THE EFFECTS OF INSTITUTIONS ON INNOVATION:

THE CASE OF

CENTER-PIVOT IRRIGATION

Submitted by Stewart Landers
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ABSTRACT

The Effects of Institutions on Innovation: The Case of Center-Pivot Irrigation

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Submitted to the Department of Uprban Studies and Planning on September 3, 1978, in partial fulfillment of the requirements for the degree of Bachelor of Science in Urban Studies and Planning and Master in City Planning

This thesis describes the influence of institutions of the diffusion of a major innovation - center-pivot irrigation. Center-pivot irrigation is major due to its significant effects on production, the nature of the agriculture economy, and the environment. Initial support of the innovation comes from those that supported production - industry, farmer groups, etc. As center-pivot irrigation contributed to the increased capital intensive nature of agriculture, bankers and credit and loan institutions came to add to this support. Institutions concerned with environmental issues did not oppose center-pivot but establised an agenda of issues including groundwater control and scheduling the usage of energy. These issues have been considered independently of the relative merits of center-pivot.

The events and processes leading to these activities are analyzed from two viewpoints. In the first, innovation is considered to be the focus development. Attributes of innovation are defined and the particular changes and perceived changes surrounding center-pivot are described. In the second, the activities of organizations (representing institutions) are hypothesized and described. The activities of organizations are a function of their response to the innovation based on their perception of the innovation and the change in resources likely to follow from widespread utilization of center-pivot irrigation.

Thesis Supervisor

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INTRODUCTION:

As we enter an age in which technology is no longer seen as certain salvation, the processes that determine which technological developments are accepted or rejected should be closely scrutinized. Currently, the battleground of nuclear energy is exposing the complex relationships among regulatory agencies, environmental protection, the economics of utility companies, politics, and innovation diffusion. In this thesis, the development of a technology referred to as center-pivot irrigation (c-p) will be examined. The rapid proliferation of these devises in Nebraska has led to greatly increased production and questions about groundwater resources and land ownership.

I first went to Nebraska to record the reactions of institutions (public and quai-public agencies, interest groups, service industries) to a test of photovoltaic energy. The test, the largest use of solar-electric cells to date, was funded by the Department of Energy and prepared jointly by MIT's Lincoln Laboratory and the University of Nebraska at Lincoln (UN-L) and was situated at UN-L's Agricultural Experiment Station at Mead, Nebraska. The Department of Energy is concerned with the institutional, economic, marketing and technological issues affecting the acceptance of photovoltaics.

As a member of the research group studying institutions, I took a wide-angle view of a large, loosely structured group of individuals and organizations which we called the Nebraska AgCom (after agricultural community).* It was from these community representatives that I learned about c-p.

In comparing the community's reaction to an already accepted innovation, c-p, to the anticipated reaction to photovoltaics, we hoped to learn much about the nature of Nebraska's institutional network. Specifically, how much did the various sectors (government, education, finance, etc.) communicate? In what ways were they interdependent? What resources did each institution control? What support of grounding did they have in the broader Nebraska community? Much useful information was discovered about the potential barriers and supports facing solar electric technologies.

The institutional actions concerning the diffusion of c-p raised many other interesting questions: Why did the organizations of Nebraska lend overwhelming support to an innovation that is extraordinarily water and energy intensive? Even the groups involved in rectifying the problems contributed to by c-p have in no way voiced any opposition to the device. Why was such support for c-p forthcoming? Ideally, each organization would independently examine the innovation and react in a way consistent with its goals, functions, and

* For a complete description of how the institutions of the Nebraska AgCom were determined and organized see T.E. Nutt-Powell et.al. "Photovoltaics and the Nebraska Agriculture Community," MIT Energy Laboratory, 1978.

role within the community. However, each organization is not and cannot be independent. The ties among organizations are much less structured than, for example, the relationships between departments within a single agency or corporation. In this sense the study of institutions is similar to the study of interorganizational activity. Interorganizational relations may depend on resource dependence, tradition, commonality of purpose, interpersonal relationships, or circumstance. A number of curious interactions among institutions have contributed greatly to the development of center-pivot irrigation.

This thesis is divided into three parts, First is a chronological description of the development and diffusion of c-p. The innovation was dormant for its first fifteen years. A short (four year) period followed during which several institutional actors became involved with c-p. After that came its present era of rapid expansion. The second chapter contains the framework for the ensuing analysis. Innovation and institutions are defined and their dimensions critical to this study are described. The third section, the Analysis, looks at the innovation and how it was affected by institutional perception and action. The critical institutions involved in the diffusion of c-p may be understood by their function and role, both of which can be generalized for any institutional arena.

CHAPTER ONE
THE CASE OF CENTER-PIVOT IRRIGATION:

The groundwater level in Nebraska is dropping at an increasing rate. From fall, 1975 to fall, 1976, water levels declined in ninety-one of the state's ninety-three counties. In fifty-six of these counties the decline in water level was greater during that period than in the preceding year. Six areas in the state have experienced significantdeclines, some in excess of fifty feet, since the 1950's. In each of these areas the decline is attributed predominantly to the development of deep well irrigation methods.[1] The technology that now dominates the use of deep wells for irrigation is the center-pivot (c-p) sprinkler system.

In a part of the United States characterized by small government, extreme controls have been enacted to prevent the rapid exhaustion of groundwater reserves. In 1972, a system of Natural Resource Districts was established to monitor environmental problmes. In 1975, the Groundwater Control Act gave the locally elected directors of the Resource Districts the power to control groundwater use. Measures of contro may be as drastic as the total prohibition of the drilling of deep wells.

C-p was described to us by a man who has "dreamed about irrigation since he was a boy" as "the most significant advance in irrigation in four thousand years!" Irrigation had always been a highly labor intensive process. In gravity flow irrigation (the most extensive irrigation system previous to sprinkler system designs), a great deal of labor was required to move the pipes that carried the water to the troughs and to open and close the valves that controlled the amount of water flow. With c-p, only one-eighth to one-tenth of the labor used for gravity-flow irrigation is needed. Capital, energy, and water usage, on the other hand, are all increased. In the 1960's, energy and water costs were far below their current value and the availability of capital was high. An economic analysis of c-p diffusion would reveal how these factors influenced its development. This thesis studies institutional action in light of such conditions and how these actions supported the diffusion of c-p irrigation.

1.1 The Early Development of Center-Pivot Irrigation, 1949-1966

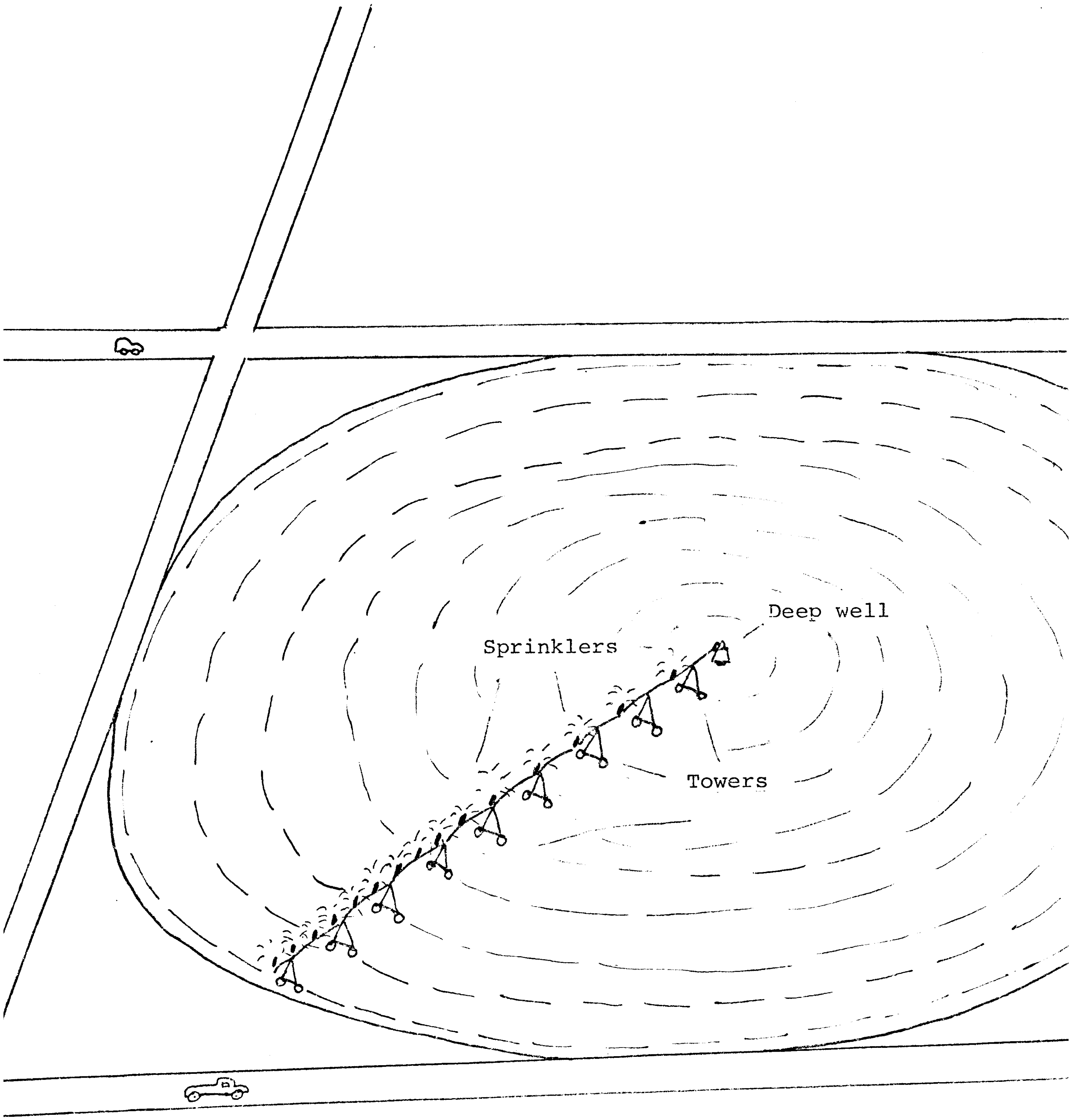
Center-pivot irrigation was conceived of by Frank Zybach in 1949. He had his first working model and his patent in 1952. In that first year, he and his partner, A.E. Trowbridge, manufactured nineteen units, some of which were operated by Trowbridge's nephew, Bill Curry, on his land in Columbus, Nebraska. This attracted the attention of the Nebraska Farmer, and it was an article in that publication that first brought c-p to the attention of the Nebraska agriculture community.

C-p is a systen of sprinkler systems mounted on a long pipe (see Diagram 1) The pipe is supported by mobile towers and is attached on one end to a deep well. The pipe and sprinklers move around the well like a hand of a clock and water is pumped from the well through the sprinklers to irrigate the field.

The majority of pivots in operation are a quarter-mile long. Thus, they irrigate a circular field that occupies 133 acres of the 160 acres in a quarter section (a square quarter mile). A pivot can circle that size field in as little as twelve hours, but usually does it once in three or four days. The average depth of a c-p well is 180 feet and an average of 900 gallons of water is pumped per hour. Most c-p's are powered by diesel engines while others are driven by natural gas powered engines and still others by electric motors. In an average circuit a c-p deposits one inch of water into a field. Over the course of a summer, a c-p uses enough water to supply a town of one thousand people of one year.

Due to its design, center-pivot allows much land to be irrigate that previously could only be irrigated with great

Diagram 1   Center-pivot Systems



difficulty or not at all. Gated pipe systems required extensive leveling of land to allow gravity to move the water. C-p towers, however, can climb inclines of up to thiry degrees, though it is recommended not to be used on inclines greater than ten degrees due to erosion problems. Thus hilly land can be irrigated by c-p with little preparation. Very sandy soil could not be irrigated at all by gravity flow methods because the water, as applied through troughs, would pass through such soil too quickly. By allowing precise water application, c-p systems put down only enough water at a time as sandy soil can hold and plants can use.

C-p, among its other advantages, guarantees a crop. Irrigation systems that depend on water diversion from streams or rivers do not guarantee guarantee a crop in years with very low precipitation. As long as groundwater is available, c-p will assure a crop.

C-p is an energy intensive innovation. In applying twenty-two inches of water over a season, a c-p consumes ten times the fuel needed to till plant, cultivate and harvest a crop such as corn. Currently, forty-three percent of the energy used by the Nebraska agriculture industry is used to pump water for irrigation purposes.[2]

However, water and energy were not the concerns of the Valley Manufacturing Company (Valmont Industries after 1966), which bought Zybach's patent in 1953. While further improving and refining the technology, the marketing concerns of the company centered on the public's perception of the device. The barriers to acceptance were seen as three-fold:

1. The seemingly poor logic of trying to put a circle inside a square field.

2. The inefficiency of having corners left over (and then "what to do with them").

3. The reluctance on the part of the technical community to endorse c-p. It was feared that water application would exceed soil capacity.[3]

Valmont thus became involved in seeking proof that c-p would work. By supplying universities with c-p systems at no or very low cost, it encouraged research. Arangements of this kind were made with the Universityies of Kansas, Texas, Minnesota, Maryland, and Ohio State University. The particular rout by which c-p came to be studies at the University of Nebraska at Lincoln (UN-L) was a combination of chance, Valmont's efforts, and the University's own process of choosing research projects.

In October, 1966, the Institute of Agriculture and Natural Resources (The IANR is the agriculture school within UN-L.) was planning an irrigated pasture system at the North Platte Experiment Station. The system was to use a tow-line irrigation process. At the same time, Alfred Ward was completing a purchase of several center-pivot systems with Al Wahl, then general sales manager of Valmont Industries. Mr. Ward suggested they stop at the North Platte Station, as he had heard about research work being done there in which he was interested. Once there, Mr Wahl found out about the planned irrigated pasture system and suggested the Station "go modern" and use c-p instead of tow-line irrigation. One of the concerns, however, of the Station was budget. Mr. Wahl offered the Station use of a center-pivot system as a research grant. Thus the system could be obtained at no cost.

The other concern of the Experiment Station was whether they should use c-p at all. Tradititonally, research priorities are decided by the superintendent of the Agricultural Experiment Station on the recommendation of the faculty within a specialty. Their decision, in turn, is based on "felt need." That is, are farmers interested in knowing what they are studying? Apparently, by that time, enough c-p's were in use to have generated some interest.

Thus Valmont's offer was accepted and the study got under way in fall, 1967. Although this may have been the first time c-p was ever studied, it was somewhat incidental to the main concern of the research being conducted (comparing the effects on cows of irrigated pasture versus dry-lot feeding). The study did, however, prove that c-p worked, and accounts were kept of water and fertilizer application. The support of center-pivot by the University system began at this point and continued throughout the next two periods of c-p diffusion.[4] This support, as will be shown, was critical to the acceptance of c-p in the Nebraska AgCom.

1.2 Before the Boom, 1967 - 1970

From 1967 to 1970, the number of pivots grew steadily, but in small numbers across the state. Figures are available about the number of c-p's in a nine-county region in southwestern Nebraska from 1965 through 1970.[5] The following are the cumulative annual totals for this region.

TABLE 1.1

Year	1965	1966	1967	1968	1969	1970
Total No. of C-p Systems	14	29	71	161	296	349

While this growth was occurring, the University was beginning to publish research results on c-p.[6] The increased production resulting from c-p was confirmed. Research was also done comparing the economics and energy consumption of various irrigation systems and on the proper application of water, herbicides, and fertilizer. These research results were disseminated to the general population through the Agriculture Extension Service of UN-L.

Meanwhile, the Nebraska Rural Electric Association, representing thirty-two of the thirty-six rural electric districts, engaged in activities that encouraged the acceptance of c-p. These activities began in 1965 and became exceedingly high-powered in 1970- 71. In 1965, peak electric loads in Nebraska were in the winter. Increased electric use for non-peak times was encouraged and a variety of electric appliances were supported including c-p. At non-peak load times, rural electric districts had to pay a minimum of sixty-five percent of peak load to whomever they purchased their electricity from (such as the Nebraska Public Power District). Thus it seemed efficient to level peak load amounts as much as possible.

The spread of center-pivot irrigation was also seen as fostering rural development by making it profitable for more farmers to keep operating. In this way the rural population would remain the same or hopefully increase. To support c-p, the association conducted tours of c-p units for bankers, farmers, and newspaper editors. Ads were placed on radio and in the REA magazine and speakers were sent to 4-H groups and chambers of commerce. However, according to our informant, the most effective tactic was showing the cost-benefit relationship of c-p to bankers.[7]

The connection to the finance community was a most critical one. The support of lending institutions was crucial to c-p acceptance. Few, if any, c-p's were financed before 1967. However, it is estimated that currently ninety-five percent of all c-p's are financed in some manner.[8]

The Production Credit Association waited to lend to the "practical" innovators - those who had learned from the mistakes of the early innovators who might have lost their shirts. The Farmer s Home Administration held off until 1967, after which they would lend to farmers who had satisfactory soil and water conditions. Private banks and insurance companies waited until the devices were in the field for ten to fifteen years. Dealers, associated with Valmont Industries, would invite local bankers to Valmont where they could learn about c-p and the company.[9]

In 1969, the exclusive patent on c-p held by Valmont expired and many firms began manufacturing c-p systems. As many as forty entities were producing c-p systems in the early seventies and there are currently approximately ten c-p manufacturers operating in Nebraska employing at least 2500 persons and according to some estimates as many as 6000 persons.[10] The effects of the expiration of the patent on the expansion of the industry nad the diffusion of c-p is another aspect of c-p on which an economic analysis would be useful. Clearly, the expansion of the industry was supported by the research and dissemination activities of the University and the backing of c-p by the finance community.

1.3 Center-Pivot's Boom Period, 1971 - Present

The growth rate for c-p's has been increadibly high in the 1970's. Diffusion of c-p has been particularly extensive in the sandhills of the north-central (Holt County) and south-western (Dundee County) parts of the state. TABLE 1.2 shows the growth of c-p in Nebraska from 1972 to 1976.

TABLE 1.2

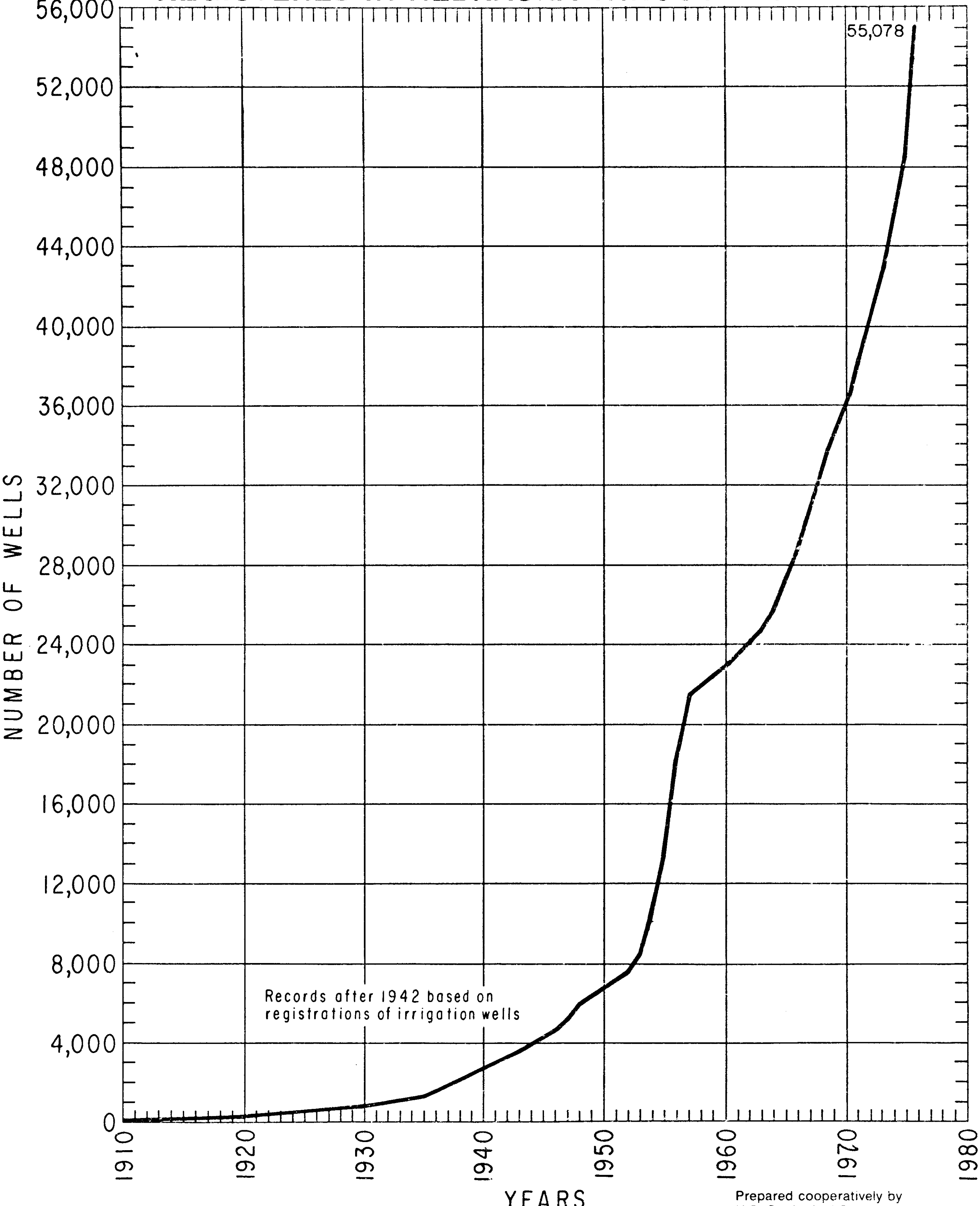
Center-pivot systems in Nebraska:

	Yearly Additions				
Up to 1972	1973	1974	1975	1976	Total
2,665	1,119	2,232	2,501	3,164	11,681

The number of irrigation wells being dug is increasing at an equally rapid rate (see TABLE 1.3). Yearly additions of pivots and deep wells increased at a rate ranging from 115

Table 1.3

CUMULATIVE TOTALS OF IRRIGATION WELLS REGISTERED IN NEBRASKA THROUGH 1976



Prepared cooperatively by
U.S. Geological Survey and
Conservation and Survey Div., IANR,
The University of Nebraska-Lincoln

percent to 180 percent over the previous year. Since 1965, approximately 98 percent of all new irrigation utilizes groundwater (as opposed to surface water). C-p systems are currently irrigating 1.5 million acres of land in Nebraska and represent half of all newly irrigated land since 1969, and seventy-five to eighty percent of newly irrigated land in 1974 and 1975. Center-pivot systems are now found in as diverse locations as Colorado, Minnesota, Texas, Florida, the Pacific Northwest, Libya, Australia, Hungary, France and the Middle East among others.[11]

With widespread use of c-p irrigation, the secondary attributes of c-p (secondary attributes are defined in Chapter 2) contributed to problems involving groundwater control, energy use, and land management.

In the area of groundwater control, a number of domestic wells have gone dry due to the use of c-p in the same aquifier. Most of these have been settled out of court, but in two cases that did reach judicial decisions, the landowners of the deep wells were held liable and ordered to compensate those whose wells ran dry.

These cases have spurred a series of questions regarding underground water rights. The first question being, who owns the groundwater? A report on water rights is currently being prepared at the initiation of State Senator Maurice A. Kremer, who chairs the Public Works Committee, and Dave

Aiken, a UN-L attorney concerned with water issues. This report is expected to be the basis for legislation on groundwater ownership. However, underlying ownership questions are the concerns with groundwater depletion which have already been addressed by the State Legislature. As the Nebraska AgCom becomes increasingly reliant on deep well irrigation, the preservation of groundwater reserves is critical.

In 1972, the Nebraska Unicameral (the State Legislature) set up a system of twenty-four Natural Resource Districts (NRD's), to sponsor data collection, economic efficiency studies, and educational functions. Thus, groundwater depletion would be monitored and set in the context of economic development. In 1975, the Groundwater Control Act was passed which allowed the NRD's to establish groundwater control districts. In these districts, controls of many kinds can be implemented, including a complete ban on the drilling of deep wells.

The Conservation and Survey Division (CSD) of UN-L, thought of by its director as a quasi-state agency, undertook a five-year study, modeling the water system in a western Nebraska district. This work, and others done by the CSD,has contributed to the declaration of two groundwater control districts, the Upper Republican and the Upper Big Blue Natural Resource Districts. The Upper Republican, the first control district, was declared on August 1, 1977 and the Upper Big Blue on December 9, 1977. Controls implemented in the Upper Republican control district include the allocation of groundwater among users (to be measured by meters which must be installed by 1980) and a minimum spacing requirement between wells.

In the area of energy use, shifts in electricity demand and the perception of energy resources have altered the market for c-p's. C-p's growth has coincided with shifts in patterns of electrical energy use. Widespread use of air conditioning changed peak electrical loads from winter to summer. The oil embargo in 1972 switched energy producers from an expansion to conservation mentality. The REA no longer campaigned for electricity demanding devices but for mechanisms such as time clocks and radio signals to control when a c-p operates. C-p's would be shut down when peak loads are about to be exceeded. Customers would receive a discount on their electricity in exchange for the inconvenience. Even with such a scheduling plan, a waiting list for c-p has been established. Land ownership and usage has been altered by center-pivot.

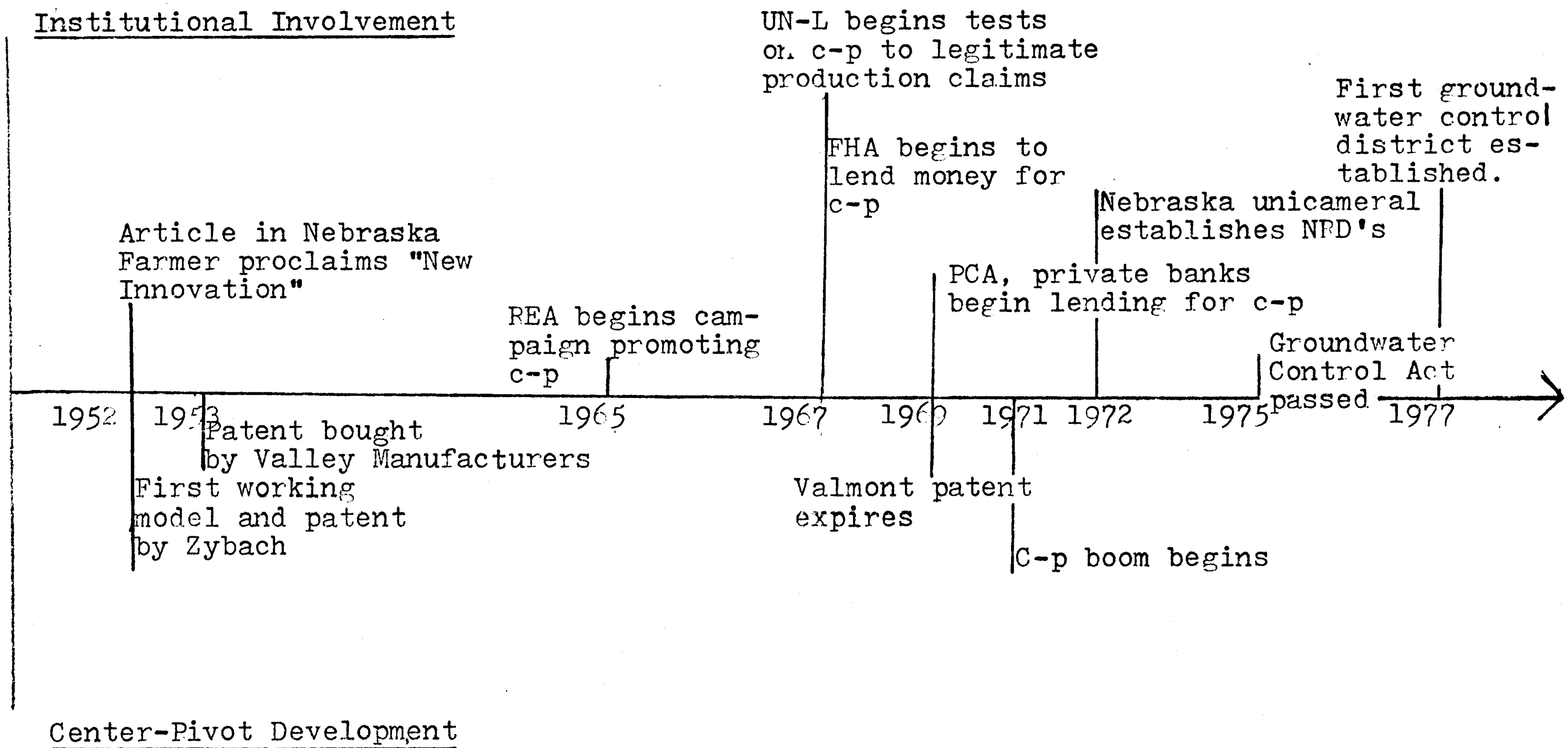
The rise of c-p has been accompanied by an increase in investor owned (as opposed to operator owned) farms. A study conducted by the Center for Rural Affairs, a private research center concerned with the status of the family farm, reported that investor ownership of pivots increased from 17 percent to 33 percent in Dundy County in 1975 alone. By making agriculture capital intensive, c-p enables speculators to profit. Lawyers from a farm investment corporation, learned from UN-L that ground water supplies in Dundy County would last at least fifteen years. Since this is about the same length of time as c-p depreciation, it was considered a good investment.[12]

General concern has been voiced (by the CRA among others) about the use of marginal land with c-p. Marginal land is land considered unsuitable for crops (definitions and grades of land are provided by the USDA). Most of the concern centers on land unsuitable for irrigation due to susceptibility to wind erosion. Such land may be productive and financially successful over a ten-fifteen-year period. Severe damage to the land from cultivation may make it completely unsuitable for use (by turning it into a dust bowl for example).

In summary, the early development of c-p was similar to that of most innovation -- the primary concern was with production of the device, patents, and there was limited publicity. Institutional involvement came first in the form of support for the aspects of c-p that were productive and a boost to the economy. Later, institutional action was concerned with controlling the negative aspects of the device that became magnified upon large-scale diffusion. (See Table 1.4 for a chronological summary.)

TABLE 1.4

CENTER-PIVOT TIME LINE



CHAPTER TWO
ANALYTIC FRAMEWORK:

This chapter describes the analytic framework used to study center-pivot irrigation as an innovation and the influence of institutions on its acceptance. This framework has three parts. First, innovation is defined and described. The concept of innovation differentiation is introduced as a critical part of innovation diffusion. Recent studies are described that indicate a growing awareness of the impact of institutional action on innovation diffusion. Second, institutions are defined and described. The dimensions of institutions -- function, activity, and role -- are useful to understand and interpret the part institutions play in innovation acceptance. Finally, the details of this particular research design are elaborated.

2.1 Innovation Differentiation

In discussing innovation, H.G. Barnett distinguishes between "configurations" and "innovations." A configuration is the linkage or fusion of two or more elements not previously combined in this way. An innovation is this fusion on a mental plane, that is, the linkage between ideas. An idea may be an "idea of a thing with substance" or an "idea of some intangible." An innovation always has antecedents; it is always a new combination of previously existing ideas.[1]

The process of innovation adoption over time is diffusion. A central premise to this analysis is that diffusion is characterized by innovation differentiation. Differentiation entails, at least, the following four phenomena:

1. Different perceptions of the same innovation by different users.
2. Different perceptions of the same innovation by a single user at different times,
3. Corollaries to an innovation resulting from increased diffusion or broader applications,
4. Effects from an innovation necessitating an innovative response from the environment. (The environment refers to the entire array of institutional entities.)

Nuclear fission can be used to illustrate each of these concepts:

1. Nuclear fission is viewed by the Department of Defense as a source of new weapons (bombs, submarines) but by utility companies and the Department of Energy as a generating source of electricity.
2. Oppenheimer worked on the Manhattan Project and had a positive vision of what nuclear fission would mean. Years later, he testified that the dangers of this technology outweighed its benefits.

3. With expansion of nuclear energy use came the formation of the Nuclear Regulatory Commission to monitor and control its application.

4. An effect of nuclear generating plants is the heating up of water used in some plants' cooling systems. An innovative response is needed to find a way to dispose of this water without upsetting the ecological balance of localities where nuclear plants are situated.

When an innovation is diffused, the particular mental configuration may be different in each actor. For the inventor of c-p, the linkage may have been "sprinkler system -- deep well -center-pivot." For the farm equipment manufacturer it may have been "sprinkler-well-pivot-ground-water depletion," for the farmer "sprinkler-well-pivot-increased production-guaranteed crop!" and so on.

Surprisingly, the attributes of an innovation have been treated as fixed variables by innovation researchers, an approach rendered inadequate by the concept of differentiation.[2] In this analysis a broader view of innovation will be used, defining it as a process involving time, individuals, organizations, and a linkage of ideas with either substantial (product) or intangible (concept) manifestation. This definition realizes that innovation is set in a larger environment and is not separate from it and its elements and ongoing processes. The attributes of a new idea or even a piece of technology are not given or fixed, but the product of the interaction between the innovation and a myriad of societal forces. The increased complexity of interactions requires more complex analytic tools. One innovation may be used for several purposes or may give birth to several new forms. If any innovation is major, its diffusion will be evident in a variety of ways rather than a single interaction repeated "n" times.

One analytical construct must be imposed to study differentiation. Downs and Mohr distinguish between primary and secondary attributes of an innovation. A primary attribute is one not subject to change due to the perception of the observer. An automobile is an automobile to all concerned; it is not a subway car or airplane. A secondary attribute is one which varies with the perception of the observer. Innovation differentiation occurs in relation to secondary attributes. A Volkswagen is not a Cadillac.

Thus, the attributes of an innovation such as center-pivot irrigation are not simply defined. The primary attributes are clear -- c-p is a long pipe sprinkling water onto a field as it rotates around the field. But what are the secondary attributes? They can be named, questions can be asked relative to them, but they can only be determined by proposing hypotheses and then testing them. The following secondary attributes and questions are raised to illustrate the four types of innovation differentiation:

1. C-p is labor saving. But, is c-p for use by family farmers who wish to farm more land or who have seen their sons or daughters move to the city? Or is c-p for use on corporate farms that are characterized by absentee owners, farm managers and hired hands?

2. C-p increases production. What about the dangers of over-production? If corn prices drop low enough, will c-p price itself out of the market? If increased production is no longer a primary goal, will the view of c-p change?

3. C-p uses large quantities of groundwater. Will use of c-p drop groundwater levels significantly? Can groundwater be recharged naturally or could technology find a way to replenish it? Will groundwater have to be regulated? Can groundwater be regulated in a non-discriminatory manner?

4. C-p can irrigate sand hills and very hilly land. What happens to land, especially fragile land such as sand hills, after it has been irrigated by c-p for 15 years? 25 years? What happens to land improvement contractors if the need for their services is significantly reduced? What happens to the supporting services of the rural agriculture economic community (small businesses, health providers, etc.) if corporate farms increase and

provide these services in-house?

A substantial proportion of innovation research deals primarily with questions concerning the decision to adopt, the adopter-innovation exchange. However, many factors controlling this decision may be influenced or determined by the actions of individuals or organizations other than the adopter or producer. These actors do not purchase or use the innovation but may perform some other activity which influences or is influenced by it. Until recently, innovation diffusion was considered to be determined solely by producers and adopters with information as he intermediary. In a true free enterprise economy this would constitute satisfactory theory. However, as our society has experienced growth and become aware of the limits to growth, the free enterprise system has been increasingly regulated by institutions. Selznick has dubbed institutions "the regulators of change."[3] Institutions have been defined as "collective action in control, liberation, and expansion of individual action" by Commons.[4] The wide range of activities that may influence innovation includes legislation, court decisions, published research, media coverage, public demand, political necessity, and so on. As such, institutions are a major contributor to the process of diffusion and differentiation in either a positive or negative sense.

2.2 Institutions and Innovation

Institutional actions regarding an innovation may be part of their normal activities or may constitute new behavior. Parsons indicates that some societal mandate, either direct or indirect, is necessary for legitimate institutional behavior.[5] This mandate permits or requires action regarding the innovation, altering its characteristics or its potential adopters. Studies of innovation are increasingly aware of the variety of concerns that impinge upon the relationship between producer and adopter. In developing criteria for determining the success of an innovation, George White found that government regulation is likely to prevent the success of super-sonic transport (the SST) and likely to guarantee the success of automotive microprocessors.[6] A recent newspaper article by columnist Jack Anderson cites the structure of the automobile industry as preventing the marketing of a tire that is stronger, longer lasting, and more efficient than those currently being used.[7] Indeed the term "regulation" is now routinely used to describe a part of the innovation process through which an innovation must pass (Myers and Sweezy, 1978).

Nutt-Powell uses institutions to refer to an entity that is a repository for social meaning.[8] He defines six institutional entities. Three are organizational -- formal organizations, informal organizations, and members -- and three are not -- social orders, collectivities and persons. The dimensions of institutions are labeled function, activity, and role.

Function broadly defines the area of an institution's concern. Activities are undertaken to support that function. Roles represent strategies taken in a particular situation to implement a functional activity.

A list of institutional functions, roles, and activities, provided by Nutt-Powell, is a good starting point when attempting to conduct an analysis of institutional effects on innovation.

Functions	Activities	Roles
Research	Investigating	Vendor
Socialization	Reporting	Linking-pin
Service	Experimenting	Plunger
Political	Analyzing	Early adopter
Financial	Educating	Integrator
Production	Contemplating	Protector
Regulation	Resting	Translator
	Endorsing	Sponsor
	Playing	Seer
	Assisting	Legitimator
	Controlling	Watering hole
	Supplying	Instigator
	Making	Follower
	Marketing	Administrator
	Financing	Listening post
	Pricing	
	Informing	
	Adjudicating	
	Legislating	
	Promulgating	
	Advocating	
	Enforcing	
	Adjusting	
	Assuring	

Institutions establish exchange relationships with various members of the environment to form an institutional network. The exchange may involve information, services, goods, or personnel. An institution will respond to an innovation in either an institutionalized or innovative way. The difference between these responses is as follows:

1. Institutionalized - The innovation establishes routine linkages with the institution, enabling the institution to utilize a standard procedure, structure, or set of guidelines.[9]

2. Innovative - The innovation, either from its primary or secondary attributes, creates new linkages and therefore provokes an innovative response. The process of differentiation is one which moves the response from innovative to institutionalized; the tendency of institutions is to routinized the non-routine.

Another way to think about isntitutional response to innovation is in terms of the resource configurations of the organization and its members. If the responsed to innovation is institutionalized, it will not substantively alter the resource allocation of the institution or its members. The innovation will take the place of existing relationships or be added on incrementally to the institution's concerns. If the response in some way alters the allocation of resources in a way that is not simply "add on," then the response is innovative and the institutional arena is disrupted or altered. Resources, as in exchange, may be information, services, goods, or personnel (clients, adopters).

The four response categories that will be used in this analysis are intended to describe the nature (institutionalized or innovative) of the interaction between the institution and the innovation and the resulting resource configuration. The categories are as follows:

1. None - This indicates that the innovation has no impact on the institution, in either primary or secondary attributes. It is not part of the institutional network.

2. Institutionalized response - The innovation is supported by the institution in a routine manner.

3. Cooperative response - The innovation is supported by the institution in a way that expands the resource configuration of the innovation and the institution.

4. Conflict response - The resource configuration of the innovation cannot expand except at the expense of the institution, or vica versa.

The first two responses are institutionalized in that there is no disruption in the institutional arena. The latter two are innovative in that resources are re-allocated or new activities are performed by institutions. The conflict/cooperative division is intended to separate the institutions likely to support an innovation from those likely to oppose it.

2.3 Research Design

Understanding the influence of instiutions on innovation acceptance entails a simultaneous focus on each, in a specific situation in which innovation appears. The following steps provide a structure for such a study:[10]

1. Define the innovation, by primary attributes.
2. Determine the particular context for study.
3. Identify those institutions likely to be part of the institutional network.
4. Investigate the institutional responses to innovation.
5. Determine the direct and indirect effects of such responses on qualities of the innovation, and how those qualities effect diffusion possibilities.
6. Examine the functions, activities, and roles of each institution in order to assess mechanisms leading to reported responses.
7. Analyze innovative responses to understand ramifications of innovation on institutions and vica versa.

This study focuses primarily on two of the six institutional entities - formal organizations and members. This choice was made in part because, as McDermott notes, "specific organizations are necessary as a vehicle for the institutions, and the performance of the organization is one determinant of the effect of the institutions.[11] Within the context of a larger study (Nutt-Powell et. al., 1978b), an hypothesized institutional arena for the Nebraska Agriculture Community (the AgCom) was developed. Organizations likely to be part of the institutional network impacting c-p were specified, based on function and activity.

Information exchange was chosen as a key focus for data collection. The role of information as institutional activity is a central analytic concern of this thesis. To many analysts, information is the key to innovation acceptance or rejection. For example, one study (Beal, Rogers, and Bohlem, 1957) considers nothing but information when attempting to verify a theorized five-stage innovation adoption process. More recent work has been critical of the large emphasis placed on information dissemination by past researchers (Roberts, 1977). While recognizing the validity of this criticism (Indeed one point of this thesis is to emphasize the wide range of institutional actions that effect innovation diffusion including information dissemination.), the role of information as a precursor of activity is viewed as critical.

Information nay be divided into two types: "technical" and "personal." Technical information focuses on evaluative data on the innovation. Personal information emphasizes the source of the data. It is hypothesized that personal information speeds the acceptance of innovation, as it is more likely to lead to an institutionalized response.

Data were collected through personal interviews with key members of the organizations determined to be central to the institutional network. A semi-structured open-ended survey instrument was developed. (A list of those interviewed is included as Appendix A and the survey instrument is included as Appendix B.) Questions about the attributes of the innovation were asked to balance questions concerning information channels, and the nature of the organizations and members and their activities. Attributes of the innvoation will be conveyed by information, but the weight given various attributes, and therefore the determinant of the activity, will vary with the type of information received by the organization and the functional activity or role of the organization.

The role of the individual in effecting institutional action is also considered briefly. In many cases, an individual can build an institution and control its activities. Powerful individuals can substantially block or support an innovation.

A particular focus in the analysis is on the roles adopted by the institutions studied. Several, such as translator linking-pin, and legitimator, have direct relevance to the innovation-institution interaction. The data will be structured according to the roles adopted by organizations and the consequences for institutional action in general and related to c-p.

CHAPTER THREE
ANALYSIS:

The following analysis looks at the interaction between an innovation -center-pivot (c-p) irrigation - and institutions - the Nebraska Agriculture Community (AgCom) - from two perspectives. Analysis from the first perspective considers the development of the innovation and how its diffusion influenced the Nebraska institutional arena. Briefly, the innovation was perceived as satisfying a need and fulfilling certain normative values within the community. When it appeared that c-p might satisfy these needs, institutions attempted to determine whether c-p satisfied the requirements of those normative values. By satisfying both requirements, center-pivot irrigation spread widely and rapidly. In doing so it changed the environment. In the new environment created by c-p (as well as other events), new problems became apparent. These paroblems are related to c-p but due to continuing values and institutional roles premised on c-p's institutionalization, the institutional perception of c-p has not significantly changed. Rather than prompting a rejection of c-p, these new problems have spawned a new innovation - groundwater control.

The second perspective focuses on the institutions and the roles that they have played in the diffusion of c-p. A controlling social order[1] - felt need - has affected the roles of industry, the university, and the finance community with regard to center-pivot. The institutional response to center-pivot is characterized by positive and institutionalized and cooperative responses to a technology seen as labor saving and productive. These reaction were facilitated by encountering the innovation through exchange relationships with personal information as the medium. This enabled the organizations to respond to c-p in institutionalized ways.

3.1 Innovation Diffusion and Differentiation in an Institutional Context

The overriding concern of the agriculture community in the 1950's and 1960's was production. Any product or process that supported or increased production was viewed positively. New products or processes were tested and, if results were positive, spread rapidly. A good example of this is hybrid corn which went from a single application to almost universal acceptance in only a few years.

In view of the concern with production, technology and its various manifestations in farm equipment have become highly valued. The development of new technology has made agriculture increasingly capital, rather than labor, intensive, especially during the 1960's, when the availability of capital was very high and technology was perceived as a primary solution to any problem.

Another factor that encouraged the development of certain kinds of technology during this period was the increasing availability of electricity in rural areas. The Rural Electrification Associations (REA's) were operating beneath peak load capacity, especially during the summer months. The REA's encouraged the use of many electrical appliances by farmers, center-pivot irrigation included.

Thus, at this time the central questions concerning an innovation such as c-p were: Does it work? Does it improve production? Is it economical? Not surprisingly the research done on c-p by the University of Nebraska's Agricultural Experiment Station focused on these issues.

C-p, at its onset, was characterized as the most major step in the mechanization of agriculture since the advent of the tractor. After the rate of rotation and water application is set, a c-p practically runs on its own. Abundant power sources and groundwater were available to operate c-p. The device could increase production on existing farmland and increased the amount of land that could be irrigated. It could irrigate hilly land and sandy soils.

At initial encounter these attributes would appear to match the AgCom's norms - notably increased production and automation. Thus the initial response was institutionalized - research to confer these claims. Research done primarily by the Experiment Station on c-p focused on its ability to perform and on the production that could be expected under various conditions. Among the aspects studies were the proper scheduling and amounts of water application, various soil compositions, and the application of herbicides, pesticides, and fertilizer. Economic analyses focused on corn prices, expected production, and costs of production (these include irrigation device and installation, irrigation labor, cost of energy, land, insurance, and taxes).

The research (a differentiation process) showed that c-p would increase production by allowing precise control of water, herbicide, pesticide, and fertilizer application. It was also priven that due to its application control, c-p could be used to irrigate sandy soils. Because it utilized a sprinkler system rather than a series of gravity powered troughs, it also could be used on very hilly ground. Thus c-p met the prevailing norm of increased production. It did not require an innovative response as far as any restructuring of the agriculture business. Rather, its use by farmers was institutionalized (mechanized water delivery - seeded land - harvest - increased production) as other technology had been (tractors - seeded land - mechanized harvest - production). There was no apparent need for any innovative response on the part of farmers or researchers.[2] Thus, c-p was legitimated[3] and its diffusion keyed to the increase in land that could be irrigated and the productivity of irrigable land.

However, with the passage of time, a new set of problems confronted the Nebraska AgCom. In 1972, the embargo on oil by the OPEC nations put the term "energy crisis" int the American vocabulary. Until then, cheap and abundant fuel was taken for granted. With the advent of air conditioning and the spread of irrigation technology, peak load times for electricity occurred in the summer months, reversing the earlier situation. Center-pivots, which are highly energy intensive (as described in the first chapter) could not be powered as easily or cheaply. The REA's are limiting the number of wells or the total horsepower they will provide in any area. Scheduling programs have been proposed so that peak load capacity will not have to be increased. Natural gas distributors have also limited the amounts of gas they will provide for irrigation due to limited supply lines and reserve gas supplies.[4]

The energy crisis was only the first of several challenges to the prevailing normative structure of the AgCom. Increased production and productivity prompted concerns about overproduction and, to a lesser extent, land use and farm ownership. Overproduction causes a drop in prices potentially beyond the capability of federal price support programs to balance. A drop in cash flow, especially if sustained and pervasive to the AgCom, is a real threat to its current, and with c-p, even more capital intensive economic structure. Simply, if prices fall low enough, c-p systems are no longer economical. The price of corn, however, is partly determined by such institutional externalities as the level of price supports offered to farmers and the amount of exports allowed by the government. With institutional controls such as these, producing as much as possible is no longer the obvious goal. Instead of increased production, efficiency in achieving optimal outputs is now the highest value as far as production is concerned.

The biggest problem of all connected with c-p's that "appeared" in the environment, is the drop in groundwater levels in the state. With groundwater dropping at a rate of one to three feet annually in many parts of Nebraska, the norm is no longer that water can be pumped indiscriminately. Controls of some kind were determined to be necessary by the Nebraska Unicameral (the state's one house legislature). The Groundwater Control Act of 1975 gave the Natural Resource Districts (NRD's) the power to, after public hearings, declare irrigation control areas. The law authorized NRD's to register wells, increase well spacing, allocate maximum well withdrawals for various crops, order rotation pumping and declare a moratorium on further welldrilling for up to one year as a final resort.

The differentiation which accompanied c-p diffusion over time is reflected in the chronicling of c-p by the Omaha World-Herald, the state's major daily newspaper. The stories that ran on c-p evolved thusly: In 1967 to the early seventies, the stories concentrated on production benefits of c-p. At first the stories were about the use of c-p for corn and then later on its use with specialty crops such as sugar beets and potatoes. In 1971-1972, the articles centered on land erosion in western soils due to poor management. Finally, in 1973-1975, the concern focused on underground water supplies and the passage of the Groundwater Control Act.

In the differentiation of the secondary attributes of c-p, the qualities of the innovation that came to be viewed as negative were disconnected from c-p and treated as a second innovation. Thus, groundwater depletion became a problem - a new problem and therefore an innovation nessitating response of some kind. In keeping with the high value of technology in the Nebraska AgCom, one informant expressed hope that ways of recharging groundwater could be developed. In the absence of such a technological solution, there was still no reaction against c-p, but rather the establishment of government controlled management solutions. This avoided any need for re-evaluation of the primary and other secondary attributes of c-p or the values supporting those attributes as positive.

Critical to the separation between c-p and groundwater control is the role played by the Conservation and Survey Division (CSD) of the Institute of Agriculture and Natural Resources at UN-L. Vince Dreeszen, director of the CSD, may be seen as a linking-pin[5] in the institutional structure connecting groundwater to irrigation. As head of the CSD he helps prepare studies of groundwater supplies that are used in the determination of control districts. As an ex-officio director of the Nebraska Welldrillers Association, he has had extensive involvement with the people who drill wells for irrigation development. He has intervened and kept out of court a number of disputes in which deep water wells have caused smaller domestic wells to go dry. Yet he sees no connection between what he does and the diffusion of c-p.[6] His inability or disinclination to make that linkage illustrates the separation of the two innovations (c-p and groundwater control) and the extent to which c-p is now institutionalized and groundwater continues to provide innovative response.

The creation of Natural Resource Districts and the passage of the Groundwater Control Act of 1975 may be looked at as the creation of a second innovation - government control of groundwater. Until the passage of this Act, there was no formal structure of ownership rights concerning groundwater. Indeed, the Act itself, it was said in one interview, will probably be tested with regard to its constitutionality. If it survives such a test, the Act will probably be the basis for further legislation clarifying who has what rights with respect to underground water. Thus this innovation is still in its early phases, as even its primary attributes are as yet undeveloped.

3.2 The Effects of Institutions On Innovation

The companion analysis to a consideration of an innovation's differentiation in an institutional arena is the manner in which particular institutions responded to the innovation. Analyzing the particular institutional reactions to c-p is like putting together a puzzle. To understand the roles each organization adopts, it is helpful to have an idea of what the broader institutional environment looks like. In this instance, a knowledge of normative behavior within this arena helps explain the diffusion of center-pivot irrigation.

Industry in Nebraska has traditionally been the source of innovation in agriculture. Within the agriculture community, the free market tradition reserves the right to initiate to those who are the most entreprenurial. This industry has as its primary goals the making of money and increased efficiency in production. Valmont's role as the producer of c-p's is that of a vendor and as such must convince the controlling institutions as well as the consumer that its product is needed. The profit motivation of the industry will also restrict its efforts to innovation adoption, without regard for broader impacts.

Valmont acted to convince the consumer population by first identifying and influencing two key institutional actors, the University of Nebraska at Lincoln (UN-L) and the finance community. While industry does conduct a great amount of research in Nebraska, it is the research activities of the University which possess the critical roles of legitimator and translator[7] regarding new products or processes (innovation).[8]

The critical roles of UN-L as a legitimator and a translator grow out of the historic concern of the federal government for education and research. This concern resulted in the 1862 Morrill Act which established land grant colleges in every state in the Union. In 1887, the Hatch Act established Agricultural Experiment Stations and in 1916 the Smith-Lever Act completed the basic functions by establishing Cooperative Extension Services, both to be operated in conjunction with the land grant colleges. McDermott describes the presence of both research and extension to be essential as extension was considered as the extending of information that presumably was produced by the Experiment Station.[9]

In serving the agriculture community, the Extension Service acts in response to "felt need." "Felt need" is identified by extension agents based on questions that are raised by farmers in the area they serve. In their role as linking-pins, county agents connect farmers to information which meets their "felt need." If no such information exists, the linking-pin county agent conveys the need to extension specialists (The University has specialists in over twenty fields.). Specialists are the translators, taking available research results and providing needed information. alternatively, if no information exists at all, specialists translate the need into a research need. At this point, products and processes (innovation) which might meet this need are identified, here seen as testing the device to see if it meets norms, and thus research is conducted which determines whether the innovation(s) legitimately meet the need. Only infrequently is more basic research undertaken.

The translator role has been critical in supporting the legitimator powers of the research system. McDermott notes how "extension" served an almost evagelistic function in promoting science and rationality in farming.[10] This effort reinforced the validity of the role of the academic entity as the legitimator, since its existence and practices are based on science and rationality.

A limitation of this system is that innovation must make itself known in some way before questions from farmers ("felt need") wil occur. For the producer this entails making a connection between its innovation and prevailing norms, at least among the early innovators. Valmont promoted c-p for its production raising potential, emphasizing its labor saving qualities. Its use by plungers[11] was advertised. Thus when UN-L was going to test a new system and Valmont approached them with the offer of a c-p, the felt-need had been created and the University was prepared to respond. Its response was institutionalized, enabling an initially positive attitude.

As farming was becoming more capital intensive and as c-p's are expensive,[12] the role of the finance community in supporting c-p is seen as the third part of this institutional puzzle. Approximately ninety-five percent of c-p's are financed. Both private and public finance institutions are involved in lending money for the purchase of c-p systems. The availability of capital and the tendency of the agriculture sector towards increased capitalization indicate why the support of c-p by finance institutions was so critical to its success. One informant stated that a farmer was more likely to spend $50 - 60,000 in 1977 than $14 - 15,000 in 1965 due to the availability of financing.

Public and private banks differ as to roles and method of operation. The private banks are seen as vendors and operate in that way. They are interested solely in making good investments and therefore were conservative in evaluating the worthiness of c-p. Only after ten to fifteen years of experience with c-p's did they begin to lend money for them. Thus, commercial banks were not interested in c-p as an innovation, but wanted it well institutionalized. Indeed, to the banks the nature of the capital investment is not even considered. As one informant stated, "If the farmer is worth it, it doesn't matter what he spends his loan on." In this respect the action of banks with respect to differentiation is corollary.

TABLE 3.1

Activity of private finance institutions as a corollary of c-p diffusion

C-p → Production increaed → Income of farmer increased
Banker → Loan approved → Sound investment ←

The bankers don't have to consider the complete set of primary and secondary attributes belonging to c-p.

The public finance institutions were more specific as to how they considered innovation. The Production Credit Association's (PCA's) institutionalized response to innovation is to wait for the "practical" adopters - those who have learned from the mistakes of the plungers. The Farmers Home Administration is labeled an administrator because it primarily tries to process loans to those farmers whose credit is not the best and who have been turned down elsewhere. Surprisingly, this conservative organization started lending money for c-p in 1967 about two years earlier than most finance organizations. This is due to established institutional connections with the Soil and Conservation Service. The Farmer's Home Administration checks on the water levels and soil composition of those to whom it lends money for c-p irrigation to see if they are adequate to support such a system.

3.3 Institutional Perception of and Response to C-p

The organizations expected to influence c-p were categorized with respect to hypothesized perception of and response to c-p (TABLE 3.3) and then with respect to actual perception of and response to c-p (TABLE 3.4) based on information obtained from interviews (see Appendix B).

The hypothesized table was constructed as follows. Perception of c-p is described by the outstanding attribute of c-p. The predicted perception of c-p is based on the function of the institution. A finance institution, is expected to be concerned with the finances of c-p. For an organizations such as the Farmer's Union which "supports whatever is good for the farmer" will not have an obvious predictable perception of c-p. In cases such as that, the actual perception is used in order to place the organization on the chart.

The response to c-p is classified according to the categories described in the analytic framework. The "none" response is not included in the hypothesized chart because it is expected that all institutions will have a response (That is why they were included in the institutional arena in the first place.). The predicted response depends on two factors. First are activities. Are the activities engaged in by an organization likely to benefit or support the innovation, or conflict with development of the innovation by threatening the resource (good, services, natural resources, personnel) of the innovation? Does the innovation take resources from the institution?

Second, what effects does action towards c-p have on the members of the organization? If activities are supportive of innovation, but the organization's members do not particularly benefit from such activity the result is likely to be institutional. That implies the response is likely to be as routinized as possible. If supporting activities are likely to benefit organizations members, a more innovative (cooperative) response is likely. Those in conflict with c-p are also seen as likely to be innovative in order to avoid damage. Thus the array of expected responses based on benefits to members of organizations and supporting or conflicting activities looks as follows:

TABLE 3.2

Predicted Response to C-p

		Benefits to Members of Organizations: Yes	Benefits to Members of Organizations: No
Activities	Supporting	Coopera-tive	Institution-alized
	Conflicting	Conflict	Conflict

The largest number of organizations expected to be supportive of c-p were those thought to perceive the outstanding attributes of the device as either "production boom" or "labor saving." These are closest to primary attributes of the innovation on which the innovation's success is based. "Water issues" and "land use" are secondary attributes resulting from widespread diffusion. Perception of secondary attributes is expected to vary and both "conflict" and "institutionalized" responses are expected.[13] For the most part both of these expectations held true.

A major shift was the large amount of organizations with a repsonse of "none." In general those organizations reflect the belief that technology, as part of the free enterprise system, is not something to be "supported" or "opposed" at all. Surprisingly many of the organizations expected to be in conflict with c-p fell into the response category of "none."

In fact, of all of the organizations expected to exhibit a conflict response to center-pivot, the only one to do so was the Center for Rural Affairs. The Nebraska Land Improvement Contractors Association agreeed that c-p was hurting their business since land irrigated by c-p requires much less grading than those irrigated by gravity flow methods. They had not, however, opposed c-p in any way and saw it positively as "labor saving." In fact, they supported the device in a routine way by advertising for the minimal grading work required by c-p.

The Nebraska Association of Resource Districts, the Department of Environment Control, and the Chairman of the Public Works Committee - Senator Kremer - all of whom were expected to conflict with c-p on the basis of "land use," were not opposed to c-p. Instead, NARD and DEC saw it as a "management" tool and separated their concern with land use, water, and ecology in general from their opinion of c-p. They preferred to see the positive secondary attributes of c-p and create a separate category of concern - groundwater control. In this way there was no direct conflict with the norms of Nebraska supporting technology and production, yet both organizations continued their activities that are leading toward control of deep well irrigation.

Management is thus a critical and highly differentiated secondary attribute. It has been attributed to c-p relatively recently, representing a time and effect differentiation. Valmont Industries, producers of c-p systems, spoke of concern about groundwater conservation and the need to promote c-p as a management tool. This reflects a shift in their understanding of the innovation from production in volume to optimizing production. By viewing c-p as a managemetn device it is seen as part of a strategy to control resources rather than as a huge resource utilizer.

The Agriculture Experiment Station did not materially benefit from c-p diffusion and thus was expected to and did react in an institutionalized way. The usefulness of an innovative response from the University is high, but was not expected and did not occur. The First National Bank did have something to gain by supporting c-p's at an early stage. The device was highly profitable, and FNB could have made many more loans for them had they started earlier in time. By missing the chance for an innovative response they missed an opportunity. Their institutional connections were not as good as the Farmers Home Administration (FHA), which was expected to and did respond in an institutionalized way. However, because of close ties between the FHA and other government institutions such as the Soil Conservation Service, the institutionalized response of the FHA took place two years before that of private banks.

The Conservation and Survey Division should have responsed in a conflicting way since it would bring to light the water depletion attributes of c-p. By reporting the impact of c-p on groundwater, it partially fostered the circumstances that led to the creation of the Groundwater Control Act and which led to new duties for the CSD - the preparation of studies used in the declaration groundwater control districts. The CSD did not, however, link dropping water tables to the rise of c-p. It in no way sought to oppose diffusion of c-p.

Valmont, had it wanted to sell more pivots, could have worked closer with private banks in order to elicit the innovative response that would have sold more pivots at an earlier date. The path it took was innovative, but could have been even more accelerated. The Rural Electric Association (REA), which stood to benefit from increased electrical use was innovative in the campaign it launched to sell c-p's. REA was innovative again when circumstance changed and they were forced to optimize the distribution and operation of c-p so as not to exceed peak load capacity.

Given the way the groundwater issue arose so suddenly and dramatically, it is fortunate that Valmont was not more successful in the selling of c-p. The failure of the linkage of c-p's to groundwater depletion like primarily in the normative structure of this institutional arena, which did not concern itself with the larger impacts of a new innovation and later chose to isolate the problem as a separate innovation requiring and separate and innovative response once c-p had entered and become a part of the institutional structure.

TABLE 3.3 Hypothesized Institutional Perception of and Response to C-p

Attributes \ Responses	Institutionalized	Cooperative	Conflict
Management		SOPP	DEC
Water Issues	NSIA CNPPID		SC CSD
Production Boom	Ag Builders NCC MFREDA	Valmont NFO Welldrillers FU Farmland NFI/NGFA NSA	
Labor Saving	Om W-H AES NCEAA NSIA Ag Council Ag Exp Sta	REA FSC FB Grange	
Land Use	Neb. Farmer DA Ex A		NLICA NARD Sen. Kremer CRA Sen.Schmidt
Energy Use	NPPD NPC		SEO
Finances of C-p	Sen. Warner DED FHA PCA NBF NBA NFSMRA	FNB	
Age of C-p	DI		

A listing of these acronyms can be found in Appendix A

TABLE 3.4 Actual Institutional Perception of and Response to C-p.

Attributes \ Repsonses	None	Institu-tionalized	Cooperative	Conflict
Management	DEC	NARD	SOPP Valmont	
Water Issues	Ag Builders SC	FHA CNPPID		
Production Boom	NFO FU Farmland		NSA	
Labor Saving	Ag Council NCEAA SEO Grange FB	NSIA AES Ag Exp Sta Sen. Kremer NLICA	REA FSC Om W-H CSD Welldrillers Sen. Schmidt	
Land Use	DA NCC Sen. Warner	NBA Neb. Farmer Ex A		CRA
Energy Use		NPPD		
Finance of C-p	MFREDA	NPC FNB NSFMRA PCA DED NBF	NFI/NGFA	
Age of C-p		DI		

A listing of these acronyms can be found in Appendix A.

CONCLUSION:

Thus we have seen how the institutional network of Nebraska supported the widespread diffusion of center-pivot irrigation, in spite of uncertainty about the severity of impacts on resources and the economic well-being of the sector.

The diffusion of center-pivot irrigation was slow for the first fifteen years. Uncertainty about its claims concerning production and the predominantly labor-intensive agriculture community accounted for its slow start. After initial hesitation, the University of Nebraska conducted research on c-p, legitimating its production claims, and then disseminated this information through its extension service. Once assured that c-p was a secure investment, private and public funding sources opened up for the device. A campaign by the Rural Electrification Association helped sell farmers and bankers on this technology. C-p sales boomed with growth rates of almost 200 percent in the early seventies.

A discussion of the innovation indicated the existence of primary and secondary attributes of innovation. Secondary attributes vary with the perception of the adopter or institutional actor and account for innovation differentiation. C-p's differentiation included that change of certain institutional norms such as changing the agricultural arena's concern with absolute production to efficiency in the achievement of optimal outputs and the new perception of water and energy as scarce rather than abundant resources. This differentiation led to one particularly outstanding second innovation -- government regulation of groundwater.

Institutional dimensions were defined in order to sort the kinds of behavior institutions exhibit. Two concepts -- resource configuration and types of information -- were defined to explain the kinds of institutional behavior that constitute a response to innovation. The particular responses of the organizations in Nebraska were categorized and examined. Private organizations were held more likely to respond in innovative ways since they had more to gain by adapting to the particular attributes of this innovation. Had they behaved more in such a manner, c-p might have diffused at an even greater rate. Public institutions supported c-p much in the same way as private institutions. When the issues evolving from c-p became apparent, they had been separated from the institutions' concerns with c-p. Thus there was no backlash against c-p, as each institution was able to fulfill the goals of their organization by addressing these new, distinct, issues.

FOOTNOTES - CHAPTER ONE:

1. Details on groundwater levels are available in "Groundwater Levels in Nebraska., 1976 by Michael J. Ellis, U.S. Geological Survey and Darryll T. Pederson, Conservation and Survey Division/ Nebraska Water Survey Paper Number 44

2. William E. Splinter, "Center-Pivot Irrigation," in Scientific American, June, 1976, vol. 234 No. 6, p.90.

3. Interview with Dean Howard of Valmont Industries on Feb 8, 1978.

4. Details of this story were obtained in an interview with Les Sheffield, Asst. to the Vice Chancellor, Institute of Agriculture and Natural Resources, University of Nebraska on Feb. 7, 1978

5. Ibid.

6. See for example, Terry Lavy, "Herbicide Transport in Soil Under C-p Irrigation Sustems." UN-L, Department of Agronomy, R.E.J. Retzlaff and D.W. O'Dea, "Cost of Operating Center-Pivot Systems on Irrigated Pastures - 1972-1974 and Projected Costs for 1975 - 1976, UN-L, Department of Agriculture Economics, 1975 No. 68.

7. This is according to Robert L. Anderson, a former employee of the REA in an interview on August 9, 1977.

8. Interview with Les Sheffield, op.cit.

9. Interviews took place with these individuals at the following times: Kirk Jamison, Production Credit Association August 5, 1977. Bill Waldo, Farmers Home Administration on August 8, 1977. Everett Shirk, First National Bank on Feb. 7, 1978.

10. These figures were arrived at with the help of estimates by the Nebraska Department of Economic Development.

11. William E. Splinter, op.cit.

12. "Wheels of Fortune" prepared by the Center for Rural Affairs, Walthill, Nebraska.

FOOTNOTES - CHAPTER TWO:

1. H.G. Barnett, Innovation: The Basis of Cultural Change, New York: McGraw-Hill, 1953. p. 181.
New York: McGraw-Hill, 1953, p.181

2. Rogers, for example, considers attributes such as complexity, divisibility, communicability as fixed and discernible. Zaltman et.al. has a much longer list of variables treated similarly. See Everett M. Rogers, Diffusion of Innovation, New York: Free Press, 1962. Zaltman, Duncan, and Holbek, Innovation and Organizations, New York: Wiley, 1973.

3. Phillip Selznick, The Organizational Weapon New York: The Free Press, 1960 pp. 72-73.

4. Commons is paraphrased by J.K. McDermott, "Extension Institutions," in Institutions in Agricultural Development, Melvin G. Blase, (ed.) Ames Iowa: The Iowa State University Press, 1971. p. 152.

5. Talcott Parsons, Structure and Process In Modern Societies, New York: The Free Press, 1960, Chapter 5.

6. George R. White,"Innovation Criteria," Technology Review Feb., 1978.

7. Jack Anderson, "Industry Shuns Revolutionary Tire," Boston Globe, Feb. 13, 1978.

8 For the full discussion of institutions and their dimensions see T.E. Nutt-Powell wt.al. "Toward A Theory of Institutional Analysis," MIT Energy Lab, 1978.

9. March and Simon use the term "institutionalization of innovation to refer to this response. See March and Simon, Organizations, New York: John Wiley and Sons, Inc., 1958.

10. The theoretical background for this approach is presented in Nutt-Powell, op. cit.

11. J.K. McDermott, op.cit. p. 152.

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Myers and Sweezy, "Why Innovations Fail," Technology Review, March/April, 1978.

Nutt-Powell et. al. "Photovoltaics and the Nebraska Agriculture Community," MIT Energy Laboratory, 1978.

Edward B. Roberts, "Increasing the Utilization of Government and Industrial Research" 1977

George M. Beal, Everett M. Rogers, and Joe M. Bohlen, "Validity of the Concept of Stages in the Adoption Process," Rural Sociology, Vol. 22 No. 3, December 1957.

G.W. Downs Jr. and L.B. Mohr, "Conceptual Issues in the Study of Innovation," Administrative Science Quarterly, Vol. 21, No. 4, Dec. 1976, p.700 -714.

FOOTNOTES - CHAPTER THREE

1. A social order is defines as "a societal disposition without specific members" in T.E Nutt-Powell, et.al., "Toward A Theory Of Institutional Analysis" 1978, p. 19.

2. An innovative response in this case would have been for the Agricultural Experiment Station to investigate the impact on natural resources on the extensive use of c-p, or the economic consequence of energy dependence.

3. A legitimator is defined as "an actor giving status, authority, and/or credibility" see Nutt-Powell, op.cit., p. 33.

4. Leslie F. Sheffield, "The Economics of Irrigation," in Irrigation Journal, January/February 1977, p.22.

5. A linking-pin is defined as "a connector of actions among institutions," see Nutt-Powell, op.cit. p. 32.

6. Interview with Vince Dreeszen, Director, Conservation and Survey Division, UN-L on July 29, 1977.

7. A translator is defined as "a conveyor and usually interpretor of information from one source to another," see Nutt-Powell, op.cit., p. 33.

8. In an interview with Robert L. Anderson, an officer with the Nebraska Fertilizer Institute, on August 9, 1977, it was learned that at one time the fertilizer industry felt the University's research re fertilizer use with c-p was five years behind that of the industry. Mr. Anderson met with the head of the Institute of Agriculture and Natural Resources and after their discussion the research priorities of the University were redirected in this area.

9. J.K. McDermott, "Extension Institutions," in Melvin G. Blase (ed.) Institutions in Agricultural Development, Ames Iowa: The Iowa State University Press, 1971, p. 153.

10. Ibid., p. 154.

11. A plunger is defines as "the ultimate initiator, trying out new ideas/things simply because the are new, generally with limited regard as to risk." See Nutt-Powell op.cit., p. 32.

12. The first c-p cost $7,000 to build and install. Current costs of a c-p range from $35,000 to $60,000 depending on the size of the system.

13. A secondary attribute such as "water use" illustrates the various kinds of differentiation. The Central Nebraska Public Power and Irrigation District was concerned with water as a corollary of c-p. Its concern was with the amount of water needed as the number of pivots grew and with changing water allotments from a fixed amount to a demand basis as seasonal fluctuations increased. The Farmers Home Administration was concerned with the availability of water before lending to an individual: this reflects a time differentiation of c-p - that the economic feasibility of a c-p changes with time if water resources run out. Both the Sierra Club and the Agriculture Builders of Nebraska (a group of individuals informally organized to represents the interests of agribusiness) were concerned with the effects of c-p as groundwater changed from an abundant resource to a controlled substance. The Sierra Club is concerned with the interrrelation between "c-p's, underground water and stream flow." The Agriculture Builders of Nebraska were going to meet and "start reviewing plans for water use and planning." So while water use was a critical component of c-p diffusion and the institutional reaction, the exact nature of water concerns and approaches represent an array of secondary attributes that are the consequence of various differentiations.

Appendix A

Interview List

Each listing includes the name of the individual interviewed, the organization(s) represented and the acronym used in this paper for the organization.

AES
Agricultural Extension Services
Leo Lucas, Director

Ag Builders
Agriculture Builders of Nebraska
Gib Erickson, President
Farmland
Farmland Industries

Ag Council
Nebraska Agriculture Council
Paul Grabouski, President

Ag Exp Sta
Agricultural Experiment Station
Dr Warren Sahs

CNPPID
Central Nebraska Public Power and Irrigation District
R.D. Dirmeyer, General Manager

CRA
Center for Rural Affairs
Don Ralston

CSD
Conservation and Survey Division
Vince Dreeszen, Director
Welldrillers
Nebraska Welldrillers Association

DA
Department of Agriculture
Glenn Kreuscher, Director

DEC
Nebraska Department of Environment Control
Jack Subavaty

DED
Nebraska Department of Economic Development
Steve Kale

DI
Nebraska Department of Insurance
Don Deale

Ex A
Extension Agent
Marshall Logan

FB
Nebraska Farm Bureau Federation
Richard Gooding

FHA
Farmers Home Administration
Bill Waldo, Acting State Director

FNB
First National Bank
Everett L. Shirk

FSC
Farm Safety Council
Rollin Schneider

FU
Farmers Union of Nebraska
Louis Wiebe, President

Grange
Nebraska State Grange
Edward Anderson, President

MFREDA
Midwest Farm Retail Equipment Dealers Association
Don Virgin

NARD
Nebraska Association of Resource Districts
Richard Hahn, Director

NBA
Nebraska Bankers Association
Harry Argue

NBF
Nebraska Department of Banking and Finance
Jack Riley, Director

NCC
Nebraska Cooperative Council
Maynard Ortegren, President

NCEAA
Nebraska County Extension Agent Association
Jane Bierman

Neb. Farmer
Nebraska Farmer
Bob Bishop, Editor

NFI/NGFA
Nebraska Fertilizer Institute/ Nebraska grain and Feed Dealers Association
Robert L. Andersen, Executive Vice President

NFO
Nebraska National Farmers Organization
Ed Tvrdy, President

NLICA
Nebraska Land Improvement Contractors Association
Ron Gaddis

NNG
Northern Natural Gas Company
Paul Ducharme

NPC
Nebraska Petroleum Council
Donald Crosier, Assistant Director

NPPD
Nebraska Public Power District
Henry Rice, Executive Director

NSA
Nebraska Seedsman Association
Bill Monke

NSFMRA
Nebraska Socity of Farm Managers and Rural Appraisers
Doug Duey

NSIA
Nebraska State Irrigation Association
Henry Lange

Om W-H
Omaha World Herald
Don Ringler, Farm Editor

PCA
Production Credit Association
Jamison Lincoln, President

REA
Nebraska Rural Electric Association
Harry Hackbart, Vice President

SC
Bluestem Sierra Club
Gary Lutman, Chairman

Sen. Kremer, Chairman
Public Works Committee

Senator Schmidt, Chairman
Agriculture and Environmental Committee

Senator Warner, Chairman
Appropriations Committee

SEO
Nebraska State Energy Office
George Dworak

SOPP
State Office of Planning and Programming
Warren White

Valmont
Valmont Industries Inc.
Dean Howard

Also Interviewed:

Les Sheffield, Chairman
Department of Agricultural Economics, UN-L

William Splinter, Chairman
Department of Agricultural Engineering, UN-L

Martin Massengale, Vice Chancellor
Institute of Agriculture and Natural Resources, UN-L

Appendix B

Interview Schedule

C-p Case Studies Project: Agricultural Case Study
Note: Use actual name of organization, instead of "your organization"

Organization

1. In general, what are the purposes of your organization that are directly related to the agricultural community?

2. What activities does your organization pursue to meet these objectives?

3. Within the ________________ sector, what role does ________________________ play?

4. What are your duties and responsibilities as POSITION in ORGANIZATION?

   (a) How long have you been in this position?

   (b) How long have you worked in the ORGANIZATION? ________

5. (a) How large is ORGANIZATION?

   (b) How long has ORGANIZATION been in existence?

   (c) What is the makeup of the staff?

      (1) What are their backgrounds?

      (2) What types of training do they have?

Center-Pivot Irrigation Acceptance

We are interested in how innovations are accepted by the agricultural community and how your organization relates to that process. Rather than immediately talking about photovoltaics, we would like to discuss your organization's experience with a more widely established innovation, center-pivot irrigation.

6. Can you recall when and how your organization first learned about center-pivot irrigation?

7. In what way was your organization involved with center-pivot irrigation? (Note: 8 and 9 are prompting questions. Respondent should be answering 6 and 7 in the time and sources information mode. Use 8 and 9 to be certain ground is covered.)

8. Time-orientation

(a) What did your organization do first?

(b) What did you do then? and then?

9. Sources/information-orientation

(a) What sources of information did you rely on?

(b) What kinds of information did you get from these sources?

(c) How important was SOURCE in making your decision?

(Note: 10 a, b, are asked to flesh out data on 9 a, b, c.)

10. (a) How did the actions of other organizations influence your organization's actions?

(b) What elements of center-pivot irrigation did your organization examine (operating costs vs. initial costs, etc.)?

11. (a) We have really focused on your organization's role so far; before we move on, can you give us a summary of the process by which center-pivot irrigation came to be widely accepted: which organizations favored it; which opposed it; which participated; and which did not?

(b) As you think back, then, what were the key factors in determining your organization's role in the adoption of center-pivot irrigation?

Routine Role

12. (a) Now that center-pivot irrigation has been widely accepted, what is your routine activity concerning it?

(b) What information do you continue to need to complete these activities or to keep policies up to date?

13. In carrying out your organization's present role, do you have to deal with other organizations?

(a) Which organizations?

Other Contacts

(a) Which other people or organizations should we see?

(b) Why do you think these people or organizations are important?