0
Full professor	17.1	37.1	31.4	14.3
Research Time[a]				
Minor time	21.4	42.9	35.7	0.0
Medium time	30.0	25.0	25.0	20.0
Major time	6.9	37.9	51.7	3.4

[a]Significant chi-square at 90 percent confidence level.

and technicians, and are increasingly relied on in some instances where traditional funding sources are disappearing. Most scientists agreed these funds are difficult to obtain and entail acquisition costs. Often one to three months of the scientist's time is spent writing proposals with no guarantee of receiving funds. Further, one scientist remarked that compromises between his interests and those of the funding source had to be made. Political ties and funds with "strings attached" were other costs scientists associated with this resource. These disadvantages, however, appear to be outweighed by the opportunities these funds offer to enlarge a scientist's program.

No significant associations were observed between this resource and the strata (Table 4.22). Animal scientists (81 percent), assistant professors (69 percent), and minor time scientists (71 percent) placed the highest importance on this resource as a constraint. These results are consistent with the average weights assigned the demanders who provide outside funds (Tables 4.11, 4.12, and 4.13).

Table 4.22. Scientists' ranking of the importance of funds from outside sources in the research selection process (in percent)

Stratum	Very Important	Important	Not too Important	Not at all Important
Department				
Animal sciences	25.0	56.2	12.5	6.2
Plant sciences	20.6	41.2	32.4	5.9
Social sciences	15.4	30.8	46.2	7.7
Academic rank				
Assistant professor	18.8	50.0	31.2	0.0
Associate professor	25.0	33.3	41.7	0.0
Full professor	20.0	42.9	25.7	11.4
Research time				
Minor time	28.6	42.9	28.6	0.0
Medium time	15.0	35.0	35.0	15.0
Major time	20.7	48.3	27.6	3.4

Stage III

Now that the scientist has determined what research demands and production constraints he faces he has probably substantially narrowed the number of projects he can consider for formal proposal. We hypothesize that there is one final group of considerations he evaluates before making his final selection which we term research characteristics. Many of these characteristics are closely tied to the utility or personal satisfaction the scientist will gain by conducting a research investigation. He will attempt to maximize his utility by selecting the project(s) that has the greatest number of research characteristics he believes are important.

Research characteristics We identified seven research characteristics (Question 5) and requested each scientist to identify those he felt were important (Table 4.23). The scientist noted a project's intellectually intriguing, or problem-solving aspect as the most important characteristic (89 percent). A project that dealt with a socially significant problem or that met a social need was the characteristic considered important by the second largest number of scientists (81 percent). The type of working situation, team or solo research, was least important as a selection criterion. Except for social significance, the results in this category did not product statistically significant associations by strata. Hence, scientists indicated similar preference orderings.

Table 4.23. Scientists' ranking of the importance of the characteristics of research (in percent)

Characteristic	Very Important	Important	Not too Important	Not at all Important
High probability of success	11.1	46.0	38.1	4.8
Intellectually intriguing	39.7	49.2	11.1	0.0
Publishability	31.8	46.0	22.2	0.0
Social significance	54.0	27.0	11.1	7.9
Familiar method or technique can be used	9.5	36.5	46.0	7.9
Can work in a team	11.1	30.2	47.6	11.1
Can work alone	3.2	15.9	42.9	38.1

Success In order to determine if risk was am important selection characteristic, the scientists were asked whether they preferred projects that offered high probabilities of success. It was explained that by assigning a high importance to this characteristic, the scientist was indicating a preference for low-risk projects. Although over half of the scientists (57 percent) said this was an important criterion (summing over the very important and important responses), very few (11 percent) said it was very important (Table 4.24).

Scientists who stated that a high probability of success was an important consideration gave several reasons for this reponse. First, several scientists involved with research they consider to be applied in nature said they would not be interested in a project that might not produce usable results. Secondly, it was mentioned that it

Table 4.24. Scientists' ranking of a research project's potential success in the selection process (in percent)

Stratum	Very Important	Important	Not too Important	Not at all Important
Department				
Animal sciences	6.2	56.2	31.2	6.2
Plant sciences	11.8	41.2	41.2	5.9
Social sciences	15.4	46.2	38.5	0.0
Academic rank				
Assistant professor	12.5	50.0	37.5	0.0
Associate professor	25.0	50.0	25.0	0.0
Full professor	5.7	42.9	42.9	8.6
Research time				
Minor time	0.0	50.0	50.0	0.0
Medium time	15.0	40.0	35.0	10.0
Major time	13.8	48.3	34.5	3.4

was more important that a graduate student project be successful than a project the scientist was working on alone. The ability to attract funds was also said to rely on past research success. One scientist stated that although "you don't always succeed, you must meet a high percentage of your objectives. If not, funding will decrease." Success is what granting agencies are looking for, another researcher emphasized.

On the other hand, some scientists remarked that they are attracted to high-risk projects. They are more willing "to go out on a limb" because they believe that high benefits usually accompany high-risk projects. A compromise was suggested by one scientist when he said that he splits his activities between low-risk and high-risk investigations. In most instances, scientists stated they do not necessarily measure success on positive results. "Negative information is not a loss," one scientist emphasized.

The researchers who assigned the lowest importance to a high probability of success were minor time scientists, full professors, and plant scientists. The most risk-adverse stratum of the sample was associate professors.

Intellectually intriguing aspects Projects that presented a problem-solving situation, that were intellectually stimulating were most highly preferred by the research scientists (Table 4.25). The chance to obtain "unique rather than expected results" and to produce research that will be an addition to their field was valued by 89 percent of the scientists. For these reasons, one scientists said he did not like to do contract work.

Publishability The publishability of results was a characteristic 78 percent of the scientists said was important (Table 4.26). Contrary to what we had hypothesized, publishability was not an overriding concern of the scientists. The "publish or perish" cliche often surfaced during the interviews, but several of the researchers tempered their responses by saying that if they conduct "good" or "significant" research, the results would almost always be publishable. Therefore, they reflect a concern over the research means, rather than the end results of a project.

Table 4.25. Scientists' ranking of the importance of the intellectually intriguing aspects of a project in research selection (in percent)

Stratum	Very Important	Important	Not too Important	Not at all Important
Department				
Animal sciences	37.5	50.0	12.5	0.0
Plant sciences	41.2	47.1	11.8	0.0
Social sciences	38.5	53.8	7.7	0.0
Academic rank				
Assistant professor	25.0	56.2	18.8	0.0
Associate professor	41.7	50.0	8.3	0.0
Full professor	45.7	45.7	8.6	0.0
Research time				
Minor time	35.7	57.1	7.1	0.0
Medium time	40.0	40.0	20.0	0.0
Major time	41.4	51.7	6.9	0.0

Table 4.26. Scientists' ranking of the importance of publishability of results in research selection (in percent)

Stratum	Very Important	Important	Not too Important	Not at all Important
Department				
Animal sciences	37.5	56.2	6.2	0.0
Plant sciences	29.4	41.2	29.4	0.0
Social sciences	30.8	46.2	23.1	0.0
Academic rank				
Assistant professor	37.5	50.0	12.5	0.0
Associate professor	41.7	41.7	16.7	0.0
Full professor	25.7	45.7	28.6	0.0
Research time				
Minor time	28.6	42.9	28.6	0.0
Medium time	25.0	45.0	30.0	0.0
Major time	37.9	48.3	13.8	0.0

Publishability "signifies a good piece of work," one scientist stated. It is a measure of professional value, a "facet of accountability" for many scientists. Several scientists said they would be "cheating a graduate student if the results were not publishable." The nature of the research and the academic status of a professor, however, appeared to have an effect on the importance of publishability. For example, a scientist involved in applied research observed that "although problems with practical significance are not usually accepted by professional journals they should be considered." Several full professors also indicated that "at their stage of the game" publishability is not a major concern. This was reflected in the lower percentage of full professors (71 percent) compared to associate (83 percent) and assistant professors (88 percent) who consider publishability to be an important selection criterion.

Major time scientists assigned the highest importance in the rank strata to this characteristic (86 percent), perhaps reflecting the use of publications as a measure of professional competence. Animal scientists ranked publishability the highest (94 percent) of all the strata. This result may indicate an organizational structure that emphasizes publishability.

Social significance The socially significant aspect of a project was the characteristic the second largest number of scientists said was important in research selection. There was little difference in the responses of the department and research time strata, however, there was a statistically significant difference between the academic ranks (Table 4.27). Assistant and full professors placed a greater emphasis on social significance than did associate professors. They emphasized a desire to choose research that would have applied aspects. This is particularly true, one full professor commented, with projects conducted on station money. "If it doesn't apply to Iowa, it (the project) shouldn't be done," he said. Many assistant professors indicated they had selected their area of research because they perceived it to be socially significant.

Another professor disagreed with the majority of the responses by stating that "the function of the university is not to save the world." Several persons indicated that social significance was important only for obtaining research funds. The concern of most scientists to produce research applicable to Iowa's problems outweighed this view.

Research method Less than half of the scientists surveyed (46 percent) stated it was important that the projects they select involve statistical methods or research techniques they have had experience using (Table 4.28). Rather, several scientists mentioned they were not adverse to using new methods and that it was "fun" to learn new techniques. A project may, in fact, be purposely selected because it requires new techniques. "As long as I can locate expertise I will go with it," one plant scientist said.

Table 4.27. Scientists' ranking of the importance of social significance in research selection (in percent)

Statum	Very Important	Important	Not too Important	Not at all Important
Department				
Animal sciences	43.8	31.2	12.5	12.5
Plant sciences	58.8	20.6	11.8	8.8
Social sciences	53.8	38.5	7.7	0.0
Academic rank[a]				
Assistant professor	50.0	43.8	6.2	0.0
Associate professor	50.0	0.0	33.3	16.7
Full professor	57.1	28.6	5.7	8.6
Research time				
Minor time	71.4	14.3	14.3	0.0
Medium time	30.0	40.0	15.0	15.0
Major time	62.1	24.1	6.9	6.9

[a]Significant chi-square at the 90 percent confidence level.

Table 4.28. Scientists' ranking of the importance of research method or technique in the selection process (in percent)

Statum	Very Important	Important	Not too Important	Not at all Important
Department				
Animal sciences	12.5	31.2	43.8	12.5
Plant sciences	8.8	35.3	50.0	5.9
Social sciences	7.7	46.2	38.5	7.7
Academic rank				
Assistant professor	12.5	37.5	50.0	0.0
Associate professor	0.0	58.3	41.7	0.0
Full professor	11.4	28.6	45.7	14.3
Research time				
Minor time	14.3	42.9	35.7	7.1
Medium time	10.0	35.0	50.0	5.0
Major time	6.9	34.5	48.3	10.3

A distinguished professor attributes the majority of his research work specifically to the development of new methods.

Other scientists said that using familiar techniques simplified the research process. New research methods requiring large expenditures for equipment were discarded in favor of methods using tools already in the scientists' possession. A shortage of time was another factor that discouraged some scientists from using new techniques. One scientist commented that "the degree of change would depend on my time availability."

The results show that social scientists from the sample are slightly less willing to try unfamiliar research methods or techniques. Minor time and associate professors also reflected some reluctance to stray from familiar techniques. No significant association existed between this variable and the strata.

Working situation In order to determine if a scientist considered the working situation when making a project choice, he was asked if he preferred team or solo research. The results indicate (Tables 4.29, 4.30) that this research characteristic was least important as a selection criterion.

Team research was preferred by some because it provided an atmosphere for stimulating, intellectual interchange between scientists and disciplines. Joint research was described as "stronger, more productive research." One full professor stated he believes that "major problems cannot be solved unilaterally in a discipline."

Table 4.29. Scientists' ranking of the importance of team work (in percent)

Stratum	Very Important	Important	Not too Important	Not at all Important
Department				
Animal sciences	6.2	31.2	56.2	6.2
Plant sciences	11.8	26.5	47.1	14.7
Social sciences	15.4	38.5	38.5	7.7
Academic rank				
Assistant professor	0.0	43.8	50.0	6.2
Associate professor	0.0	22.9	58.3	8.2
Full professor	20.0	22.9	42.9	14.3
Research time				
Minor time	0.0	28.6	57.1	14.3
Medium time	10.0	40.0	35.0	15.0
Major time	17.2	24.1	51.7	6.9

Table 4.30. Scientists' ranking of the importance of working alone (in percent)

Stratum	Very Important	Important	Not too Important	Not at all Important
Department				
Animal sciences	0.0	31.2	43.8	25.0
Plant sciences	5.8	8.8	41.2	44.1
Social sciences	0.0	15.4	46.2	38.5
Academic rank				
Assistant professor	6.2	12.5	56.2	25.0
Associate professor	0.0	8.3	50.0	41.7
Full professor	2.9	20.0	34.3	42.9
Research time				
Minor time	0.0	14.3	42.9	42.9
Medium time	5.0	5.0	45.0	45.0
Major time	3.4	24.1	41.4	31.0

Rather, he prefers pooling resources, therefore allowing him to use the "ears and eyes of many disciplines." Intellectual compatability and confidence in their partners' ambitions and abilities were factors considered important for successful teamwork.

In contrast, some scientists preferred projects in which they could work alone. "I like to call my own shots, set my own time-table," a plant scientist remarked. One professor observed that although he participated in collaborative projects "on paper," in practice his team worker did not "cross paths" with him very often.

The results in Table 4.29 show that of the departments social scientists placed the highest amount of importance to teamwork (54 percent). Correspondingly, no social scientists reponded that working alone was a very important selection criterion. This may reflect an intradisciplinary tendency in social science research.

Major time scientists also indicated a stronger preference for solo projects. A possible explanation is that because these scientists usually have more graduate student and technician help, there is less pressure to rely on colleagues to accomplish research objectives. This group is not as large as the major time researchers preferring team projects, however.

Except for associate professors, who assigned a very low importance to solo projects (8.3 percent), there were only slight differences between working preferences and academic rank.

Final project preparation and proposal Once the research entrepreneur has assessed the factors in each stage of the selection process, he narrows his possibilities to the project or projects that will be formally proposed. The nature of this preparation and proposal process was also examined by the survey.

Preparation time Each scientist was asked how much time he devoted to developing and writing his last formal proposal. The response formed four natural categories (Table 4.31). It can be seen that a high percentage of experiment station scientists (61 percent) spent one week or less in preparing their projects for submission. Eighty-seven percent of the scientists spent two weeks or less at project preparation.

This result can be partially explained by the responses of several scientists. Many said that because station proposals often grow out of projects prepared for granting agencies, little time was needed to rewrite a proposal for station funding. In some instances proposals were merely rewrites of projects that needed to be renewed. This may be one reason assistant professors spent more time writing their latest (and probably first) station proposal.

Table 4.31. Project preparation time (in percent)

Strata	3 days or less	5-6 days	2 weeks	1 month or more
Department				
Animal sciences	50.0	0.0	25.0	25.0
Plant sciences	46.4	17.0	28.6	7.1
Social sciences	30.0	30.0	20.0	20.0
Academic rank				
Assistant professor	26.7	13.3	40.0	20.0
Associate professor	58.3	16.7	16.7	8.3
Full professor	47.4	21.0	21.0	10.5
Research time				
Minor time	50.0	16.7	25.0	8.3
Medium time	21.4	14.3	50.0	14.3
Major time	55.0	20.0	10.0	15.0
Total	43.5	17.4	26.1	13.0

Assistance During the time the scientists were developing their latest proposal, a majority stated they sought assistance. Colleagues, statisticians, and literature searchers were the sources most often mentioned. Other sources that aided the scientists were graduate students, DEO copies of old projects, PREPS, the experiment station administration, the associate dean of research (College of Home Economics), extension personnel, granting agency offices, and the USDA.

Informal acceptability The scientists were also asked if they informally checked for acceptability of proposals before writing them. Two-thirds of the scientists said they had checked with their department heads. Therefore, a majority of the scientists indicated a desire to allocate time to writing only the projects they could be fairly certain would be approved. Only one-third contacted the experiment station administrators (Table 4.32).

Social and plant scientists showed a statistically stronger tendency to check out the acceptability of a project with their DEOs than animal scientists (Table 4.32). This is a reflection of department structure and procedure. Further, assistant and associate professors were more likely to contact an experiment station administrator before formally proposing a project (Table 4.32), perhaps reflecting a greater reliance on station funds as well as inexperience with the proposal process.

Table 4.32. Percent of scientists informally checking project acceptability with their DEO and station administrators

Stratum	DEO	Station administrators
Department		
Animal sciences	42.9[a]	21.4
Plant sciences	75.8[a]	36.4
Social sciences	69.2[a]	38.5
Academic rank		
Assistant professor	73.3	53.3[a]
Associate professor	75.0	50.0[a]
Full professor	60.6	18.2[a]
Research time		
Minor time	71.4	21.4
Medium time	70.0	40.0
Major time	61.5	34.6
Total	66.7	33.3

[a]Significant chi-square at 90 percent confidence level.

Comments on formal proposals   Finally, each scientist was asked if they had received any oral or written comments from their DEOs or station administrators once the project had been submitted. Surprisingly, except for notification of approval or rejection, the scientists said they had not receivedany such comments. This method for transmitting research signals is being ignored.

CHAPTER V: SUMMARY AND CONCLUSIONS

The agricultural experiment station faces the formidable task of efficiently and equitably allocating its resources to research. The experiment station administrators, department heads, and research scientists must make these sensitive allocation decisions. This study focuses on the largest group of research decision-makers, the scientists, because they are the originators of research proposals.

We hypothesize that experiment station scientists are entrepreneurs. For, like business entrepreneurs, they must vie for competitive research funds, allocate them efficiently, and be willing to bear the risk of reseach project failure once the investment in an experiment is made. The decisions they make concerning which research investigations to pursue are of vital importance to their productivity and success within the experiment station. Collectively their decisions help determine the productivity of the station. The purpose of this study is to identify the framework of and the influences surrounding these decisions.

To complete the objective of this study a personal interview survey was designed to ascertain and measure the important factors in this decision-making process. Results were obtained from the responses of a sample of 64 Iowa State University Experiment Station scientists. Statistical analysis and descriptive techniques are used to determine and report the factors affecting the decision-making process.

The scientist's research decision-making process is divided into three stages. Each stage represents a successive narrowing of research possibilities until the scientist reduces his choices to a proposal he will formally submit for funding. The manner in which a scientist defines his area of professional specialization and the job description under which he is hired are the two variables in the first stage that initially determine the scope of research possibilities a scientist will consider when making research choices. The results indicate that the scientists are almost evenly divided between medium and narrow degrees of specialization. There is also a positive and statistically significant association between research time and degree of specialization. Whereas medium and minor time scientists are more likely to describe their specialty in broad terms, over half of the sample's major time scientists provided a very specific description of their professional specialization. Most major time scientists seem to have found it advantageous to concentrate their research in a narrow area of study.

The scientist's area of specialization is often an extension of the area under which he was hired. This is particularly true for new scientists. Although job descriptions may not be highly formalized, most DEOs said there is usually a "general understanding" or "implied contract" over job expectations when the scientist is hired.

In stage two the research scientist further assesses his narrowed set of research choices with the messages or signals he receives that indicate to him which research results will have the highest value. This study hypothesized fourteen groups might comprise major demanders of experiment station research. The survey results indicate that the major sources of research value are fellow scientists, demanders most often of intermediate research products. The sources with the greatest overall frequency were departmental colleagues, friends who are non-ISU scientists, professionals through journals or conventions, and the DEOs.

Reseachers, therefore, look to scientists with similar research interests and academic backgrounds for information on research value. Least frequent influences are the mass media, contract offers from government and private industry, and the general public through legislators.

To further assess the demand information scientists were asked to assign a relative amount of influence to each source. The results indicate that no demand source exerts a major influence on research selection. However, more influencial sources are professionals through journals or conventions followed by departmental colleagues, non-ISU friends, and granting agencies. Contrary to the opinion that experiment station research is very responsive to special interest groups the results indicate instead that the scientists are more interested in what their fellow professionals perceive to be valuable research. Perhaps the research entrepreneurs are implying that in order to succeed in the academic work environment, they must first meet the research demands and expectations of their peers.

Once the entrepreneur assimilates the demand information pertinent to his program he must determine which outputs could be feasibly produced with the available resources at his disposal. The scientists indicate that their own human capital, embodied in their personal interests and research skills, are the resources they weigh most heavily in their research decisions. Availability of facilities is also a major consideration. The respondents are fairly evenly divided between the importance of experiment station funds. To some scientists projects could not be conducted without these funds whereas others consider the amount of station funds received to be "insignificant." Common adjectives applied to station funds are "constant," "steady," and "certain."

Entering the third stage the scientist has determined what research demands and resource constraints he faces and has probably substantially narrowed the number of projects he is considering for formal proposal. We hypothesize that there is one final group of considerations the scientist evaluates which we call research characteristics that are closely tied to the utility or personal satisfaction the scientist will gain by conducting a particular research investigation. A project's intellectually intriguing or problem-solving aspects are assigned the highest overall importance. Social significance and publishability are also major considerations.

Once the research entrepreneur has assessed the factors in each stage of the selection process, he narrows his possibilities to the project or projects that will be formally proposed. The nature of this preparation and proposal process was also examined. A high percentage of scientists spend one week or less in preparing their project proposals for submission. A majority of the scientists indicates they had checked with their department heads and one-third with the station administrators before formalizing a proposal. Finally, each scientist was asked if they had received any oral or written comments from their DEOs or station administrators once the project had been submitted. Surprisingly, except for notification of approval or rejection, the scientists said they did not receive any such comments. This method for transmitting signals is being ignored.

Although each scientist surveyed expressed an individual approach to making research project decisions, the low number of statistically significant associations that resulted from their responses implies that they basically approach their allocative tasks in much the same way. Particularly the research characteristics and resource constraints identified in the survey tend to have the same importance in the research decision-making process of the scientists surveyed.

When asked what groups were sending messages of research value a stronger divergence among the strata surfaced. Contrary to critics' claims, the results show that special interest groups desires are a small part of the sizeable number of research messages received by

This study has described a possible sequence of factors involved in a scientist's research decision-making process. As with any hypothesized model, no one scientist will adhere rigidly to the sequence outlined. The factors involved in the scientists' allocation decisions remain essentially the same. Administrators as well as scientists can use the results of this study to evaluate and better coordinate the station's important allocation decisions.

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ACKNOWLEDGEMENTS

I would like to thank the Iowa State Experiment Station administrators and scientists for their willingness to participate in this study. The candor and interest expressed during each interview was greatly appreciated.

I wish to thank Dr. Arnold Paulsen for his guidance and participation in developing this thesis and Dr. Ronald Powers and Dr. Marvin Julius for serving with him on my graduate committee.

Thanks is also extended to Marilyn Mortvedt and Shelley Murrell for typing preliminary drafts and the final copy of this thesis.

Appreciation is especially directed to my parents who made my college experience the best possible. I would also like to give a special thank you to my husband who gave me his support, patience, and help in completing this study.

APPENDIX A: SURVEY OF INDIVIDUAL SCIENTISTS' RESEARCH PROPOSAL DECISIONS

Information to be completed from official records before the interview:

Scientist's Name: ______________________________

Department: ______________________________

Rank: ______________________________

Portion of time budgeted in the Agricultural Experiment

Station in 1978-79 ______________

Total dollar expenditure on scientist's research program from

10/77 - 9/78 ______________

New projects approved through the experiment station since July 1, 1975 (or the date of the last project approved if none approved since 1975):

Project No.	Starting Date	Title

Survey Questions

1) a) What do you consider your principal area(s) of professional specialization?

b) In which areas are you actively pursuing research this year?

c) What proportion of your total professional effort do you estimate you spend at research?

2) Since July 1, 1975 have you submitted any other formal written proposals to the experiment station, department, or other funding source? If so, please list.

Title	Source	$/year

3) Looking at the above research program approved or proposed, are there other topics or investigations that you would strongly prefer to be working on now but have never proposed? _____ Yes _____ No

If yes, would you list the topics and give for each a) the reason you would like to do it; and b) the reason you have not requested resources to research it.

Topic	Reason for preferring	Reason for not proposing

4) What in general are the major resources or requirements you consider when deciding which research possibilities to propose?

	Very Important	Important	Not too Important	Not at all Important
a) Interests and abilities of graduate students				
b) Interests and abilities of technicians				
c) Project matches my skills and experience				
d) Project matches my interests				
e) Physical facilities (plots, laboratories, data, methods, etc.) were available				
f) Time required for project completion matched time available				
g) Funds available from experiment station				
h) Funds available from an outside agency				
i) Other (please specify)				

5) Which characteristics of research and research results do you find most attractive or important in project selection?

	Very Important	Important	Not too Important	Not at all Important
a) High probability of success. You were likely to get the information or product sought				
b) The subject is intellectually intriguing to me				
c) The results were publishable in a professional journal or other respected form				
d) Socially significant problem				
e) The results could be obtained through the application of preferred research methods or statistical techniques				
f) Could team-up with another scientist with whom I like to work.				
g) Can work alone				
h) Other (please specify)				

6) a) From time to time agricultural scientists are encouraged or discouraged to undertake specific kinds of agricultural research. Can you recall receiving such messages?

Yes_____ No______

b) If yes, which of the following sources have urged you to pursue or not to pursue certain kinds of projects? Check each.

Urged Not to	Urged to	
______	______	a) Department colleagues
______	______	b) Other ISU professors (outside your department)
______	______	c) Scientists and researchers outside ISU who are my friends
______	______	d) Other fellow professionals through the journal or conventions
______	______	e) Your department head or chairman
______	______	f) ISU Experiment Station administrators
______	______	g) Adopters or users of your research results (through questions after speaking engagements, phone calls, visits, correspondence, etc.)
______	______	h) The general public, state or federal officials, or legislators
______	______	i) Area mass media such as newspapers, farm magazines, etc.
______	______	j) Extension, field staff (program requests or suggestions)
______	______	k) Regional research committees, interstate task forces, etc.
______	______	l) Granting agencies' announcements, requests for proposals
______	______	m) Contract offers from government agencies (federal, state)
______	______	n) Contract offers from private industry
______	______	o) Other (please specify) __________________________

7) What is the approximate distribution of influence each source has had on the selection of research you have developed and formally proposed in the past 3 years (or when last project was proposed)? Please assign a relative weight to each of the sources, whether you have received any messages or not, such that the total equals 100.

_____ a) Department colleagues

_____ b) Other ISU professors (outside your department)

_____ c) Scientists and researchers outside ISU who are my friends

_____ d) Other fellow professionals through the journal or conventions

_____ e) Your department head or chairman

_____ f) ISU Experiment Station administrators

_____ g) Adopters or users of your research results (through questions after speaking engagements, phone calls, visits, correspondence, etc.)

_____ h) The general public, state or federal officials, or legislators

_____ i) Area mass media such as newspapers, farm magazines, etc.

_____ j) Extension, field staff (program requests or suggestions)

_____ k) Regional research committees, interstate task forces, etc.

_____ l) Granting agencies' announcements, requests for proposals

_____ m) Contract offers from government agencies (federal, state)

_____ n) Contract offers from private industry

_____ o) Other (please specify) ____________________________________

____

8) How many days did you devote to developing and writing the latest formal project proposals?

Latest proposal

Next to last proposal

9) During the time you were developing and writing the latest formal proposal did you seek assistance? Yes_____ No______

If yes:

1. What was the source and what kind of assistance was received?

	Source	Assistance
Latest proposal		
Next to last proposal		

10) Did you informally check out the administrative acceptability of your latest project proposals before you wrote them up? Yes or no

Latest proposal	_____	Department Chairman	_____	Station administration
Next to last proposal	_____	Department Chairman	_____	Station administration

11) What comments did your department head or chairman make, either written or oral comments, on your latest formal proposals after they were submitted?

Latest proposal

Next to last proposal

12) What comments did the experiment station administration make, either written or oral comments, on your latest formal proposals?

Latest proposal

Next to last proposal

APPENDIX B: DATA AND STATISTICAL TESTS FOR SIGNIFICANT FACTORS IN CHAPTER IV

Table B.1. Chi-square tests for associations between number of scientists receiving demand signals and strata [a]

Source	Department	Academic Rank	Research Time
Departmental colleagues	0.97	2.32	1.40
Interdepartmental colleagues	1.38	2.17	0.76
Friends who are non-ISU scientists	0.10	1.10	5.43[b]
Professionals through journals or conventions	0.17	1.90	1.06
DEO	7.73[b]	4.00	1.04
ISU Experiment Station administration	0.46	0.12	1.26
Adopters of research results	1.23	1.01	0.84
General public, legislators	4.61[b]	5.25[b]	1.53
Mass media	5.30[b]	2.32	1.12
Extension	0.00	0.35	0.02
Regional research committees	0.09	1.58	4.25
Granting agencies	1.04	1.90	1.59
Government contracts offers	0.73	0.80	1.44
Private industry contract offers	3.47	1.99	5.53[b]

[a]Chi-square values have two degrees of freedom.

[b]Significant chi-square at 90 percent confidence level.

Table B.2. Average influence of each demand source

Source	Sample Size	Mean	Standard Deviation	t value[a]
Departmental colleagues	63	14.6	19.8	5.87
Interdepartmental colleagues	63	6.1	9.4	5.14
Friends who are non-ISU scientists	63	8.9	12.2	5.84
Professionals through journals and conventions	63	15.6	21.5	5.75
DEO	63	7.4	10.3	5.75
ISU experiment station administration	63	5.3	10.3	4.11
Adopters of research results	63	6.3	10.1	4.99
General public, legislators	63	2.0	4.1	3.75
Mass media	63	1.1	4.0	2.21
Extension	63	5.3	8.5	5.01
Regional research committees	63	5.9	8.7	5.36
Granting agencies	63	8.2	17.5	3.74
Government contract offers	63	4.3	10.4	3.30
Private industry contract offers	63	2.6	6.4	3.18

[a]t values are all significantly different than zero at 95 percent confidence level.

Table B.3. Student's t tests for significant mean differences between departments: influence of each source on research selection[a]

Source	Between Animal and Plant Science	Between Animal and Social Sciences	Between Plant and Social Sciences
Departmental colleagues	0.82 (48)	0.79 (21.2)	0.01 (40)
Interdepartmental colleagues	0.01 (48)	-0.70 (15.4)	-1.78 (13)[b]
Friends who are non-ISU scientists	-0.53 (48)	0.58 (27)	0.99 (45)
Professionals through journals and conventions	0.55 (48)	2.12 (21)[b]	1.82 (45)[b]
DEO	-1.77 (48)[b]	-3.15 (14.8)[b]	-2.24 (45)[b]
ISU Experiment Station administration	-0.91 (48)	-1.02 (17.8)	-0.51 (45)
Adopters of research results	0.47 (48)	0.51 (27)	0.17 (45)
General public, legislators	0.55 (18)	0.42 (22.1)	-0.17 (45)
Mass media	0.32 (18.5)	-1.28 (14)	-1.43 (12.2)
Extension	-0.55 (48)	-1.40 (15.7)	-1.12 (15)
Regional research committees	-0.72 (48)	-0.63 (27)	-0.01 (45)
Granting agencies	0.84 (19.6)	1.40 (17)	0.51 (40.8)
Government contract offers	0.40 (48)	0.67 (19.8)	0.51 (40.8)
Private industry contract offers	-2.27 (38.6)[b]	0.59 (27)	2.53 (37.5)[b]

[a]Degrees of freedom appear in parentheses.

[b]Significant t value at the 90 percent confidence level.

Table B.4. Student's t tests for significant mean differences between academic ranks: influence of each source on research selection[a]

Source	Between assistant and associate professors	Between assistant and full professors	Between associate and full professors
Departmental colleagues	2.22 (14.4)[b]	-2.30 (43.9)[b]	0.03 (45)
Interdepartmental colleagues	0.40 (26)	-0.79 (45.3)	-0.45 (41.8)
Friends who are non-ISU scientists	-0.48 (26)	-0.97 (42.5)	-1.13 (45)
Professionals through journals and conventions	-0.94 (26)	0.32 (49	-0.83 (45)
DEO	-0.08 (16.8)	1.00 (49)	0.54 (14.4)
ISU Experiment Station administration	0.79 (16.9)	-0.05 (49)	0.80 (14.5)
Adopters of research results	0.71 (16.6)	-3.46 (42.3)[b]	-2.51 (42.4)[b]
General public, legislators	0.91 (14)	1.36 (49)	1.47 (11.9)
Mass media	-0.25 (23)	0.74 (17.8)	0.79 (45)
Extension	-0.37 (25)	0.25 (49)	-0.16 (45)
Regional research committees	-0.53 (26)	-0.60 (44.2)	-1.12 (36)
Granting agencies	-0.67 (26)	0.23 (49)	-0.50 (31.2)
Government contract offers	-0.32 (26)	1.42 (49)	0.57 (13.6)
Private industry contract offers	0.30 (26)	-1.06 (47.7)	-0.80 (44.2)

[a]Degrees of freedom appear in parentheses.

[b]Significant t value at the 90 percent confidence level.

Table B.5. Student's t tests for significant mean differences between research time divisions: influences of each source on research selection[a]

Source	Between Minor and Medium Time	Between Minor and Major Time	Between Medium and Major Time
Departmental colleagues	-1.75 (15.2)[b]	-1.62 (14.7)	0.39 (47)
Interdepartmental colleagues	2.19 (24.5)[b]	1.12 (41)	-1.66 (23.1)
Friends who are non-ISU scientists	1.32 (32)	1.07 (41)	-0.35 (47)
Professionals through journals and conventions	1.87 (26.4)[b]	3.02 (34.6)[b]	1.28 (46.8)
DEO	-1.94 (17.5)[b]	-1.93 (18.8)[b]	-0.04 (47)
ISU Experiment Station administration	-0.61 (32)	-0.96 (14.7)	-0.32 (23.7)
Adopters of research results	2.49 (23.8)[b]	1.02 (41)	-2.08 (22)[b]
General public, legislators	-0.82 (15.8)	-0.44 (15.4)	0.88 (47)
Mass media	0.32 (28.9)	0.39 (41)	-0.06 (27.9)
Extension	-0.93 (19.1)	-1.26 (15.4)	-0.53 (47)
Regional research committees	1.16 (30.3)	1.67 (41)	0.29 (47)
Granting agencies	0.61 (31.3)	2.03 (36.8)[b]	1.49 (44)
Government contract offers	-0.95 (20.6)	-1.29 (13.9)	-0.40 (23.5)
Private industry contract offers	1.04 (23.6)	1.86 (41)[b]	0.05 (28.9)

[a]Degrees of freedom appear in parentheses.

[b]Significant t value at the 90 percent confidence level.

Table B.6. Chi-square tests for associations between importance of resource constraints and strata[a]

Resource	Department	Academic Rank	Research Time
Graduate students	3.88	20.86[b]	2.22
Technicians	12.97[b]	7.16	6.70
Personal interest	2.09	1.22	3.60
Facilities	23.90[b]	4.78	4.64
Personal skills, abilities	7.17	2.31	6.01
Completion time	7.43	9.05	8.33
Experiment station funds	7.68	7.10	12.39[b]
Funds from outside sources	4.32	4.55	5.08

[a]Chi-square values have six degrees of freedom.

[b]Significant chi-square at 90 percent confidence level.

Table B.7. Chi-square tests for associations between research characteristics and strata[a]

Characteristics	Department	Academic Rank	Research Time
High probability of success	2.17	6.35	4.85
Intellectually intriguing	0.31	2.58	2.72
Publishability	3.40	2.53	2.47
Social significance	3.38	14.12[b]	8.72
Familiar method or technique can be used	1.58	7.70	1.61
Can work in a team	2.38	8.46	5.46
Can work alone	6.26	4.17	4.17

[a]Chi-square values have six degrees of freedom.

[b]Significant chi-square at 90 percent confidence level.

Table B.8. Chi-square tests for associations by strata

	Department	Academic Rank	Research Time
Project preparation time[a]	5.07	4.50	7.79
Informal check for project acceptability with DEO[c]	4.84[b]	1.22	0.55
Informal check for project acceptability with station administrators[c]	1.18	7.61[b]	1.31
Professional specialization[c]	1.25	0.22	4.50[b]

[a]Chi-square values have six degrees of freedom.

[b]Significant chi-square at 90 percent confidence level.

[c]Chi-square values have two degrees of freedom.