CONSEQUENCES OF DIFFUSION OF INNOVATIONS: THE CASE OF MECHANIZATION IN U. S. AGRICULTURE

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ABSTRACT

CONSEQUENCES OF DIFFUSION OF INNOVATIONS: THE CASE OF MECHANIZATION IN U.S. AGRICULTURE

By

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The subdiscipline--diffusion of innovations--originated to a large extent in rural sociology. Although, initially applicable to agricultural extension in North America, subsequent incorporation of communication theory and confirmation of diffusion theory in developing countries culminated in the classical diffusion model of Rogers with Shoemaker (1971). However, anomalies from this cross-cultural application have stimulated a criticism of the diffusion model. It is evident that diffusion theory has had an individualistic or psychological bias attributable to its North American origins, and that the theory fails to predict consequences of diffusion of innovations arising from social structural factors.

Little attention has been given to the notion of consequences. The classical diffusion model treats consequences of innovations superficially, acquiring several concepts from the theoretical perspectives--systems analysis and functional analysis. Heeding the criticism of the functionalism aspects of diffusion, these concepts are rejected when

establishing guidelines for further study. Consequences of diffusion of innovations is defined as a subprocess of social change that may affect individuals or groups other than those directly involved in the decision-making. Consequences are classified into three dichotomies--anticipated-unanticipated, desirable-undesirable, and direct-indirect. Of great importance is the notion of distribution of consequences; that is, consideration of differential effects on segments of the social system, and not merely the average level of effect.

Much work is needed for both developing a theory of consequences and for empirical testing of that theory. Theory construction will need to be deductive at the outset, and propositions in the causal process mode. Thus, the logic of causation must be considered in determining the appropriate methodology. The ideal approach is through longitudinal, comparative studies, but case studies and trend data lend further support to causal hypotheses. Given sufficient empirical research then generalizations are possible.

Consequences of mechanization in U.S. agriculture is not only an important social change process in its own right, but confirms the guidelines set in this thesis for studying consequences of diffusion of innovations. The consequences not only affect farm decision-makers, but their families, their employees, rural nonfarm people, and the urban

population. Mechanization may have resulted in improved levels of income to farms and farm people, but the inequality of distribution of income also increased. Further, consequences of mechanization cover the spectrum of anticipated-unanticipated, desirable-undesirable, and direct-indirect. However, agricultural mechanization studies--like consequences studies in general--are deficient in both methodological rigor and in theoretical framework. Suggestions are made on how to overcome such deficiencies.

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"Men of conservative temperament have long suspected that one thing leads to another" (John Kenneth Galbraith, 1971, p 249).

PREFACE

This thesis is the culmination of two years development in my thinking about the subdiscipline called "diffusion of innovations."[1] I first confronted this topic in Fall, 1974, when taking a graduate course called "Communication and Change: The Diffusion of Ideas and Information." The text was Rogers with Shoemaker (1971), Communication of Innovations: A Cross-cultural Approach. Since that time I have become increasingly critical of the content of that text, and this thesis is the formal presentation of that criticism.

This dislike for Communication of Innovations was initially intuitive, based on my five years experience as an agricultural extension agent. I was particularly concerned with the "manipulative" aspects of the "classical diffusion model."[2] Of the 103 generalizations in the text, 70 specifically dealt with individual characteristics; and more than 90 percent of the studies referenced would have been individual-specific. The use of the value-laden term "laggard"[3] epitomizes what has come to be called the "psychological" or "individualistic" bias (Rogers, 1973; Bostian, 1974; Havens, 1975).[4]

In this context two important points must be made before proceeding with this thesis. Firstly, I am not rejecting

the theory of diffusion of innovations as it applies to improved technology in U.S. agriculture. Hence, there is an "ideological constraint" on my re-interpretation of diffusion theory; that is, this thesis cannot move beyond the implicit assumptions that preserve the status quo for developed countries. Frank (1972), Havens (1972) and Beltran (1976) have rightly challenged these constraints for application of the diffusion model to Latin America, but my own thinking has not reached a point where I can successfully do likewise for the U.S. However, I will address these criticisms and attempt to compensate for the psychological bias by concentrating on structural aspects of diffusion. A convenient way to do this is through a comprehensive treatment of consequences of diffusion of innovations.

My second point is that criticism of the classical diffusion model as described in Communication of Innovations is not a criticism of the senior author, Everett M. Rogers. Dr. Rogers has changed his position markedly since publication of the 1971 text. He recently edited a special issue of Communication Research (1976) which testifies to this shift. That issue includes a number of articles, and references to many others, that point to the deficiency of the classical diffusion model in application to underdeveloped countries.[5]

An important question remains: If recent research has found the theory of diffusion of innovations wanting in its

application to underdeveloped countries, does the diffusion model also have the same limitations for the U.S.? I contend that the answer is a qualified yes. A systematic review of the diverse literature concerning consequences of mechanization in U.S. agriculture will support this. Consequences of mechanization represents the most significant research tradition in diffusion of innovations: agricultural innovations in the U.S. Anomalies of application of the classical diffusion model to agriculture in underdeveloped countries and in the U.S., prompted the comprehensive treatment of consequences of diffusion of innovations. The goal of this thesis is to elaborate on a sociological (rather than social-psychological) perspective to diffusion of innovations and to develop guidelines for future work on consequences of innovations.

FOOTNOTES

[1]"Diffusion" originally designated the process by which a culture was spread through societies (Gould and Kolb, 1964, pp 199-200). "Diffusion of innovations" refers to the permeation of a new technological device or new cultural manifestation through a whole social system (Hagerstrand, 1968, p 174). Given the large amount of research pertaining to diffusion of innovations it can justifiably be called a subdiscipline. See further, Chapter I, pp 9-12.

[2]The term "classical diffusion model" will be used throughout this thesis to refer to the Rogers with Shoemaker paradigm (1971) for diffusion of innovations.

[3]"Laggard" is a term used to describe the last 16 percent of a client system to adopt an innovation (Rogers with Shoemaker, 1971, p 181).

[4]For further discussion see Chapter I, pp 17-20.

[5]These criticisms are elaborated in Chapter I, pp 12-19, of this thesis.

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CHAPTER I

DIFFUSION OF INNOVATIONS

Introduction

This review will substantiate the claim that there are limitations to the theory of diffusion of innovations. It will do so by detailing the development of the subdiscipline called diffusion of innovations and its culmination in the classical diffusion model. The limitations to this paradigm will become evident from the results of three recent studies in diffusion of agricultural innovations in underdeveloped countries. The specific limitations of psychological bias and unanticipated consequences will be discussed. Therein lies the task of this thesis: to elaborate on a sociological (rather than social-psychological) perspective for diffusion of innovations and to develop guidelines for further study of consequences of diffusion of innovations.

History of Diffusion of Innovations

In the terminology of the classical diffusion model, literature on diffusion of innovations has followed the adoption frequency curve. That is, the number of research publications per year of publication has approximated a normal curve (see Figure 1)[1]. Diffusion of innovations

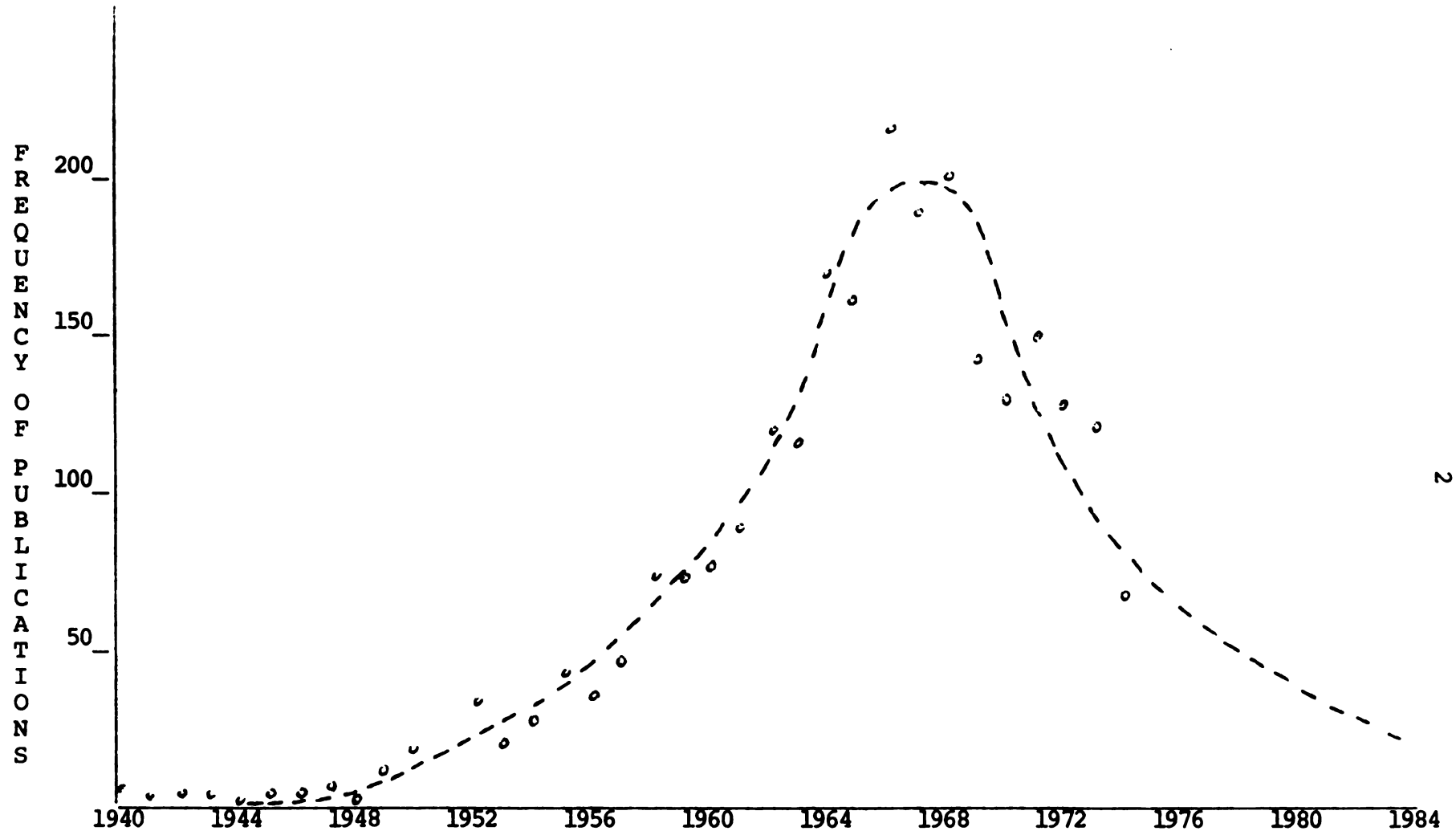


Figure 1. The Number of Diffusion Documents Published Per Year and Recorded in the Bibliography on the Diffusion of Innovations (1975)*

*Rogers and Thomas (1975)

reached its peak in about 1968, then followed publication of Rogers with Shoemaker's Communication of Innovations, 1971. This text integrated about 1500 diffusion research findings from several research traditions, both U.S. and international, and incorporated communication theory. About 45 percent of the studies were from the rural sociology tradition and about eight percent from communication. It is particularly the rural sociology tradition that will be reviewed here.

The oldest research tradition was, in fact, anthropology, but it had a great influence on diffusion studies in rural sociology. Anthropology introduced the term diffusionism; "the point of view in anthropology that explains change in a society as a result of the introduction of innovations from another society" (Rogers with Shoemaker, 1971, p 48). A particular concern among diffusionists was the introduction of modern Western ideas to primitive societies, and there was a tendency to emphasize social consequences of innovations. Exemplar publications of the anthropology research tradition were:

Ralph Linton The Study of Man, 1936;

Homer G. Barnett Innovation: The Basis of Cultural Change, 1953; and

Edward H. Spicer Human Problems in Technological Change, 1967

(Rogers, 1962, pp 24-28; Rogers with Shoemaker, 1971, pp 48-52).

Early research in sociology by Tarde (1903) contributed some important concepts to diffusion of innovations. However, the sociology research tradition did not start until the 1920s, continuing into the 1940s. The motivating interest was diffusion of innovations which promised to contribute major social changes (Rogers, 1962, pp 28-31; Rogers with Shoemaker, 1971, pp 52-53).

These studies in anthropology and sociology initiated the most significant research tradition in diffusion of innovations: rural sociology. As a research tradition, it was associated with the Land Grant Colleges in extension education to U.S. farm families, and commercial interests selling farm technology. The Hatch Act (1887) created the Agricultural Experiment Stations to boost agricultural research but it was soon realized that there was a large and growing gap between research and practice. Hence, adult education activities were sponsored by the Smith-Lever Act (1914) creating the Federal Extension Service, and the Smith-Hughes Act (1917) creating Vocational Agriculture training. There was a need for techniques to effectively communicate new ideas and practices to farmers. In the 1920s the U.S. Department of Agriculture launched a series of evaluation studies of diffusion campaigns. The measure of rate of adoption was developed (Rogers, 1962, pp 31-32; Bohlen, 1964, pp 265-266; Rogers with Shoemaker, 1971, p 53).

The classic studies of diffusion in rural sociology were mainly in the 1940s with the number of studies increasing rapidly in the 1950s and 1960s. Diffusion became the second most important topic researched in rural sociology (Rogers, 1962, p 4) and occupied several sessions of the Annual Meetings of the Rural Sociological Society. Most rural sociologiests were employed by the Land Grand Colleges with finance provided through Agricultural Experiment Stations and the U.S. Department of Agriculture. Exemplar publications of the rural sociology tradition were:

> North Central Rural Sociology Subcommittee for the Study of Diffusion of Farm Practices How Farm People Accept New Ideas, 1955;
>
> Eugene Wilkening "Communication and Technological Change in Rural Society," "The Process of Acceptance of Technological Innovations in Rural Society" in Alvin Bertrand's Rural Sociology, 1958;
>
> Herbert F. Lionberger Adoption of New Ideas and Practices, 1960;
>
> North Central Rural Sociology Subcommittee for the Study of Diffusion of Farm Practices Adopters of New Farm Ideas: Characteristics and Communication Behavior, 1961;
>
> Joe M. Bohlen "The Adoption and Diffusion of Ideas in Agriculture" in James Copp's Our Changing Rural Society, 1972

(Rogers, 1962, pp 36-38; Bohlen, 1964, pp 266-268; Rogers with Shoemaker, 1971, pp 55-57).

There were two important aspects of this particular phase of the rural sociology tradition that apply to this thesis. The social-psychological approach was used to

determine relationships among individual personality characteristics, first by Wilkening (about 1951) and then by many others (Rogers, 1962, p 36). Lionberger noted that there was scant attention given to sociological theory at this time, and the overriding tendency was towards raw empiricism (Rogers with Shoemaker, 1971, p 56). These are pertinent because in more recent times diffusion thought has been criticized for having a psychological or individualistic bias (Rogers, 1973; Bostian, 1974; Haven, 1975).[2]

In the 1960s the number of publications strictly in the rural sociology tradition level off, then started to decline. However, there was integration of several research traditions into "a single, integrated body of concepts and generalizations" (Rogers with Shoemaker, 1971, p 95). The two key volumes in this consolidation were:

Everett M. Rogers Diffusion of Innovations, 1962; and

Everett M. Rogers with F. Floyd Shoemaker Communication of Innovations: A Cross-cultural Approach, 1971.

Diffusion thought was encased in a more general theory of social change (Larson and Rogers, 1964, pp 39-40; Rogers with Svenning, 1969, pp 3-10; Rogers with Shoemaker, 1971, pp 6-18; Rogers and Burdge, 1972, pp 10-16). Social change was analyzed using the typological tradition of sociology that was particularly popular in the 1950s (McKinney and Loomis, 1961) in an effort to account for the role of structure of the social system.

The theory construction and testing procedure used for this integration was middle range analysis as a "rapprochement between research and theory" (Rogers with Shoemaker, 1971, p 47). However, the contributions of Robert Merton (1957) were not restricted to this theoretical tool. Concepts such as cosmopolite-localite and function-dysfunction were incorporated. The effect of the Merton brand of theoretical sociology on diffusion thought has also been reason for recent criticism.[3]

In the late 1960s diffusion of innovations "went international." A number of researchers who had previously worked in the rural sociology tradition, transferred their research locations to developing countries such as Colombia, Taiwan, India, Kenya and Nigeria. The U.S. Agency for International Development funded much of this research. Although this phase of diffusion may have started as a cross-cultural testing of diffusion generalizations, it was responsible for a partial merger of diffusion of innovations with communication development (Berlo, 1968, preface; Rogers with Svenning, 1969, pp vii-ix; Rogers with Shoemaker, 1971, pp xvii-xix).

Communication development was a research tradition that originated prior to the "decade of development" of the 1960s. It had hitherto led a separate existence from diffusion of innovations. Of particular interest was the role of mass media in national development. Key publications in this field were:

Daniel Lerner The Passing of Traditional Society, 1958;

Lucian W. Pye (ed.) Communication and Political Development, 1963;

Wilbur Schramm Mass Media and National Development; and

Daniel Lerner and Wilbur Schramm (eds.) Communication and Change in Developing Countries, 1967.

The integration of aspects of communication development into diffusion knowledge introduced new concepts such as modernization, development and empathy. The logic of the connection was detailed in Joseph Ascroft's Ph.D. Dissertation Modernization and Communication: Controlling Environmental Change (1969) and exemplified in the publications:

David K. Berlo (ed.) Mass Communication and the Development of Nations, 1968; and

Everett M. Rogers with Lynne Svenning Modernization Among Peasants: The Impact of Communication, 1969.

The increased importance of communication theory, and with it the individual-level concepts involved (Rogers with Shoemaker, 1971, pp 6-7, 11-16) reinforced the psychological bias. This extension of diffusion knowledge to other cultures has been significant because it is from this phase that most criticisms of diffusion of innovations has occurred.[4]

In summary, the most important single research tradition in diffusion - rural sociology - has undergone several phases. It culminated in the classical diffusion model of Rogers with Shoemaker (1971).

Classical Diffusion Model

The classical diffusion model is the "single, integrated body of concepts and generalizations" that appears in Rogers with Shoemaker's Communication of Innovations, 1971. The basic elements are outlined here.[5]

An innovation is defined as an idea, practice, or object perceived as new by an individual (p 19). Diffusion is the subprocess by which these new ideas are communicated to members of a social system. Communication is the process by which messages are transferred from source to receiver (p 11). Diffusion is a special type of communication in which there are four main elements: (1) the innovation (2) which is communicated through certain channels (3) over time (4) among the members of a social system (p 18). These elements of diffusion differ only in nomenclature from the essential elements of most communication models. There is close correspondence with the S-M-C-R model of Berlo (1960) as shown in Figure 2.

COMMUNICATION	Source	Message	Channel	Receiver
DIFFUSION	Inventor Change agent Opinion leader	Innovation	Communication channels	Members of a client system[6]

Figure 2. Correspondence Between the Elements of Diffusion of Innovations and the S-M-C-R Communication Model

The classical diffusion model deals with communication and change at two levels: (1) attitude and behavioral change for the individual participating in the innovation-decision process, and (2) social change for the client system measured by rate of adoption.

The innovation-decision process is the mental process through which an individual passes from first knowledge of an innovation to a decision to adopt or reject, and to confirmation of that decision (p 25). Four main steps are conceptualized in this process: (1) knowledge, (2) persuasion, (3) decision, and (4) confirmation. The knowledge function occurs when the individual is exposed to the innovation's existence and gains some understanding of how it functions. The persuasion function occurs when the individual forms a favorable or unfavorable attitude toward the innovation. The decision function occurs when the individual engages in activities which lead to a choice to adopt or reject the innovation. The confirmation function occurs when the individual seeks reinforcement for the innovation-decision that has been made. The process is shown in Figure 3.

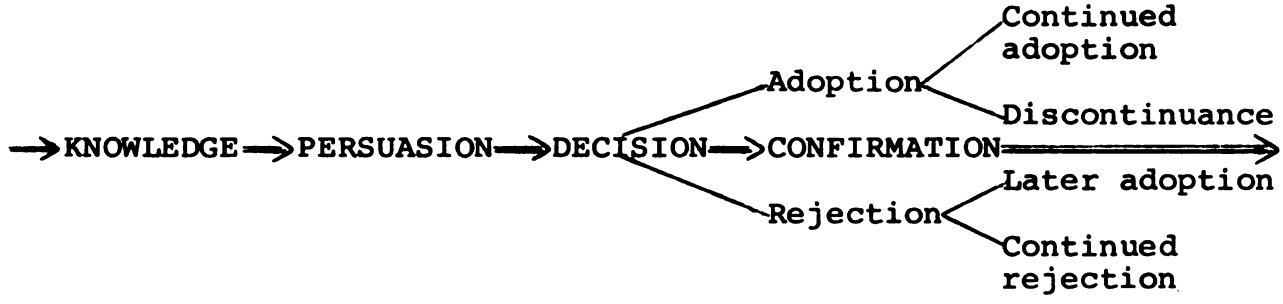


Figure 3. The Innovation-decision Process (p 102)

Adoption is a decision to make full use of a new idea as best course of action available (p 26). The innovation may then be used continuously or rejected at a later date: discontinuance. The alternative may be to reject the new idea, but with the possibility of later adoption. Discontinuance and later adoption occur from messages received for confirmation which were contradictory to the initial decision.

Innovativeness is the degree to which an individual is relatively earlier in adopting new ideas relative to the other members of a social system (p 27). On the basis of innovativeness, these individuals are classified into five adopter categories: (1) innovators, (2) early adopters, (3) early majority, (4) late majority, and (5) laggards. Rate of adoption is the relative speed with which an innovation is adopted by members of a social system (pp 27-28). This is usually measured by the length of time required for a certain proportion of members of a system to adopt an innovation. Important variables explaining the rate of adoption are: (1) perceived attributes of the innovation, (2) nature of the communication channels, and (3) nature of the social system (Figure 4).

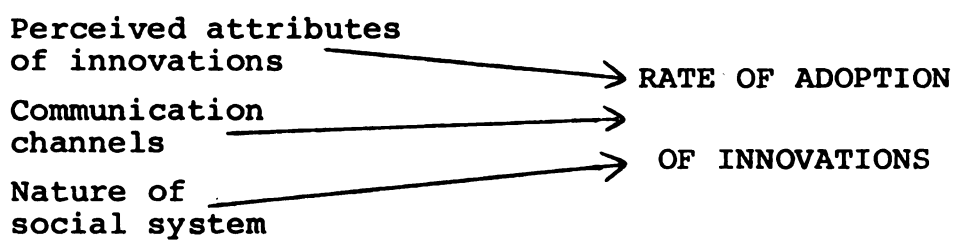


Figure 4. Variables Determining Rate of Adoption (p 158)

To the extent that the members in a social system are differentiated, there is structure in the system. The social structure acts to impede or facilitate the rate of diffusion and adoption of new ideas through what are called system effects. System effects are the influences of the system's social structure (norms, statuses, heirarchy, etc.) on the behavior of the individual members of the social system (p 29). These may be as important in explaining individual innovativeness as the individual characteristics themselves. Diffusion may also change the structure of the social system. Diffusion and social structure are interdependent: structure affects diffusion, and diffusion affects structure.

The application of the classical diffusion model to agricultural extension in the U.S. has generally been considered successful. However, some recent studies have exposed its limitations when applied to agricultural development in other countries. These anomalies of application are worth studying in some detail. Not only have they prompted a criticism of the theory of diffusion of innovations in the cross-cultural setting, but also give some clues to the biases and limitations in application to U.S. agriculture.

Anomalies of Application

Three separate studies will be described that demonstrate the psychological bias inherent in the classical

diffusion model, and its inadequacy for predicting consequences.

Institutional Constraints - Colombia

Havens and Flinn (1975) examined the diffusion of new coffee-producing technology (new varieties, fertilizers, herbicides) to a region in Colombia, from 1963 to 1970. Of the original 64 owner/renter families, 17 adopted the innovations. Meanwhile, 11 of the nonadopters had become landless rural and urban laborers.

The adopters increased real income faster than the nonadopters who had remained in farming, and the differential in income was largely accounted for by adoption of the new technology. The adopters were able to acquire additional land, and the average acreage for nonadopters still farming actually decreased.

This may appear to be a typical diffusion situation except in this case nonadopters were measured and found to represent a majority of the intended client system. It was not the personal characteristics of the farmers that best explained this adoption pattern, but a factor called "institutional constraints" (Aiken et al., 1974). Because adoption of the new technology meant a substantial loss in income for several years, financial assistance was required. Yet credit availability was contingent on applicants having some formal education, which many farmers did not have. Consequently, members of the client system did not have equal access to

financial assistance and so many of those who did not adopt were not rejectors but nonparticipants. Lack of adoption was partly due to the institutional constraints of perceived or real blocks to credit availability (Havens and Flinn, 1975).

Structural Differentiation - Bangladesh/Pakistan

Gotsch (1972) compared the distributive consequences of an innovation for two different social systems. The innovation was the tube well which was capable of irrigating 50 to 80 acres of farmland. The two situations were Bangladesh and Pakistan. In Bangladesh the median farm size was 1 to 2.5 acres and with a relatively equal distribution across size categories. In Pakistan the median size was 7.5 to 12.5 acres with a concentration of landholding among a few farmers.

Although less than one percent of the Bangladesh farms were large enough to adopt the innovation either singly or in partnership, adoption proceeded through cooperative village wells. However, 50 percent of the Pakistan farmers were potential adopters, and the rate of adoption was high. In Bangladesh smaller farmers benefited from the tube wells as much as larger farmers. The distribution of benefit was fairly equitable. In Pakistan 70 percent of the tube wells were controlled by farmers with more than 25 acres. Only four percent of the farmers with 0 to 13 acres had adopted. The innovation added to the personal power of the community leaders and the marketing of water to nonadopters was not

optimum as if a free market had prevailed. Access to irrigation water was necessary to take full advantage of the Green Revolution technology that was available to all of these farmers.

Again the individual characteristics of the farmers were less explanatory than social structural factors. Where there was a low degree of structural differentiation, benefits were distributed relatively evenly. Where there was high structural differentiation, there was a concentration of benefits to the more-advantaged.

Imperfect Equalizer - Kenya

Roling et al. (1976) saw diffusion processes as "imperfect equalizers." Findings from their Tetu Extension Project in Kenya support some logical reasons for this phenomenon. There were eight innovations involved in this study, and farmers were ranked using a progressiveness index which reflected the number adopted and the time for each. The more progressive farmers had greater financial resources, larger farms, better access to water and labor, and were more likely to have a fully titled farm.

Roling et al. (1976) described the following imperfections due to diffusion. Innovations do not come one at a time such that one diffusion process finishes before the next begins. Instead, innovations come in rapid succession. While less progressive farmers were still adopting earlier innovations, the more progressive ones were already

benefiting from recently introduced ones. Early adopters get windfall profits, from the price differential when the product is still relatively scarce and there are incentives for increased production. This additional advantage could be social as well as economic, such as the added prestige of being the first to use a new idea. Innovations take time to diffuse, rarely less than five years. Later adopters not only have less resources for adoption, but over time may find necessary acquisition of additional resources to be more expensive.

The classical diffusion model condones the progressive farmer strategy (Roling et al., 1976). Assessment of extension communication in the Tetu Project showed that the progressive farmers received disproportionate attention. Thus, new information was channeled through a fixed clientele, strengthening their advantages through earlier adoption. Diffusion practice also tends to assume that the innovation is the message, yet communication messages lose fidelity very quickly. The progressive farmer may have an accurate, first-hand message but rapid distortion through diffusion means the less innovative are less likely to benefit from new technology. Thus, the more-advantaged persons get additional benefits of earlier knowledge, higher quality information, higher proportion of necessary resources and additional incentives.

This role of diffusion in creating inequitable development had been confirmed by earlier studies (cited by Roling

et al., 1976). The second phase of the Tetu Project was specifically focused on less progressive farmers and succeeded in raising their level of adoption relative to the more progressive farmers. It was concluded that "it is not the characteristics of farmers as much as it is the characteristics and deployment of (change agency) services which are prime determinants of diffusion efforts" (p 168).

The limitations of the classical diffusion model for Colombia, Bangladesh/Pakistan and Kenya fall into two categories. Firstly, there was an inability to account for social structural variables that were more complex than simple aggregation of individual characteristics. Secondly, there was an inability to predict events that followed the first innovation-decisions, particularly beyond the specific social system for which the innovations were intended. The first limitation has been the object of the recent critique of diffusion theory. The second limitation leads to consideration of consequences of diffusion of innovations.

The Recent Critique

These anomalies of applying the classical diffusion model should not be viewed as isolated cases. There has been a growing literature that is critical of the cross-cultural application of diffusion theory from its North American origins.[7] Two publications that contributed to this recent critique are:

> Robert H. Crawford and William B. Ward (eds.) Communication Strategies for Rural Development, 1974; and

Everett M. Rogers (ed.) "Communication and Development: Critical Perspectives" Communication Research, 1976.

The majority of the critics agreed that the main deficiency of the classical diffusion model was its "insensitivity to contextual and social-structural factors in (Latin American) society" (Beltran, 1976, p 108). This has been labeled an individualistic or psychological bias (Rogers, 1973; Bostian, 1974; Havens, 1975). Beltran (1976) attributed this to the historical origins of communication science and to the ideological underpinnings of diffusion theory.[8]

> Certain general assumptions, explicit or not, were made in and for the situation of highly developed countries (such as the United States) and then uncritically applied to the different conditions of Latin America and other countries. One basic assumption of the diffusion approach is that communication itself can generate development, regardless of socio-economic and political conditions. Another assumption is that increased production and consumption of goods and services constitute the essence of development, and that a fair distribution of income and opportunities will necessarily derive in due time. A third assumption is that the key to increased productivity is technological innovation, regardless of whom it may benefit and whom it may harm (pp 110-111).

Analysts of the Latin American experience with diffusion challenge these assumptions. They contended that technological diffusion and growth is not what is needed, but an overall change of social structure as the prerequisite to development.

Beltran (1976) explained that the origin of such assumptions lies with the historical development of communication as a new academic discipline in the U.S. War time propaganda

campaigns in Nazi Germany stimulated the initial concern with political persuasion. This knowledge was applied to advertising, education and agricultural extension, but within the specific structural constraints of the U.S. This was a period of growth, prosperity and relative stability.

> It was also a society where individuality was predominant over collectivism, competition was more determinant than cooperation, and economic efficiency and technological wisdom were more important than cultural growth, social justice, and spiritual enhancement (Beltran, 1976, p 115).

Consequently, "exaggerated emphasis was placed by communication researchers on the individual as the unit of analysis to the neglect of relationships between sources and receivers" (Beltran, 1976, p 116).

To make generalizations from such individual-oriented studies is to engage in aggregate psychology. In the theory of diffusion there had developed the assumption that individual decision-makers have equal control over their destiny, through equal access to the innovation, and equal access to the information and other resources needed for adoption. However, it is clear from the case studies and the recent critique that potential adopters will not be equally predisposed to defining the adoption situation as a desirable or attainable condition for themselves.

Person-Blame Causal Attribution Bias

Caplan and Nelson (1973) have warned of possible unanticipated and negative consequences of applying psychological

thought and research to the problems of society. Bias is initiated when defining the problem. Problem definitions are based on assumptions about the causes of the problems. They determine the change strategy, course of action and criteria for evaluation. If the problem is defined in person-centered terms then it is logical to initiate person-change treatment techniques. External factors would be assumed to have little importance. If the explanations are situation-centered then efforts toward solution would logically have a system-change orientation.

Psychological research focuses on person-centered variables which creates a person-blame causal-attribution bias when applied to social change. Person-blame is the tendency to hold individuals responsible for their problems. The alternative is system-blame, where the social structure is held accountable for the problems. Caplan and Nelson (1973) claim that there is a subtle political advantage of person-blame research for those agencies initiating planned change programs, and for those controlling resources. Person-blame interpretations are in everyone's interests except those subjected to the analysis.

Diffusion research has concentrated on psychological-level variables. Yet social change occurs in a context of institutions and social structure. Thus, it was inevitable that diffusion practice should have a person-blame causal-attribution bias.

Conclusion

The classical diffusion model has limitations in cross-cultural application. Its psychological bias is obvious in underdeveloped countries. This begs the question: Has there been the same limitations and bias in application of the classical diffusion model to a highly developed country such as the United States? The remainder of this thesis will support the yes answer.

The cross-cultural experience revealed that the theory of diffusion could not predict events that followed the first innovation-decisions. Further discussion will show that little research effort has been put into predicting consequences of diffusion of innovations. Chapter II will review the work that has been done, and establish some guidelines for further analysis. Chapter III will discuss methodological issues for measurement and theory construction. Chapter IV examines consequences of one diffusion process in the U.S.: mechanization of agriculture. The result is a greater understanding of consequences as a subprocess of social change, and realization that the classical diffusion model has its limitations in the United States.

FOOTNOTES

[1]This distribution of research publications over time was calculated from Rogers and Thomas' Bibliography on the Diffusion of Innovations published in April, 1975. It is probable that a number of publications prior to that date had not yet been detected, and 15 months have elapsed since. For example, Brown (1974, 1975) has edited two issues of Economic Geography dealing exclusively with spatial diffusion. However, it still seems as though the frequency of publications has declined since 1968. See Bostian (1974) for several factors thought responsible for this decline.

[2]See further discussion in this chapter, pp 17-20.

[3]See Chapter II, pp 34-44.

[4]See further discussion in this chapter, pp 12-19.

[5]This whole section is adapted from Rogers with Shoemaker (1971), and the relevant page numbers of that text follow definitions.

[6]The term client system is used to distinguish diffusion receivers from any other social system. Although it may imply planned change, this is not necessarily the case.

[7]See in particular the following:
From Crawford and Ward (1974) - Beltran, pp 11-16; Rogers, pp 50-59; Diaz-Bordenave, pp 205-208; Bostian, pp 226-227;
From Rogers (1976) - Beltran, pp 107-126; Diaz-Bordenave, pp 139-145; Roling et al., pp 157-164; Rogers, pp 227-230;
From other sources - Marceau (1972), Rogers (1973), Golding (1974), Rogers (1975).
Note that diffusion is not the only approach to development; alternative approaches may be better suited (Havens, 1972).

[8]Beltran's article, "Alien Premises, Objects, and Methods in Latin American Communication Research" (pp 107-134), is an excellent discussion on which the rest of this section is based.

CHAPTER II

CONSEQUENCES OF INNOVATIONS: THEORETICAL CONSIDERATIONS

Introduction

The three cross-cultural studies demonstrated the inadequacy of diffusion knowledge to predict consequences beyond adoption of the innovation. This deficiency is related to psychological bias, in that it suffers from an inability to explain the role of social structure in the diffusion and consequences processes. Another reason is the few studies of consequences that have been done.

In the 1971 analysis of nearly 1500 diffusion publications, only 38 investigated consequences (Rogers with Shoemaker, 1971, p 324). Almost one-fourth of these appeared in a single volume of case studies (Spicer, 1952). Rogers with Shoemaker provided three generalizations about consequences: (1) one concerning intrinsic elements of the innovation, supported by a participant observation study, and (2) two concerning the role of the power elite, one supported by a case study and the other without support at all. Certainly, there have not been satisfactory longitudinal nor comparative studies.

Consequences are not new to social thought:

> In some one of its numerous forms, the problem of unanticipated consequences of purposive action has been treated by virtually every substantial contributor to the long history of social thought. The diversity of context and the variety of terms by which this problem has been known, however, have tended to obscure the definite continuity in its consideration. In fact, this diversity of context - ranging from theology to technology - has been so pronounced that not only has the substantial identity of the problem been overlooked, but no systematic, scientific analysis of it has as yet been effected" (Merton, 1936, p 894).

And the situation still appeared unchanged in 1971:

> In spite of the importance of consequences, they have received very little study by diffusion researchers. The data we have about consequences are rather 'soft' in nature; most of them are based on case studies only. Lack of research attention and the nature of data make it difficult to generalize about consequences" (Rogers with Shoemaker, p 319).

A survey of social science texts found no conceptual treatment of consequences as a social process, even though one well known book (Etzioni and Etzioni, 1964) included consequences in its title.[1]

It will be fruitful to trace the history of the little work that has been done on consequences before establishing some guidelines for further study.

The Conceptual Heritage of Consequences

Unanticipated Consequences of Purposive Social Action

Merton stated in 1936 that although the problem of unanticipated consequences of purposive social action had been recognized by many social scientists and philosophers, there had been "no systematic, scientific analysis of it." Although

40 years have elapsed, the Merton primer to this area of study is extremely useful and is summarized here.

The elements of this analysis need to be defined. Action may be differentiated into two types: (1) unorganized; and (2) formally organized. The particular concern is with formally organized actions; those from "when like-minded individuals form an association in order to achieve a common purpose" (p 896). Formally organized actions may grow out of unorganized actions. Purposive social action is the "action which involves motives and consequently a choice between various alternatives" (p 895). There is correspondence between purposive action and what is generally called planned change. Rogers with Shoemaker defined planned change as "caused by outsiders who, on their own or as representatives of change agencies, intentionally seek to introduce new ideas in order to achieve goals they have defined" (1971, p 9). Diffusion practice is most often of the planned change type. Consequences of purposive social action were rigorously defined by Merton as "those elements in the resulting situation which are exclusively the outcome of the action; i.e., those elements which would not have occurred had the action not taken place" (p 895). However, a strict definition like this creates methodological problems in attributing causation. More realistically the consequences are those elements resulting "from the interplay of the action and the objective situation (the conditions of action)" (p 895). These

consequences may not only be for members of the designated system, but also for others mediated through the social structure or culture of society at large. Unanticipated consequences of purposive social action are those that were unforeseen by participants in the process, but are not necessarily undesirable (Merton, 1936).

Merton's focus was exclusively on unanticipated consequences, yet for a theory of consequences there must also be account for anticipated consequences. Anticipated consequences are those foreseen by the actors or members of the designated system. This raises another methodological problem in what is the designated system and who are its members? Meanwhile, the overwhelming need for a theory of consequences is for prediction of unanticipated consequences, and hence the importance of Merton's analysis. He raised two methodological issues. Firstly, there is "the problem of ascertaining the extent to which consequences may justifiably be attributed to certain actions" (p 897). This is the task of attributing causation.[2] Secondly, there is the problem "of ascertaining the actual purposes of a given action" (p 897). This relates to the distinction between anticipated and unanticipated consequences from ex post facto measurement. The original purposes may be partly concealed by subsequent rationalizations.

In practice, there are several limitations to correct anticipation of consequences (Merton, 1936). Firstly, there

is inadequate current knowledge and this certainly typifies the general situation for diffusion of innovations. However, increased research is not necessarily the complete solution. Most social research finds correlational rather than causal relationships. Judged from the three studies described earlier, it seems that many facts and details are needed for even highly approximate predictions of unanticipated consequences. Attempting to gather this knowledge is costly and time consuming.

A second limitation to correct anticipation of consequences is occurrence of error in the prediction procedure. Mistakes can be made in appraisal of the change situation; in converting such observations into a prediction; in selection of an appropriate course of action; or, in execution of the chosen action. Consequences from error in prediction are unanticipated. Thirdly, the overriding concern for immediate consequences may exclude consideration of further consequences from the same diffusion process. Fourthly, such a constraint may come from the basic values held by the participants. Lastly, the very actions of making predictions may affect the dynamics of the social system and cause changes in behavior. Thus, there are several practical limitations to prediction of consequences, in addition to the prime consideration of this thesis - an inadequate theory.

Consequences may occur within or outside the "designated system," when defined for the purposes of diffusion of

innovations. Merton (1936) recognized the importance of the interplay between the designated system and the broader social system in which it is placed. Actions may be initiated in a selected and defined social system with a known set of dominant values, but consequences are not restricted to that system nor to that value set. These "external" consequences are generally unanticipated and ignored. Yet given the interrelationships of the designated system with larger society, outside changes can react on that system and create further changes within it. This phenomenon has been conceptualized as interdependence.[3] Like causation, it is a very important notion for the analysis of consequences of innovations.

An enlightening but little known advance of Merton's conception was in Philip Selznick's study of the Tennessee Valley Authority (1966, pp 253-259). The subtitle - "A Study in the Sociology of Formal Organization" - indicates that his intended application was more restricted than for diffusion of innovations, but important issues were raised,

> It is a primary function of sociological inquiry to uncover systematically the sources of unanticipated consequences of purposive action (Selznick, 1966, p 254).

Although a certain set of causal factors may result in a certain action, the meaning of that action can only come from the realm of its consequences. The consequences ramify widely in a social system. Those chosen for study will be a mere subset of the total and are almost certain not to

coincide with the stated goals of that particular action.

> Hence, the notion of unanticipated consequence is a key analytical tool: where unintended effects occur there is a presumption, though no assurance, that sociologically identifiable forces are at work (p 254).

For Selznick, the notion of commitment "defined the inherent predisposition for unanticipated consequences" to occur.

> A commitment in social action is an enforced line of action; it refers to decision dictated by the force of circumstance with the result that free or scientific adjustment of means and ends is effectively limited (1966, p 255).

The change agency is committed to certain objectives (ends) and strategies (means). The designated system is committed by the nature of that system and its members, by the nature of the social and cultural environment, and by the centers of interest generated in the course of action. The commitments for a change process in a social system define the character of that system. The importance of this notion of commitment is that tensions are bound to occur, and where they do occur, "significant possibilities inherent in the situation have not been taken into account (a breakdown in control)" (p 258). Thus, minimization of intended consequences will be achieved to the extent that theory indicates the sociological forces at work.

This rather abstract treatment of consequences has raised more questions than it answered. However, there are some valuable insights for further discussion.

(1) The distinction between anticipated and unanticipated consequences is sociologically significant, with the latter reflecting a lack of understanding of causal forces at work on the designated system, and hence a lack of control by that system.

(2) The relationship between the designated system and the larger social system needs to be understood.

(3) Sophisticated research methods are needed to attribute causation and to separate out unanticipated consequences.

The Classical Diffusion Model

A more recent conceptual treatment of consequences of innovations appeared in Rogers with Shoemaker (1971) Communication of Innovations.[4] It is reviewed here.

Consequences and Social Change. Social change[5] is the process by which alteration occurs in the structure and function of a social system (p 7). The structure of the social system is provided by various statuses which compose it. Status refers to the rights and obligations of an individual or group that accompany occupancy of a position in a social system (Galloway, 1974b, p 3). The functioning element within this social structure is role behavior. Role refers to reciprocally held expectations about performance that accompany occupancy of a position (Galloway, 1974b, p 3).[6] Social function and social structure are closely interlinked.

An innovation may bring about social change via the three sequential steps: (1) invention, (2) diffusion, and (3) consequences. These subprocesses are shown in Figure 5. Invention is the subprocess by which these new ideas are created or developed. Diffusion is the subprocess by which these new ideas are communicated to members of a social system as a result of the adoption or rejection of the innovation (p 7).

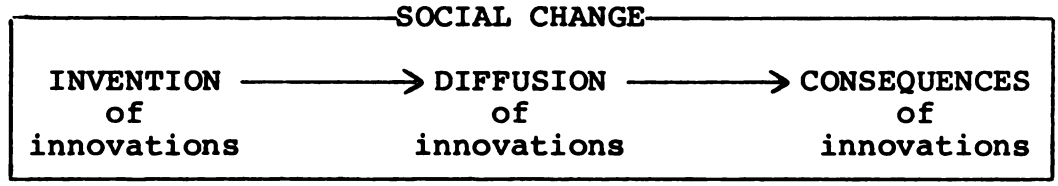


Figure 5. The Process of Social Change

An innovation is of little value until it is distributed to members of the system and used by them. Thus, invention and diffusion are but means to an ultimate end: consequences from adoption of the innovation. The diffusion subprocess is a necessary and sufficient condition for occurrence of the consequences subprocess.

An innovation is an idea, practice, or object perceived as new by an individual (p 19). It may be invented within the social system (immanent change) or outside the social system (contact change). The recognition for the need to change may be by members of the social system (selective change) or by agents external to that system (directed change). The classical diffusion model is particularly oriented to

directed, contact change. This planned change[7] is caused by external change agencies and their agents who intentionally seek to introduce innovations according to certain goals (pp 8-9). The target social system is the client system.[8]

Classification of Consequences. Consequences may be simply divided into desirable versus undesirable. The concept of cultural relativism is important here. It is the viewpoint that each culture should be judged in light of its own specific circumstances and needs (p 325). Consequences should be measured as to their desirability in terms of the clients' culture, without imposing the outside evaluator's normative beliefs about the needs of the client system. Measurement of desirability is difficult.

Rogers with Shoemaker (1971, pp 330-335) have classified consequences into: (1) functional versus dysfunctional, (2) direct versus indirect, and (3) manifest versus latent. Functional consequences are desirable effects of an innovation in a social system. Dysfunctional consequences are undesirable effects of an innovation in a social system (p 330). The determination of whether consequences are functional or dysfunctional depends on how the innovation affects adopters. Functionality may differ between consequences to the social system overall and those to the individuals within the system, or between some individuals or groups and others. Functionality also depends on time. An innovation's short run and long run effects may be quite different.

Direct consequences are those changes in a social system that occur in immediate response to an innovation. Indirect consequences are changes in a social system that occur as a result of direct consequences of an innovation (p 333). Manifest consequences are changes that are recognized and intended by the members of a social system. Latent consequences are changes that are neither intended nor recognized by members of a social system (p 333). Almost no innovation comes without "strings attached." The more "revolutionary" the innovation, the more likely its introduction is to produce many consequences; manifest and latent.

This list of types of consequences need not end here. The important point is that consequences are not unidimensional.

Ideal Rate of Change. Change agencies must be concerned with consequences of innovations, and are in the strategic position to not only predict such consequences but have some degree of control over them. A major question for change agents is: What is the ideal rate of change? The long range goal should be to produce dynamic equilibrium in the social system (pp 338-340). Equilibrium is the tendency of a system to achieve a balance among various forces operating within and upon it (p 339). Dynamic equilibrium occurs when the rate of change in a social system is commensurate with the system's ability to cope with it (p 339). When the rate of change is too rapid for adjustment there is disequilibrium.

Theoretical Underpinnings

Many of the concepts introduced so far were adapted from systems analysis (Parsons, 1968) and from functional analysis (Merton, 1967). Further discussion of these two approaches to social change will help clarify some of the sources of criticism of the classical diffusion model.

Systems Analysis. Systems analysis provides specific meanings to the concepts social system, interdependence and function. The social system "is generated by the process of interaction among individual units. Its distinctive properties are consequences and conditions of the specific modes of interrelationship" among those units (p 459). Thus, a basic distinction is made between the unit or "actor" and the social system. The social system does not occur in isolation but in a context of superordinate systems and may contain more than one sybsystem. Interdependence between units may occur within the system or across system boundaries. The concept function applies to the development and maintenance of interchanges across system boundaries (Parsons, 1968).

Functional Analysis. Functional analysis, as developed by Merton (1967), is a tool for sociological interpretation. It can be applied to any phenomenon, provided that the object of analysis can be standardized. Function is a basic concept. A source of confusion in functional analysis is the failure to separate the "subjective dispositions (motives, purposes)" of the actors from the "objective consequences (functions,

dysfunctions)" for those actors. This is partly due to the several, varied meanings of function.

> We have observed two prevailing types of confusion enveloping the several current conceptions of "function":
>
> (1) The tendency to confine sociological observations to the positive contributions of a sociological item to the social and cultural system in which it is implicated; and
>
> (2) The tendency to confuse the subjective category of motive with the objective category of function.
>
> Appropriate conceptual distinctions are required to eliminate these confusions.
>
> The first problem calls for a concept of multiple consequences and a net balance of an aggregate of consequences.
>
> Functions are those observed consequences which make for the adaptation or adjustment of a given system; and dysfunctions, those observed consequences which lessen the adaptation or adjustment of the system. There is also the empirical possibility of non-functional consequences, which are simply irrelevant to the system under consideration.
>
> In any given instance, an item may have both functional and dysfunctional consequences, giving rise to the difficult and important problem of evolving canons for assessing the net balance of the aggregate of consequences. (This is, of course, most important in the use of functional analysis for guiding the formation and enactment of policy.)
>
> The second problem (arising from the easy confusion of motives and functions) requires us to introduce a conceptual distinction between the cases in which the subjective aim-in-view coincides with the objective consequences, and the cases in which they diverge.
>
> Manifest functions are those objective consequences contributing to the adjustment of the system which are intended and recognized by participants in the system;

Latent functions, correlatively, being those which are neither intended nor recognized.*

---

*The relations between the "unanticipated consequences" of action and "latent functions" can be clearly defined, since they are implicit in the foregoing section of the paradigm. The unintended consequences of action are of three types:

(1) those which are functional for a designated system, and these comprise the latent functions;
(2) those which are dysfunctional for a designated system, and these comprise the latent dysfunctions; and
(3) those which are irrelevant to the system which they affect neither functionally nor dysfunctionally, i.e., the pragmatically unimportant class of nonfunctional consequences (Merton, 1967, p 105).

The first solution of "a net balance of an aggregate of consequences" is restrictive. In practice, it can only be calculated by addition/subtraction of unit-level measures, weighting each unit equally, to give the aggregate score. It is necessary "to consider a range of units for which the item has designated consequences: individuals in diverse statuses, subgroups, the larger social system and culture systems" (Merton, 1967, p 106). Consequences may be functional for some units and dysfunctional for others.

The second solution of manifest-latent functions has been expanded since. Elements were termed manifest if intended and recognized by participants in the system of action, and latent if neither intended nor recognized. In addition, they may be termed UIR if unintended but recognized by participants and IUR if intended but not recognized

(Levy, 1968, p 25). The potential classification scheme for consequences becomes more complex (see Figures 6 and 7).

	Recognized	Not recognized
Intended	MANIFEST	IUR
Unintended	UIR	LATENT

Figure 6. Types of Functions/Dysfunctions

	Functional	Dysfunctional	Nonfunctional
Manifest			
IUR			
UIR			
Latent			

Figure 7. Types of Objective Consequences

Many concepts from systems analysis and functional analysis were incorporated into the classical diffusion model. The notion of systems, superordinate systems and subsystems is useful. The "given" or "designated" system is not a closed system, but interacts with its environment. One of the inadequacies in prediction of consequences has been for unanticipated consequences outside the immediate client system. Interdependence is important to analysis of cause-effect. The relationship must have direction in the causal sense, which may not be obvious in time sequence. Social change can come from reciprocal yet incremental changes between variables. One strength of functional analysis is its potential to codify the dynamics of change, rather than the

statics of structure. Time is an important variable for consequences.

Some of the concepts incorporated into the classical diffusion model have been directly responsible for the recent critique of diffusion. The notions of equilibrium, functional-dysfunctional, and manifest-latent are strongly identified with "functionalism" by these critics (e.g. Beltran, 1976, pp 123-126). They have a conservative influence on the planning of social change by preservation of the status quo. In addition, the rigorous measurement of objective consequences relative to participants in the social system is impossible. Scientific observation is necessarily a subjective process, because measurement is a human performance. According to Beltran (1976) "to argue that one is objective may suggest precisely that one is subjective enough to blind oneself to the fact that one's own values are permeating the conduct of his inquiry" (p 125).

Toward a Theory of Consequences of Innovations

Critical review of the anomalies of cross-cultural application of the classical diffusion model and of the conceptual treatment of consequences, does allow refinement of knowledge of consequences of diffusion of innovations as a process. In this section a framework for study of consequences will be suggested, as well as a re-definition and reformulated classification scheme for consequences.

Framework for Study of Consequences

Consequences has been conceptualized as a separate and subsequent subprocess to diffusion of innovations, and has its methodological and theoretical requirements. It is important to clarify this distinction. In diffusion research the main dependent variables have been innovativeness (for the individual) and rate of adoption (for the client system). The independent variables have included perceived attributes of the innovation, communication channels, and individual and system characteristics. Innovation-decision is a necessary condition for consequences to occur. Thus, diffusion research falls one step short of consequences. Appropriate research on consequences of innovations would require that diffusion variables (innovativeness, adoption/rejection, etc.) become the predictor of an ultimate dependent variable, consequences of diffusion of innovation (Figure 8).

	DIFFUSION		CONSEQUENCES
Variables	independent	old dependent new independent	new dependent
Individual	Personal, social characteristics	Innovativeness (individual-decision)	Consequences
System	Attributes of innovation Communication channels Nature of social system	Rate of adoption (system decision)	Consequences

Figure 8. Framework for Studying Consequences[9]

This framework becomes the basis for further analysis in this thesis. Consequences occur over time and it would seem logical that longitudinal studies are qualitatively superior.

Levels of Consequence

In this section the preceding definition and classification of consequences will be criticized, and a new definition and reduced classification provided.

Definition of Consequences. Consequences of innovations were defined as the changes that occur within a social system as a result of adoption or rejection of an innovation. The innovation-decision may be optional, collective or authority. Authority decisions are forced upon the individual by someone else with strategic power. The optional decision is made by the individual regardless of the decisions of others in the client system. The collective decision is made by consensus in the client system (Rogers with Shoemaker, 1971, pp 269-270). To define consequences as changes occurring after an adoption/rejection decision is too restrictive.

Firstly, consequences is a process following on from diffusion. The change agency has a limited end-in-view if it is concerned with consequences of the innovation per se, rather than consequences of the diffusion process. By definition, planned change requires that the change agency interfere with the client system. This interaction will cause changes other than from the adoption/rejection of the innovation. Therefore, it is more accurate to seek a

definition for consequences of diffusion of innovations, rather than consequences of innovations.

Secondly, consequences do not necessarily occur exclusively to those individuals, groups or organizations that decide to adopt or reject an innovation. It is possible that some make the decision, and the repercussions are felt by others who have not decided, and by the social system as a whole. The Colombian example demonstrated this. Here was a situation where a certain proportion of the client system did not have the means to participate in the innovation-decision. They were not rejectors but were nonadopters. Yet the consequences of the agricultural development program were real enough. The instant the first decision is made regarding adoption or rejection, is arbitrarily assigned the point from which consequences may occur for any individual, group or organization of that social system. Hence, consequences are an outcome of the diffusion process having taken place, such that at least one person has participated in the innovation-decision.

A re-definition of consequences of diffusion of innovations is appropriate. Consequences are any changes that occur to a social system or any member of it, as a result of diffusion of an innovation that achieves at least one adoption or rejection. The nonadopters are also susceptible to consequences in varying degrees.

Classification of Consequences. As previously noted, the distinction between anticipated and unanticipated consequences is sociologically significant. Unanticipated consequences represent a lack of understanding of the internal and external forces at work on the client system, and its relationship with the larger social system. Recognizing the methodological problems raised by Merton (1936), this classification into anticipated and unanticipated consequences is retained for further analysis.

The divisions function-dysfunctional and manifest-latent were taken from Merton's (1967) functional analysis. Some of the recent criticism of diffusion theory has been directed at "functionalism." According to Beltran (1976), functional is that which contributes to the adjustment of a given system while dysfunctional leads to the breakdown of that system. Underlying functionality is the notion that a social system naturally requires equilibrium. Although the desired equilibrium may be dynamic equilibrium, this social change is more an adaptation or adjustment than structural change. Dysfunction is not seen as a potentially desirable transformation of the social system. Critics claim that functionalism accepts the status quo. In addition, there can be no "magical objective quality" in functional analysis as compared to other approaches to scientific observation. Functionalism is conservative and not free of value bias. On this basis the classification by functional-dysfunctional

and manifest-latent is rejected.

There is also a practical reason for rejecting the notion of dynamic equilibrium. The ideal rate of change would have to be judged in terms of the clients' specific circumstances, but which client? It may be feasible to have an optimum for the system overall, but consequences are unlikely to be distributed evenly across its members. It seems reasonable to assume that every diffusion of innovations process has some undesirable consequences for some people. There is no ideal rate of change, only varying degrees with differential impacts at each point for system members.

It is difficult to avoid a value judgment as to the desirability of consequences on the individual, group or organization concerned. They may be evaluated as good-bad, positive-negative or desirable-undesirable. Each observer will have his/her own frame of reference, influenced by cultural norms and personal beliefs. However, it is better to make a subjective judgment with awareness of possible bias than to believe that objective judgments can be achieved. On this basis, and again recognizing the methodological problems involved, the classification into <u>desirable and undesirable consequences</u> is retained for further analysis.

The third classification to be retained is the direct-indirect distinction. If consequences are conceptualized as a collection of dependent variables in cause-effect relation-

ship with an independent variable (individual and/or collective innovation-decision behavior), these relationships may be of the first order, while others are mediated through intervening variable(s) (later order). A direct (primary) consequence has direct link to the independent variable, while an indirect (secondary) consequence is linked through two or more steps to the independent variable.

These three dichotomies are analytically independent: (1) anticipated-unanticipated as perceived by the change agent(s) responsible for the diffusion process; (2) desirable-undesirable as perceived by the individual, group, social system affected by the consequence; and (3) direct-indirect according to the nature of the cause-effect relationship.

Distribution of Consequences

There is a growing concern for distribution of life chances, and particularly the inequalities of this distribution. For example, the once popular "subculture of poverty" paradigm (Lewis, 1966) explaining poverty has fallen out of favor and the "blaming the victim" explanation (Ryan, 1971) is now popular. Existing theories whether they be neo-classical economics, or structural-functionalism, or diffusion of innovations, have been found incapable of explaining inequalities. Recent efforts to include a distributional dimension in communication and development will be reviewed.

Rogers with Shoemaker (1971, p 342) made the distinction between one type of consequence of innovation as a "higher

level of good" whereas another type is the "distribution of such good." In practice, most development programs are designed to improve overall levels of development in the client system. The objective is increased average production, average education, average income, etc. for the system as a whole. This levels-raising goal has been termed the "first dimension of development" (Rogers, 1974, p 53).

As the case studies indicate, such activities may widen the differences that separate the "more-advantaged" and "less-advantaged" segments of a social system. Even though aggregate statistics show improvements, those that most need help may receive little benefit. Rural development programs should be designed to play a redistributive role in the client system: the "second dimension of development" (Rogers, 1974, pp 53-54). This means attempting to close the differentials in production, education, income, etc. The second dimension calls for further understanding of the structure and function of the social system. It is not merely a question of aggregating individual consequences to give a net balance, but being able to relate the spread of possible outcomes to the distribution of characteristics among segments of the social system. The second dimension of development is a change in distribution of benefits.

This two-dimensions concept could apply to consequences of innovations.

Substructural Rates of Change. There is a growing literature dealing with the distribution of effect from communication programs (Rogers, 1974; Galloway, 1974ab; Shingi and Mody, 1976). It has been implicitly assumed that maximum level of effect from any communication event for the intended audience is the desired result. However, there has been recent awareness that such an event can create a widening gap between the more-advantaged and less-advantaged segments of that audience. This discrepency was called the "knowledge gap" or "communication effects gap."

Tichenor et al. (1970) found support for the knowledge gap hypothesis in studying the effect of mass media:

> As the infusion of mass media information into a social system increases, segments of the population with high socioeconomic status tend to acquire this information at a faster rate than the lower status segments, so that the gap in knowledge between the segments tends to increase rather than decrease (pp 159-160).

They expressed this as a cumulative social change model: that subsystems already occur as differentiated by patterns of behavior, beliefs and values and by technology, and gaps will widen depending on how conducive the elements of these subsystems are to change. The lower status segments do not necessarily remain uninformed but their growth in knowledge is relatively less (Tichenor et al., 1970; Shingi and Mody, 1976).

The knowledge gap hypothesis has been given a broader form: communication effects gap.

> Attempts at change-oriented communication over time tend to widen the gap in effects variables between the audience segments high and low in socio-economic status (Rogers, 1974, p 55).

This hypothesis is not limited to mass media nor to knowledge effect, and there have been a number of studies to support it (see Shingy and Mody, 1976, pp 174-175).

Why do communication effects gaps occur?

> The explanations include (1) differential levels of communication skills between segments of the total audience; (2) amounts of stored information (that is, existing levels of knowledge) resulting from prior exposure to the topic (such receivers would be better prepared to understand the next communication); (3) relevant social contact (there may be a greater number of people in the reference groups of the more advantaged segment, and these receivers may have more interpersonal contact with other information-rich individuals); and (4) selective exposure, acceptance, and retention of information. Thus to the extent that communication skills, prior knowledge, social contact, or attitudinal selectivity is engaged, the gap should widen as heavy mass media flow continues (Shingi and Mody, 1976, p 175).

Galloway (1974b) further explored the role of structure in diffusion of innovations and interpreted it as the study of "substructural rates of change" and "criterion gaps." A substructure is some specified part of a social system which is defined by reference to certain statuses and roles. Substructures may be defined on the basis of socioeconomic status, or any other sociological variable. Tichenor et al. (1970) defined substructures by education in order to study differential patterns of information acquisition over time from the mass media. Substructural criterion gaps are simply

observed differences at one point in time between specified substructures in criterion variables of interest; for example, knowledge of innovations (Galloway, 1974b, p 7). It is assumed that criterion gaps may increase or decrease over time, resulting in differences in substructural rates of change.

None of these hypotheses specifically relate to consequences of innovations. The dependent variable is generally knowledge or adoption. The commonality between communication effects gap and consequences of innovations is the role of social structure in the distribution of effects/consequences between segments of a social system. Galloway's notion of criterion gaps and substructural rates of change has potential application to consequences. The criterion on which gaps are measured could be a consequence variable. Such an approach would address the claim that the adverse distributive effects of technological change in agricultural development programs must be attributed to the social and institutional context in which that change occurs. For Gotsch (1972) this would be an investigation "carried out in the context of a conceptual framework that shows how the characteristics of the technology, local institutions, and the rural social structures are related to each other at a point in time and how these relationships can be expected to evolve in a dynamic rural system" (p 338). The Bangladesh/Pakistan study illustrated this approach.

In sum, consequences can be measured on two dimensions: (1) the level of consequence, and (2) the distribution of consequence. Methodologically, the analysis of level is relatively straight-forward. It may be expressed as an aggregate total or as a measure of central tendency; most often it is the statistical mean per analytical unit.

Analysis of distribution is more complicated. As opposed to central tendency, the statistical measures themselves deal with variance, skewness and/or kurtosis. Economists have a number of ways of measuring distribution of income (Jain, 1975, pp xi-xv) including Gini ratios and frequency by percentile groups (e.g., Bonnen, 1972, pp 238-243). Social scientists have also attempted to measure distribution (Alker, 1964; Haller, 1970). Careful operationalization of Galloway's substructural criterion gaps and measurement over time would provide a useful addition to these techniques.

Conclusion

This critical review of literature relevant to an emerging theory of consequences of diffusion of innovations, resulted in the following guidelines for future study.

Framework for Consequences:

Diffusion	Consequences
independent variables	dependent variables
individual innovation-decision (innovativeness)	consequences
collective innovation-decision (rate of adoption)	consequences

Definition of Consequences:

> Any changes that occur to a social system or any member of it, as a result of diffusion of an innovation that achieves at least one adoption or rejection.

Classification of Consequences:

> Anticipated-Unanticipated
> Desirable-Undesirable
> Direct-Indirect

Dimensions of Consequences:

> Level
> Distribution

These guidelines will be employed in Chapter IV, dealing with the consequences of mechanization in U.S. agriculture. Meanwhile, some methodological issues need to be considered.

FOOTNOTES

[1]This does not deny the concern of anthropologists with consequences of social or cultural change (e.g. Spicer, 1952). However, their dominant research methodology has been the case study which offers little scope for generalization to other situations. The limitations of case studies will be discussed further in Chapter III, pp 70-74.

[2]See Chapter III, pp 64-74.

[3]See further Chapter III, pp 66.

[4]This review is adapted from Rogers with Shoemaker, pp 318-345. Many of the concepts defined will be used throughout the rest of the thesis. The key ones are underlined and followed by the appropriate page number in the text.

[5]The term social change will replace the previously used term action.

[6]The psychological bias of the classical diffusion model is evident. Social structure has more "extra-individual" aspects than is implied here.

[7]The term planned change can be substituted for the previously used purposive social action.

[8]The term client system will replace designated system.

[9]This framework specifies consequences for the individual and for the social system. This is important because consequences for the system are not necessarily a aggregation of individual consequences. The framework is adapted from Rogers with Shoemaker (1971, p 323).

CHAPTER III

CONSEQUENCES OF INNOVATIONS: METHODOLOGICAL CONSIDERATIONS

Introduction

Earlier discussion has elaborated on the need for a sociological perspective and offered guidelines for further study of consequences. A theory of consequences must come from the development of useful and valid propositions for consequences of diffusion of innovations. Hence, it is now opportune to review the principles of theory construction, and the research methodologies needed.

Propositions for a Theory of Consequences[1]

Definitions and Strategies

The case studies demonstrated that a problem with diffusion practice is the anti-social distribution of consequences. However, what is needed to take ameliorative action is the ability to anticipate consequences. If change agents/agencies and members/institutions of the client system can predict likely consequences with some reliability, certain corrective measures can be undertaken to avoid diffusion practice becoming the "imperfect equalizer" for which it is accused.

Prediction is necessary for the development of knowledge. Description, based on observation of events as they occur, does not contribute to knowledge until that information is applied outside that specific situation. To apply this information to other situations is to make a prediction. In order to predict, there needs to be understanding of the relationships between events. This is not merely describing or observing these events, but determining the associations between such events, and the causal mechanisms (if any) between them. The attempt to understand and to predict in social science has most frequently been termed explanation. Explanations may be found wanting in the light of more recent information, but extension of these earlier explanations through prediction contributes to the improvement in scientific knowledge. Explanation is the difference between social science and social description or social observation.

"To ask for an explanation in science is thus to ask for a theory" (Zetterberg, 1965, p 11). A theory is a system of explanations. The quest for prediction is the quest for explanation, which in turn, is the quest for a theory. A theory of consequences of innovations is essential to prediction of consequences and therefore to good diffusion practice.

Strategies for Developing Scientific Knowledge.[2] There are two basic approaches for developing a scientific body of knowledge: (1) research-then-theory (inductive) and (2) theory-then-research (deductive). The research-then-theory approach reflects the assumption that there are specific and

identifiable patterns in the environment ("laws of nature") and that the task of scientists is to discover these patterns. A phenomenon is selected, measured and analyzed to determine if there are any systematic patterns among the data "worthy" of further attention. Significant patterns are then formalized into theoretical statements. The utility of this approach depends on there being only a few significant patterns and a relatively small number of variables for measurement. In reality the number of variables is infinite, and in many cases there is lack of agreement among social scientists as to what are the important variables. There may then be too many potential relationships between such variables so that the problem of finding substantively interesting patterns is overwhelming.

The theory-then-research approach reflects the assumption that scientists impose their descriptions on the phenomena studied. Scientific activity becomes the process of inventing theories and testing them with an appropriate research project. The major focus of this strategy is the development of an explicit theory through a continuing interaction between theory construction and empirical research. The essence of this approach is the selection of theoretical statements for testing. A great deal of effort is needed to develop theories and social scientists tend to become ego-involved. This makes it hard to discard a theory that fails to be supported by empirical evidence.

These alternative approaches need not be mutually exclusive. There may be value in some compromise between them. The Communication of Innovations review (Rogers with Shoemaker, 1971) was largely of the research-then-theory type. About 1500 publications dealing with empirical research were analyzed to produce 103 generalizations for diffusion theory. However, this thesis is more akin to the theory-then-research approach. This is seen as more efficient because in dealing with consequences there is the difficulty of measurement, and in using a sociological approach there is the complexity of social systems. In terms of the total sequence of theory construction, testing, reformulation, further testing, etc., the thesis only initiates the process for developing a theory of consequences. The earlier chapters established guidelines within which to work. Generalizations concerning consequences of mechanization in U.S. agriculture will be used to test the utility of these guidelines.

Heirarchy of Theories.[3] Communication of Innovations employed the theory of the middle range which was a strategy developed by Merton (1957, pp 5-10). These are partial theories rather than inclusive theories. The middle range theories are specific enough that there can be the interplay between theoretical concepts and empirical data, whether theory-then-research or research-then-theory. The more inclusive theories are the grand theories as typified

by Parsons (Mills, 1959, ch 2). Abstracted to a higher level of generality; they have been criticized for being difficult to comprehend and to test empirically. However, inclusiveness is a matter of degree. Middle range theory, particularly the two concept generalizations that predominate in Rogers with Shoemaker (1971), can be too simple or too specific.

> Middle range generalizations (should) become stepping stones to more general theories of social change, once they are abstracted to get a higher level of generality (Rogers with Shoemaker, 1971, p 91).

The treatment of theory of consequences of innovations in this thesis will be more partial than inclusive. Given that there presently is no theoretical framework for consequences (although there are more general theories of social change) it would be premature to attempt theory invention at the more abstract level. Also empirical testing of the theoretical statements derived in this thesis will be essential to fidelity of a theory of consequences of innovations. This thesis is in the middle range tradition.

Conception of Theories.[4] At present there seem to be three different conceptions of how scientific knowledge can be organized to constitute a theory: (1) set-of-laws, (2) axiomatic, and (3) causal process.

The set-of-laws approach "is to accept only those statements that can be considered laws as part of scientific knowledge. A set of laws is then considered to be the

theory" (Reynolds, 1971, p 83). The necessary precision for statements to be considered laws usually precludes explanation of variables and their interrelationship(s) for social phenomena. Concepts that cannot be defined operationally and measured are excluded.

The axiomatic form of theory "is typically defined as an interrelated set of definitions and statements . . ." (Reynolds, 1971, p 92). The statements are ordered into axioms and propositions. The axioms are the set of statements from which all propositions in the theory are derived. This logical system of relationships and derivations is extremely difficult to apply to social phenomena. These two conceptions of theories as they apply to sociology may be described as analytical (Fallding, 1968, p 24). Their strict requirements are satisfied at the expense of explanatory power. The causal process form of theory is more useful.

The causal process form of theory is compatible with the axiomatic form. The major difference is that all statements in the causal process theory are considered to be of equal importance, and not classified into axioms and propositions. The causal process form provides greater explanatory power of relationships between variables. However, there is the problem of definition of the boundary of the causal process. A process has no real constraints and so arbitrary limits must be imposed. It is difficult to know

at what point all the steps in the causal linkage have been specified. The causal process form is the way most theories in social science are developed.

The causal process conception of theory is most appropriate to consequences of innovations. Important notions about consequences are: (1) process, and (2) social system. In a process, events lead to other events over time, with no real beginning or end; only arbitrarily imposed ones. The social system is a complex pattern of interrelationships such that changes in one sector can be responsible for changes in other segments of the system. In these circumstances the causal process form of theory has the flexibility to deal with social situations, particularly concepts that are difficult to measure, and has the explanatory power suited to developing a theory of consequences of innovations.

Statements.[5] Statements are the basic elements of theory. In fact, a theory is merely a collection of statements. At the core of scientific knowledge are statements that describe the relationship between two concepts. Relational statements can be classified into two types: (1) associational, and (2) causal. Associational statements describe what concepts occur or exist together. This correlation is operationalized as a coefficient that ranges from zero (no association) to unity (perfect association), and may be positive or negative. Causal statements describe the causal relationship between the occurrence of two concepts.

Causation not only requires a "strong" association but also explanation and directionality in the relationship.[6] Association is a necessary but not a sufficient condition for causation.

Theoretical statements may be given any of five different labels: (1) laws, (2) axioms, (3) propositions, (4) hypotheses, and (5) empirical generalizations. Consistency in the use of these labels is desirable. Their use depends on the relationship between the statement and systematic theory or empirical finding. A law is a statement that describes a relationship in which scientists have so much confidence they consider it the truth. Axioms are the basic set of statements, each independent of the others, from which all other theoretical statements may be logically derived. The derived theoretical statements are propositions. Hypotheses are statements selected for comparison against data collected in a concrete situation. All concepts in a hypothesis should be measurable. If the same pattern of events is found in a number of different empirical studies, the pattern becomes an empirical generalization. The use of these terms depends on which conception of theory is being developed, and its relationship to theory and data.

The question is what form of theoretical statement is appropriate for construction of a theory of consequences? In the theory-then-research strategy for developing a causal process theory, theory invention becomes formulation of

propositions and theory testing becomes testing of hypotheses. The end results are empirical generalizations, such as those derived in Communication of Innovations (Rogers with Shoemaker, 1971). There have not been sufficient studies of consequences of innovations to meaningfully support generalizations. At best it would be possible to provide hypotheses.

Concepts.[7] The basic unit of theory is the concept. However, for the purposes of theory development, concepts cannot be judged apart from their use in statements. Ideally they should provide clarity in description and in measurement. Like statements, concepts may be abstract or concrete. The abstract concepts are those that occur completely independent of time and place. If a concept is specific to a time or place, it is a concrete concept. A statement is basically the description of a relationship between two or more concepts. Since relations are always considered abstract, the level of abstraction of statements will depend on the level of abstraction of the concepts. The abstract concept can be divided into: (1) theoretical concept, and (2) operational definition. The theoretical concept is any concept more abstract than an operational definition or procedure of measurement that is considered to be a part of a theory or potentially useful for inclusion in a theory. The operational definition is a set of procedures that describes the activities an observer should perform in order to receive

sensory impressions that indicate the existence, or degree of existence, of a theoretical concept.

For the initial stage of theory construction in this thesis the concern is with theoretical concepts. Through a six-tiered operation these concepts can be synthesized into a tentative theory of consequences of innovations so as to improve diffusion knowledge and practice (Figure 9).

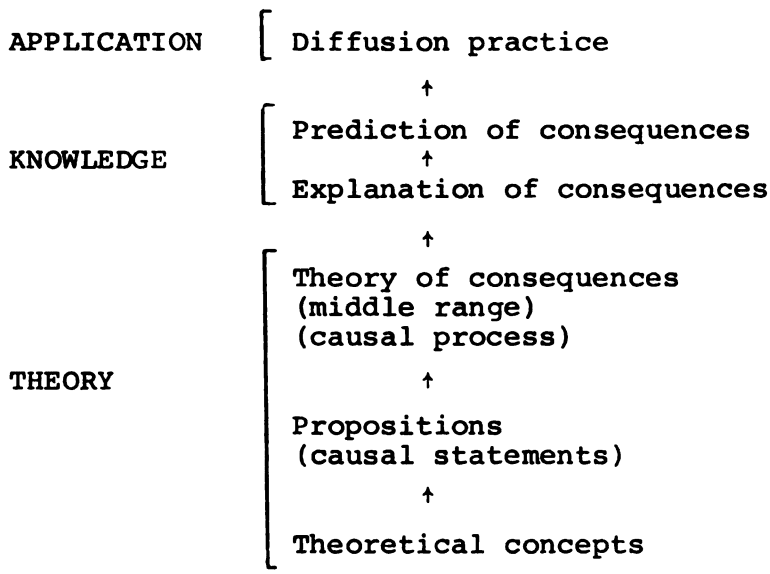


Figure 9. Tiers of Theory Construction for Better Diffusion Practice

Generalizations for Consequences of Mechanization[8]

Definitions and Strategies

The three case studies concerned with consequences of innovations covered a relatively short time period when considered in the context of the consequences process. Only several years elapsed from introduction of the innovation to

measurement of consequences. Only members of the immediate client system were surveyed, though there may have been effects on the larger system. For the purposes of theory construction these studies were truncated. Consequences of mechanization in U.S. agriculture is a process that has been occurring at least 40 years, and some would claim 140 years. It has affected more people now outside the farm client system than those within. The consequences have been anticipated-unanticipated, desirable-undesirable, direct-indirect, and levels raising-distributive. They were part of a very important change process.

To initiate a theory where little existed before is a difficult exercise. However, to describe and rationalize a consequences process that embraces the issues raised in the critique of diffusion research would seem to provide valuable heuristic assistance. A schema of generalizations with consequences of mechanization as the dependent variable will give sensitivity to the sociological principles that need be considered. In Chapter IV these consequences will be systematized into causal statements at the concrete level.

Variables: Independent and Dependent.[9] Variables are concepts operationalized for measurement purposes, and hence concrete causal statements relate variables to one another. As previously noted these relationships between concepts/variables may be associational or causal. Association is a necessary requirement for causation. Another necessary

requirement for causation is directionality - that the cause precedes the effect in time. The variables are labeled according to direction (Figure 10).

CAUSE ⟶ EFFECT	
Independent variable	Dependent variable
Antecedent Determinant	Consequent Result

Figure 10. Labels for Variables in Causal Relationships

There is a minimum requirement of two, variables for one relational (causal) statement. Many statements contain more than two and in sociology, it is normal that events have multiple antecedents and/or multiple consequents. Given this complexity, the task becomes overwhelming. Statements with two variables are acceptable as intermediary steps in theory construction, if they employ the notion of ceteris paribus or, "all other things being equal." However, in dealing with consequences of mechanization, the other known antecedents controlled by ceteris paribus will be specified, and intervening variables will be used where appropriate.

Basically, all mechanization statements will have degree of mechanization as the antecedent or independent variable. Direct consequences will be first-order consequents and indirect consequences will be second-order consequents (Figure 11).

Independent variable ⟶	Dependent variable Intervening variable Independent variable ⟶	Dependent variable
Antecedent ⟶	First-order consequent ⟶	Second-order consequent
Example: Degree of mechanization	Example: Decreased farm labor	Example: Rural-urban migration

Figure 11. Structure of Generalizations for Consequences of Mechanization

That is, the antecedent is nominated as degree of mechanization and all the other possible antecedents are "frozen" by ceteris paribus, and then the causal relationship established with the first-order consequent which is decreased farm labor in this case. The first-order consequent becomes the antecedent in the second-step relationship with second-order consequents; that is rural to urban migration. Thus, the first-order consequent is the intervening variable. The purpose of the exercise is to build a complex of two variable statements that are causal.

The Logic of Causation.[10] Specification of any causal relation has a level of uncertainty. In establishing criteria for accepting/rejecting causal relationships there is need for balance between reducing the risk of nominating generalizations that in reality are not causal, and maintaining adequate explanatory power by not being too dogmatic on acceptance of potential causal relations. Causation has been

given a great deal of attention in sociology. It will become evident in Chapter IV that attributing causation of social, economic and environmental consequences to mechanization in U.S. agriculture has been a controversial exercise. A detailed treatment of the logic of causation is warranted.

For the purposes of this thesis, criteria for causality will be based on those suggested by Paul F. Lazarsfeld. His three requirements in a causal relationship were:

> (1) that the cause precede the effect. This will be called directionality.
>
> (2) that the two variables be empirically correlated to one another. This will be called association.
>
> (3) that the observed empirical relationship cannot be 'explained away' as being due to the influence of some third variable that causes both of them. This will be called explanation (Babbie, 1975, p 370).

Directionality:[11] This criteria may appear simple and obvious, yet there are problems in establishing directionality. Zetterberg (1965, pp 69-74) lists a variety of causal linkages that include:

> A relation may be reversible (if X, then Y; and if Y, then X) or irreversible (if X, then Y; but if Y, then no conclusion about X).
>
> . . . the relation may be a sequential one (if X, then later Y) or a coextensive one (if X, then also Y).
>
> . . . where X is the independent variable (cause) and Y is the dependent variable (effect).

Reversible propositions and coextensive propositions are common in sociology. Given that causal relations need not be irreversible and sequential, the difficulty with the

directionality criterion is evident.

It is useful to identify a special type of relation that is reversible and sequential, and applicable to consequences of mechanization: interdependence.

> Let Δx and Δy be small increments in variables x and y, respectively. An interdependent relation is present when the following conditions are met:
>
> If x changes from x_1 to x_2, and $x_2 = x_1 + \Delta x$, then and only then, y changes from y_1 to $y_1 + \Delta y$; further, when y changes from y_1 to y_2 and $y_2 = y_1 + \Delta y$, then and then only, x changes from x_2 to $x_2 + \Delta x$, etc.
>
> Thus, in an interdependent relation, a small increment in one variable results in a small increment in a second variable; then, the increment in the second variable makes possible a further increment in the first variable, which in turn affects the second one, and so this process goes on until no more increments are possible. Note, however, that an immediate large change in one variable will not bring about a large change in the other variable. The only way a large change is brought about in an interdependent relation is through a series of interacting small changes (Zetterberg, 1965, pp 72-73).

It will be seen that mechanization of agriculture is at the heart of many social changes. However, it is not merely a case of adopting the innovation and then consequences occurring sequentially and irreversibly. For example, a small decrease in farm labor supply may lead to limited adoption of labor substituting machinery, which in turn, leads to further decreases in labor, and so on. This is the interdependence relation.

Association:[12] For propositions concerning causal linkages between variables:

> . . . a relation may be deterministic (if X, then always Y) or stochastic (if X, then probably Y) (Zetterberg, 1965, p 70).

A more popular term for stochastic is probabilistic. Deterministic relations are very rare in sociology, and thus, a perfect correlation between variables is not a criterion for casuality. In the probabilistic models of social science there are almost always exceptions to the posited relationship. There is uncertainty in how great the empirical relationship must be for it to be considered causal.

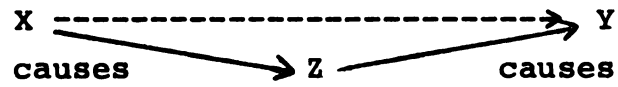
In this context it is useful to consider a popular criterion for causation: necessary and sufficient conditions. A variable X is a necessary condition for variable Y, if X must be present for Y to follow. A variable X is a sufficient condition for variable Y, if the presence of X invariably and inevitably results in occurrence of Y. If these conditions could be met then there would be conclusive evidence of causation. However, seldom in social sciences are causes both necessary and sufficient, nor, in practice are they perfectly necessary or perfectly sufficient. Thus, absence of necessary and/or sufficient conditions should not be an argument against causation. The probable existence of either can be the basis for a posited causal relationship.

Explanation:[13] This criterion for causality is the most complex and the most controversial. It is derived from the elaboration model (Kendall and Lazarsfeld, 1950, pp 131-196) and dealt with under the label of explanation or spuriousness. The function of the elaboration model is to understand the relationship between two variables through the simultaneous introduction of third variables. Mechanically, the sample under study is divided into subsets according to a selected third variable (test factor) and partial relationships computed. The comparison of partial and whole relationships, and the sequential position of the test factor with respect to the original variables, indicates the presence or absence of a causal link. The three relevant patterns of elaboration are: (1) explanation, (2) interpretation, and (3) specification.

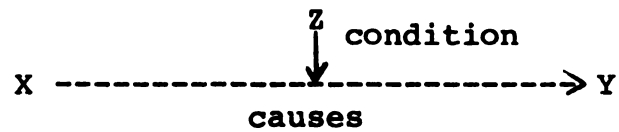
Explanation is used where the researcher is satisfied that the first of two variables causes the second, but only after eliminating all possible third factors.

The test factor must be antecedent (or consequent) to both original variables (X,Y) and the partial relationship must be zero or significantly less than was found in the original. To achieve explanation is to establish nonspuriousness.

Interpretation is similar to explanation, except that the test factor intervenes sequentially in the relationship.



The partial relationships are still zero or significantly less than the whole. Specification is when the relationship between two variables is altered as the test factor is altered. Whereas in interpretation the constancy of the function between two variables is a function of the alteration of the third and more or less guaranteed by it; specification is a matter of specifying the conditions under which different relationships between the first pair of variables hold. That is, the relationship itself changes with the differing values of the third variable.



The elaboration model is a logical device for assisting the researcher in understanding the data. By empirically discounting all possible third variables, causation can be established.

The elaboration model and the notion of explanation have been criticized for being too rigid (Fallding, 1968; Galtung, 1967). It is impossible to empirically eliminate all possible third factors. And in constructing

generalizations regarding consequences of mechanization, there are few instances where the elaboration model has been applied. All possible third factors will not have to be eliminated to establish causality. A causal linkage is acceptable where degree of mechanization (or its first order consequents) varies with and before other variables, provided fitness can be ascribed to that linkage. This "fitness" is loosely described as explanatory power that is additional to the requirements of directionality and association. Possible third factors will be mentioned.

The purpose here is not to explain all, but to describe the data on consequences of mechanization more succinctly and systematically. This involves simplification to pairs of variables connected by verbal definitions and mathematical equations, and rebuilding this series of interconnections into a schema. The term explanation is given a more general meaning, to account for the probabilistic associations, the limited knowledge of third factors, and also the inclusion of nonempirical factors. This "leniency" is justified in the greater understanding that will come from such treatment of consequences of mechanization in U.S. agriculture.

Methods of Establishing Causation.[14] In social research there is typically a gap between theory, which is often framed in causal process language, and methodology, which leads to statements about correlation coefficients. As we have seen the causal language is too dogmatic and the

correlational language is too weak. The basic difference between causation and correlation is the element of time. Correlations are time-bound, where causal process is time-ordered. Correlations for many individuals at one point in time are an insufficient basis for inference about what will happen to one individual over a period of time, although it is certainly a good basis for hypothesis formation. There are two reasons why we cannot in general infer from synchronic correlation (one point in time) to diachronic relationship (several points in time). Firstly, synchronic correlation does not account for possible changes of relevant conditions in the context of the relation. This is the problem of eliminating third factors. Secondly, synchronic correlation cannot guarantee against discontinuous jumps in combinations of variables.

> The researcher can only infer from a correlation to a process if (three) additional conditions are fulfilled:
>
> (1) the correlation holds if the same unit is measured at several points in time, not only if many units are measured at once;
>
> (2) the variables are also correlated with time, so that the finding actually refers to a covariation between time and two other variables; and
>
> (3) one of the variables can be manipulated, that is one can determine the value (at least within a range of variation) (Galtung, 1967, pp 472-472).

This support for causal generalizations comes from correlational statements and processual data. The important question is how to get processual data. A general answer is to include time as a variable in research; hence longitudinal

research. However, care is still needed.

Consider some of the methods that account for time. Trend data do not by themselves represent a solution. They are not diachronic because the same units are not measured several times. They are merely a set of synchronic studies ordered in time. The panel study by itself has limitations. Although it is diachronic, the time interval usually has to be short to avoid excessive panel mortality. This limits its applicability to short term processes. The retrospective technique by itself has limitations because of the differential memory effect from personal interviews, or changing criteria when working with secondary data. Although each method by itself makes a limited contribution to processual data, a combination of the three should give value.

In dealing with consequences of mechanization, the time intervals for longitudinal studies have been short compared to the length of the social process itself. This being the case, the existing methodologies (with computer simulation as a possible exception) are ill equipped to establish the causal process. However, if some utility is to come from the numerous contributions to consequences of mechanization, there needs to be some "leniency" in methodological criteria for causality. Both longitudinal and cross-sectional data will be considered under the following conditions:

(1) Cross-sectional studies are a good basis for generalizations when they are used in conjunction with

longitudinal data. Given a satisfactory index of mechanization, synchronic data can fulfil the association requirement. Cross-sectional studies can also contribute to explanation, through logical description of the mechanics of the relationship. For example, some of the economic analysis of the capital-for-labor substitution process helps attribute increased mechanization as a cause of decreased farm labor.

(2) Longitudinal studies are necessary for generalizations concerning consequences of mechanization. Trend data also establish association but not directionality nor explanation. However, combined with explanatory cross-sectional analysis, reasonable postulates of causality can be made. For example, the increase in farm workforce (the trend data) completes the proposition that increased mechanization caused decreased farm labor. Panel studies and retrospective techniques satisfy the requirements of association and explanation. There is a problem with directionality, because rarely are the relationships an obvious, continuous and one-way process. More commonly there is interdependence. Although it is difficult to "prove" this from the studies available, the overall schema of generalizations should be consistent with the directions postulated.

Summary: Criteria for Causality

For deriving generalizations from the studies on consequences of mechanization in U.S. agriculture, the following

criteria will apply:

Logical Criteria

(1) Directionality: that the cause precede the effect.

(2) Association: that the variables be empirically correlated or nonempirically associated.

(3) Explanation: that known third variables be accounted for, although not necessarily eliminated empirically.

Methodological Criteria

(1) Longitudinal: that time be a variable in the research. Cross-sectional studies will be used as supplemental to the longitudinal information.

(2) Trend data: that trend data are acceptable where bolstered by the explanatory power of other method-types.

(3) Panel study: that panel studies are acceptable *per se* where the time interval is sufficient.

(4) Retrospective technique: that retrospective studies be acceptable *per se* where the criteria of measurement have remained constant.

Generalizations. It has been said that this thesis is working toward a theory of the middle range and in the causal process form. Under these conditions empirical generalizations are defined as statements of relationships that recur in a number of empirical studies. However, owing to the compromises in the criteria for causality, nonempirical support will also be used. Consequently, the statements will not be purely empirical and so the more general term of *generalizations* is preferred.

In Chapter IV mechanization of U.S. agriculture will be reviewed as a diffusion process, and studies concerning consequences of mechanization incorporated into generalizations

according to the preceding criteria. This exercise will not only contribute to knowledge of mechanization as a social change process in its own right, but serve as confirmations of the preceding set of guidelines for future study of consequences of diffusion of innovation.

FOOTNOTES

[1]This section on theory invention is based on readings from Brown (1963), Fallding (1968), Nagel (1961), Przeworski and Teune (1970), Reynolds (1971), Rogers with Shoemaker (1971), Stinchecombe (1968), and Zetterberg (1965). Specific references will be acknowledged.

[2]Adapted from Reynolds (1971, pp 139-158).

[3]Adapted from Rogers with Shoemaker (1971, pp 85-95) and Zetterberg (1965, pp 14-21).

[4]Adapted from Reynolds (1971, pp 83-114).

[5]Adapted from Reynolds (1971) pp 67-82).

[6]See further discussion, pp 64-65.

[7]Adapted from Reynolds (1971, pp 45-65).

[8]This section on establishing causation is based on readings from Babbie (1975), Brown (1963), Fallding (1968), Galtung (1967), Przeworski and Teune (1970), Reynolds (1971), Stinchecombe (1968), and Zetterberg (1965). Specific references will be acknowledged.

[9]Adapted from Zetterberg (1965, pp 64-68).

[10]Adapted from Babbie (1975, pp 370-372), Fallding (1968, pp 32-36) and Zetterberg (1965, pp 64-74).

[11]Adapted from Babbie (1975, pp 370-371), Stinchecombe (1968, pp 32-36) and Zetterberg (1965, p 69).

[12]Adapted from Babbie (1975, p 371), Hirschi and Selvin (1966) and Stinchecombe (1968, pp 32-34).

[13]Adapted from Babbie (1975, pp 387-400), Fallding (1968, pp 32-36) and Stinchecombe (1968, pp 32-38).

[14]Adapted from Galtung (1967, pp 469-476).

CHAPTER IV

CONSEQUENCES OF INNOVATIONS: MECHANIZATION IN U.S. AGRICULTURE

Introduction

Consequences of mechanization in U.S. agriculture serve as an ideal illustration of the difficulties involved in isolating generalizations about consequences that have occurred. It offers the full spread of consequences: desirable - undesirable; direct - indirect; and anticipated - unanticipated. It clearly demonstrates the methodological problems involved in establishing causation, and the limitations for correct anticipation of consequences. It also is at the heart of the rural sociology research tradition of diffusion of innovations. Generalizations from this treatment of consequences of mechanization, combined with the conceptualizations from Merton (1936, 1967) and Rogers with Shoemaker (1971), will help confirm the set of guidelines towards a theory of consequences.

Mechanization of U.S. agriculture was predicted to be a significant social change process (Bonnen and Magee, 1938; Williams, 1939; Hamilton, 1939; and Raper, 1946) and more recent evidence confirms this (Beegle, 1969; Friedland, 1973; Donaldson and McInerney, 1973). It not only influences the

quality of rural life but also urban life (Fujimoto, 1969; Stockdale, 1976a). It appears to be the most important single cause of U.S. rural social change in this century.

Yet the treatment of consequences of mechanization by researchers has been both comprehensive and deficient. It has been comprehensive for the large number of studies in this general topic area, as evidenced by lengthy bibliographies (Hall, 1968; Schieffer and Fujimoto, 1969). It has been deficient because there are very few studies that have dealt with mechanization specifically as the independent variable, and its causal relationships with consequences as dependent variables. An extensive survey of the literature has found: (1) four studies that are qualitatively adequate for generalizing causal relationships between mechanization and consequences (i.e., each alone satisfied the criteria for causality);[1] (2) eight case studies that can provide strong support for such relationships;[2] and (3) four research traditions encompassing several hundred studies based on trend data, on mere speculation or on less specific independent variables. These four research traditions are: (1) agricultural engineering; (2) agricultural economics; (3) rural sociology; and (4) environmental studies. The value orientations characteristic of these research traditions have heavily influenced their interpretation of consequences. Engineers and economists have generally viewed mechanization positively, while environmentalists have generally emphasized

the negative aspects. Sociologists have had a mixed view. These deficiencies and biases in the bulk of mechanization literature had to be recognized before attempting to integrate them into valid and useful generalizations.

Mechanization as the Independent Variable

According to the analytic framework postulated in Chapter II, mechanization as the "old" dependent variable of diffusion now becomes the "new" independent variable of consequences. As such, mechanization needs to be defined conceptually, and operationalized for further analysis.

There are many varied definitions of agricultural mechanization (e.g., Gray, 1930; McMillan, 1949, p 5; Bertrand, et al., 1956, p. 3; and Jansen, 1969, p. 341). However, the central notion is that mechanization is the substitution of machine power for human power. Power requires energy input, and so it is useful to describe mechanization as the replacement of mainly on-farm animate energy input with mainly off-farm inanimate energy inputs, such as oil, coal, gas, falling water and nuclear fission (Cottrell, 1955).

A frequent oversight in the definition of mechanization in agriculture is the failure to distinguish it from industrialization or technological change. It is important to resolve this problem because different variables are implicated. The term industrialization has a multitude of

meanings and is superfluous to consideration of changes within agriculture. Technological change is the application of scientific knowledge to practical agriculture, causing increased productivity. There are two components: (1) biological advances which have increased yields through improved crop cultural and animal husbandry practices; and (2) mechanization which enabled a declining farm workforce to continue the increased production made possible by biological advances (Griliches, 1968; Rodefeld, 1974, Ch. 4). Mechanization does not increase production per unit of land per se, but allows for increased units of land operated by the same workforce, or for a smaller workforce to operate the same land area.

A serious deficiency with studies of consequences of mechanization has been the inadequate specificity in operationalizing this variable. Most studies have used the number of tractors as an index of mechanization. Case studies used indexes that were specific to the type of production; for example, number of cotton pickers or of tomato harvesters. Comparative studies used more comprehensive indexes, compiled from a diversity of statistics. The manner in which mechanization is operationalized has an important bearing on the methodological validity of the study.

Mechanization expressed as the number of tractors is a simple, convenient index which has some logic to it. Tractors are used in mechanization of most types of agricultural production in the U.S. However, there are

shortcomings. In the early part of this century, tractors were replacing draft animals as the prime source of power, but in more recent times larger tractors have replaced smaller tractors. Thus, the number of tractors no longer reflects machine power. Although tractors are represented in most types of agricultural production, there is little likelihood that they maintain a constant ratio with total machine power across production types. Indexes of mechanization used in case studies and comparative research have greater validity, but only one study attempted to construct an indicator of mechanization [3] that reliably reflects the definition of mechanization over time and across types of production.

This scarce effort given to a satisfactory measure of mechanization is a severe limitation to further analysis of consequences of mechanization. A combination of rare comparative studies with satisfactory indexes and the frequent trend data based on number of tractors will have to suffice for generalizations in this chapter; compromising fidelity for utility.

Mechanization as the Diffusion Process

The invention and adoption of machines in U.S. agriculture spans 140 years. The animal drawn plows, planters, reapers, etc. that became available during the mid and late 1800s were responsible for the transition from manpower to

animal power. The gasoline tractor appeared about the turn of the century and substitution of machine power for animal power followed for about the next 50 years. At some stage between 1935 and about 1950, the increase in machine power switched from a predominant replacement of animal power to a predominant replacement of human power. This chapter particularly focuses on 1935-1975 because it is in this period that change has been most dramatic (see Table 1), even though the causes are found right through the 140 year period.

The scientific and industrialized food and fiber system that characterizes present-day U.S. agriculture has been attributed to a unique combination of four factors:

(a) The original institutional input of the eighteenth century European capitalistic model of private ownership of land and capital as the basis for the allocation of agricultural surplus. As agriculture became commercialized in the early nineteenth century and its production took the form of commodities and ultimately money, other capitalistic concepts such as a self-adjusting market also constituted institutional foundations.

(b) An agrarian cultural system conditioned by 200 years of frontier experience lingering almost a century beyond the closing of the frontier - consisting on the one hand of an outmoded rural political system and a nineteenth century image of agriculture that can be conveniently manipulated by politicians and private interests.

(c) An agricultural policy justified by an image of beneficiaries who work and live on the land, but designed in fact to assist "producers" or owners of land and capital. This assistance includes direct subsidies to the producers as well as special protection from the external effects of their

Table 1. Changes in Basic Agricultural Production Parameters, United States, 1910-1974

Date	Agricultural land area (mill. acres)	Farm number (mill.)	Workforce number (thous.)	Agricultural production (farm output index, 1967 base)
1910	881	6.37		
1920	959	6.45		
1925	924	6.37		
1930	990	6.30	12497	
1935	1054	6.81	12733	
1940	1065	6.10	10979	60
1945	1142	5.86	10000	69
1950	1161	5.39	9926	73
1954	1158	4.78	8651	79
1959	1124	3.71	7342	88
1964	1110	3.16	6110	94
1969	1063	2.73	4596	103
	****	****		
1970	1103	2.95	4523	102
1971	1097	2.91	4436	111
1972	1093	2.87	4373	
1973	1090	2.84	4337	
1974	1087	2.82	4340	
Percentage change 1935-1974	+3.1	-59	-67	

SOURCES: U.S. Bureau of the Census, 1973, p 14.
U.S.D.A., 1972, pp 523, 537; 1974, pp 420, 435.

**** Change in criteria

land-use and labor practices

(d) The development of agricultural technology under more or less permanent frontier conditions - the constant factors of abundant virgin land, low population densities, and a dynamic encounter with ecology created by the east-to-west movement of the frontier from temperate rain forests to humid prairies to semi-arid plains to the arid lands of the West (Padfield, 1971, p. 40).

In terms of adoption of mechanization this might be interpreted as:

(1) U.S. farmers are conducive to the economic rationality of increasing production to gain financial advantages from economies to scale (Dowd, 1966, Ch. 5; Donaldson and McInerney, 1973; Frundt, 1975, Ch. 1).

(2) The large machinery manufacturing corporations would have a relatively easy task of selling their products to farmers (Donaldson and McInerney, 1973; Frundt, 1975, Ch. 1).

(3) Government price support and other subsidy programs have favored land owners, and more particularly larger farmers (Bertrand, 1951; Dowd, 1966, Ch. 5; Ford, 1973, Ch. 3; Frundt, 1975, Ch. 1).

(4) The rapid westward expansion into the prairies and plains was particularly suited to mechanization because flat, easily cultivable land was in abundant supply and labor was scarce (Hacker, 1970, Ch. 11).

These four components offer a general explanation as to why mechanization occurred.

However, farmers themselves had more specific reasons. Bertrand's (1951) Louisiana study included a question to farmers: "What was the chief motivating factor in your decision to mechanize?" The responses were:

FACTOR	PERCENTAGE OF SAMPLE
Economic	41
Labor shortage	22
Efficiency of the machine	17
Makes work easier	16
Other	4

Farmers have undergone two periods of severe oversupply and cost-price squeeze (Dowd, 1966, Ch. 5; North, 1966, Ch. 11;

McConnell, 1969, Ch. 2; Hacker, 1970, Ch. 11; Frundt, 1975, Ch. 1). From 1870 to about 1900 there was a steady decline in farm prices, complicated by unpredictable fluctuations in the export market. The situation was repeated in the 1920s and 1930s. These two periods corresponded with peak activity in the animal-for-human power and machine-for-animal power stages of mechanization. Farmers had by now been fully versed in commercial agriculture, characterized by regional specialization in types of production and expanded export markets. Under these circumstances poverty is interpreted as a low productivity problem and economic efficiency solutions prevail. Machines offered the chance for increased income through taking advantage of economies to scale. It is somewhat ironic that poor prices through overproduction have never been sufficient reason to stifle technological development, but were a stimulus to seek alternatives such as expansion of markets or increased efficiency per unit of production, which invariably encourages further mechanization. Frundt (1975, Ch. 1 and 2) attributed this to the influence of agribusiness corporations, and government policy.

Labor has traditionally been in short supply in U.S. agriculture (Donaldson and McInerney, 1973). The nineteenth century was characterized by rapid westward expansion, depleting labor reserves in the East, and scattering people thinly over the Midwest and Plains area. In the late 1800s, the industrialization process in urban America was at its

peak attracting farm labor to the cities where wages were more favorable. The World Wars also removed large proportions of labor from farms. Farmers have also generally wanted to reduce their reliance on hired labor. This was particularly true in the South during the 1930s (Bertrand, 1948). The poor economic conditions of the depressions prompted unionization of labor. Conflicts with land owners ensued and eventually there were strikes. Labor supply was no longer perceived as assured and reliable. Consequently, the Southern landholders who ignored mechanization for many years, adopted the machine as a substitute for labor (Ford, 1973, Ch. 2).

It has been previously mentioned that government policy has also encouraged mechanization (Ford, 1973, Chs. 2 and 3; Frundt, 1975, Chs. 1 and 2). Nowhere has this been more obvious than in the South. The mounting surpluses and poor market prospects in the depression years prompted the government to institute the Agricultural Adjustment Act. Farmers were required to enter contracts for reduced acreage in return for benefit payments. All farm operator/managers qualified including tenants and sharecroppers, but not laborers. Many landlords took advantage of this and shifted from tenant/sharecropper to day labor and/or mechanization. Tenants became bitter and uncooperative, conflicts occurred and further labor displacement followed.

Of course, farmers were not isolated from the rapid development of an industrial society. They were part of a

new technological world. Sometimes the mere invention of an invention of an implement may have been sufficient to stimulate its adoption (Donaldson and McInerney, 1973). Some machines may have performed an old task in a superior way, or performed new tasks previously considered difficult. Many of the machines would have offered immediate reduction in the difficulty and strain of manual labor. The prestige or status accompanying ownership of the latest in machinery may have been a motivating factor.

But, as well as having advancing mechanization demanded by farmers, there was also the push by energetic "change agents" (Donaldson and McInerney, 1973). Some of the original inventors consolidated into large manufacturers of agricultural machines. It was in their interests to promote mechanization by advertising, provision of credit, production of new models, and pricing policies. They were competitors trying to sell a product. Also the Land Grant Colleges helped promote mechanization. The solutions to the economic and political problems of the late 1800s were seen in improved technology in agriculture. This could be brought about through agricultural education, research and extension.

In terms of the classical diffusion model, what has been described here is the diffusion of the innovation - mechanization - to members of a social system - U.S. agriculture - aided by promotion efforts of change agents - machinery manufacturers and Land Grant Colleges. However,

the particular concern is with consequences of mechanization in U.S. agriculture. That is, the adoption of mechanization becomes the independent variable. Consequences of mechanization are the dependent variables.

The Consequences of Mechanization

Mechanization, by its very definition, is a labor displacement process. If machines are adopted, they take the place of animal and/or human power, either as direct machine-for-human displacement (e.g., tomato harvester) or the less direct bigger-machine-for-smaller-machine replacement (e.g., tractors). A primary consequence of mechanization in the U.S. has been a decreased farm workforce. Two other primary consequences of adoption of mechanization have been increased farm size and increased farm production/sales. These three dependent variables are fundamental to a whole nexus of consequences (see Table 2). They are dependent variables of the first order, linking mechanization to consequences at different societal levels.

MECHANIZATION

labor displacement process
decreased farm workforce
increased farm size
increased farm income

Changes in:
farm characteristics
farm workforce characteristics
rural neighborhood/community characteristics
farm and rural outmigration
societal characteristics

Table 2. Changes in Number of Tractors, Number of Farm Workers, Farm Size and Farm Output, United States, 1935-1970.

Date	Number of Tractors (mill.)	Number of Farm Workers (mill.)	Average Farm Size (acres)	Value of Farm Output ($ 1958 value per farm)
1935	1.05	12.73	155	3305
1940	1.57	10.98	175	4295
1945	2.35	10.00	195	5085
1950	3.39	9.93	216	6030
1955	4.34	8.38	258	7675
1960	4.69	7.06	297	9900
1965	4.78	5.61	340	12885
1970	4.79	4.52	273	16100
Percentage change 1935-1970	+356	-64	+141	+387

SOURCE: U.S. Bureau of the Census, 1975, pp 457, 467-468, 480-481.

The sections to follow in this chapter will deal with these consequences in the same order. The relationships between mechanization and first-order consequents are well supported by empirical and logical explanation. The relationships with other dependent variables are at best postulates. However, if decreased farm workforce, increased farm size and increased farm production/sales are accepted as consequences of mechanization, then trend data, logical argument and limited empirical explanation support the later-order consequences to a varying degree.

In developing this nexus of consequences for mechanization there are two particular objectives: (1) to demonstrate the nature of consequences of mechanization as a process;

and (2) to demonstrate that the level of effect is only part of this process - that distribution of that effect is also important.[4]

Labor Displacement Process

Mechanization in agriculture provides an increasingly favorable condition for substitution of capital for labor (Chang, 1949). Farm decision-makers have responded by adopting mechanization for the reasons mentioned earlier. Trend data clearly show the large increase in farm machinery and the large decrease in labor input for the U.S. since 1935 (see Table 3) (Bertrand, 1958; Padfield and Martin, 1965; Davis, 1969; and Uhl, 1969).

This substitution is largely an economic decision; that is, the choice of least cost alternatives. The choice is related to the factor costs of capital and labor, and the size of the farm enterprise (Heady, 1960; Davis, 1969). Given unsatisfactory prices for farm products, increasing wage demands by farm workers, and the invention of more capital efficient machines; hypothetical economic models indicate that rational decision-makers pursue continuous capital-for-labor substitution and increased size of farm operations (Chang, 1949; Davis, 1969; Wildermuth and Martin, 1969; Tweeten, 1969; Donaldson and McInerney, 1973).

The labor displacement process is not simply a continuour one-way relationship, with mechanization causing

Table 3. Changes in Machinery and Labor Inputs to Farming, United States, 1940-1973.

Date	Mechanical power, machinery input Index 1950 base	Labor input Index 1950 base
1940	49	135
1950	100	100
1955	115	85
1960	114	67
1965	118	55
1970	125	45
1971	128	44
1972	127	42
1973	130	45

SOURCE: U.S.D.A., 1973, p 12.

decreased demand for labor. The notion of interdependence applies to the way an incremental change in labor economics causes an incremental change in degree of mechanization, and vice versa. However, the result is continuous in the direction of increased capital-for-labor substitution.

Decreased Farm Workforce

The social results of the labor displacement process include a decreased demand for farm labor (Mervine, 1943; Schwantes, 1943; Schmitz and Seckler, 1970; and Grise, et al., 1975). Given restricted availability of agricultural land for farm expansion and the desire of farm workers to be fully employed, this decreased demand should be reflected in a decreased farm workforce.

MECHANIZATION HAS CAUSED A DECREASE IN TOTAL FARM WORKFORCE[5] (McMillan, 1949 // - / Tolley and Farmer, 1967; Davis, 1969; Uhl, 1969; and Vincent, 1969)

Although there has been a continuous decline in total farm workers since before mechanization, the rate of decline has increased in recent decades (Bertrand, 1958; Tolley and Farmer, 1967; and Uhl, 1969).

There are two broad categories of farm labor: (1) family labor which is relatively stable year-round; and (2) hired labor, many of which are seasonal (Chang, 1949; Bowles and Sellers, 1965; and McElroy, 1974). The economic decisions regarding capital-for-labor substitution have largely been with farm owner/operators, and consequences of these decisions would be expected to mainly affect hired labor.

MECHANIZATION HAS CAUSED A DECREASE IN HIRED FARM LABOR
(McMillan, 1949; Bertrand, 1951 // Pederson, 1954; Dillingham and Sly, 1966 / Bowles and Sellers, 1965; Padfield and Martin, 1965; Bowles, 1967; Tolley and Farmer, 1967; Holt, 1969; McElroy, 1969b; Uhl, 1969; Vincent, 1969; and McElroy, 1974)

Thus, mechanization has caused a decrease in the total farm workforce, and hired labor (day laborers, permanent laborers, tenants and sharecroppers). However, none of the comparative/case study research assesses the family farmer and unpaid family workers. Trend data show that the number of farm operators and family workers have also declined since 1935 (Raper, 1946; Tolley and Farmer, 1967). It would seem that the cause for this decline in total and hired workforce would also apply to the decline in farm family workers.

MECHANIZATION HAS CAUSED A DECREASE IN FARM FAMILY WORKERS
(- // - / Raper, 1946; Tolley and Farmer, 1967)

Changes in Composition of the Farm Workforce. This displacement of the farm workforce is not a random process. Particular groups of farm labor are more severely affected than other groups.

MECHANIZATION HAS CAUSED A GREATER DECREASE IN MINORITY WORKER GROUPS, THAN FOR THE WHITE FARM WORKFORCE (McMillan, 1949 // Pederson, 1954; Dillingham and Sly, 1966 / Hamilton, 1964; Bryant and Leung, 1967; Ford, 1973, Ch. 2)

The findings of these studies were that decreases were greater for nonwhite farm operators than for white farmers (McMillan, 1949); for Black plantation families than for white families (Pederson, 1954); and for Negro tenants over white tenants (Dillingham and Sly, 1966) (see Table 4).

Table 4. Distribution of Farms by Color and Tenure of Operator, South Region, 1935-1964.

Date	All Farm Operators (Thous.)	White Farm Operators		Nonwhite Farm Operators	
		Full Owners	Tenants	Full Owners	Tenants
1935	3422	1190	1202	150	629
1940	3007	1186	943	142	507
1945	2881	1348	690	161	476
1950	2652	1270	540	141	366
1959	1645	857	228	90	138
1964	1373	738	171	71	82
Percentage change 1935-1964	-60	-38	-86	-53	-87

SOURCE: Ford, 1973, pp 20-21.

The decline in the number of hired farm workers has been almost entirely seasonal labor (less 150 days per year farm

wagework), and in fact, the number of full time hired workers (more than 250 farm wagework) has increased slightly from 1963 to 1973 (Bowles and Sellers, 1965; McElroy, 1969b, 1974) (see Table 5). There are no studies to link this change to mechanization. However, case studies have shown that mechanical harvesters displaced seasonal labor for cotton (Metzler, 1964; Dillingham and Sly, 1966) and tomato production (Rasmussen, 1968; Schmitz and Seckler, 1970) and are predicted to do so for other fruit and vegetable harvesting (Cargill and Rossmiller, 1969) and tobacco (McElroy, 1969a; E.R.S., 1969; Grise, et al., 1975). Also the selective decrease in seasonal hired workers is consistent with changes in farm level characteristics. The requirements of technological advances, specialization in type of production and differentiation of occupational status-roles, in association with larger farms ensures a comparatively stable labor market for full-time workers with appropriate skills.

Table 5. Number of Farm Wageworkers and Percentage Change by Number of Days Worked, United States, 1963-1973.

Days of Farm Wagework in Year	Number of Farm Wageworkers (thous.)			Percentage Change		
	1963	1968	1973	1963-68	1968-73	1963-73
1- 24	1735	1299	1085	-21.7	-16.5	-37.5
25-149	1163	1039	918	-10.7	-11.6	-21.1
150-249	309	256	247	-17.1	- 3.5	-20.1
250 +	390	324	421	-16.9	23.0	+ 8.0
Total	3597	2919	2671	-18.8	- 8.5	-25.7

SOURCE: Rodefeld, 1975, p 49.

MECHANIZATION IS ASSOCIATED WITH A SELECTIVE DECREASE IN SEASONAL HIRED FARM WORKERS
(- // Metzler, 1964; Dillingham and Sly, 1966; Rasmussen, 1968; Schmitz and Seckler, 1970 / Bowles and Sellers, 1965; Cargill and Rossmiller, 1969; McElroy, 1969b; E.R.S., 1969; McElroy, 1974; and Grise et al., 1975)

In summary, mechanization involves a labor displacement process that has resulted in:

decreased total farm workforce
decreased hired farm workforce
decreased farm family workers
selective decrease in minority worker groups
selective decrease in seasonal hired workers

Increased Farm Size

Mechanization in U.S. agriculture has provided an increasingly favorable condition for expansion of farm operation. Again, this is an interdependent relationship; mechanical technology makes possible larger farm sizes, and bigger farms stimulate the development of more sophisticated machinery.

Consider farm size as measured by the total area of the farm in acres. Where the amount of total farm land is limiting, a decrease in farm number is directly related to increased farm size. This has been true for the U.S. since 1935 (Ball and Heady, 1972). Thus, any relationship between mechanization and farm number supports the inverse relationship with farm size.

MECHANIZATION HAS CAUSED AN INCREASE IN FARM SIZE
(McMillan, 1949; Bertrand, 1951; Bertrand et al., 1956 // - / Bertrand, 1958; Krause and Kyle, 1970; Kyle et al., 1972; Ball and Heady, 1972; Donaldson and McInerney, 1973)

The evidence from comparative studies was conflicting for this relationship, but backed by logical argument and overwhelming trend data, this generalization is acceptable. Further analysis of this inconsistent data raises an important methodological issue relevant to studying consequences in general. The mechanization - farm size relationship was measured in three ways: (1) the degree of mechanization at time 1 versus farm size at time 1; (2) the degree of mechanization at time 2 versus change in farm size time 1 to time 2; and (3) change in mechanization time 1 to time 2 versus change in farm size time 1 time 2. The first approach is fully static and can contribute little to establishing causation. However, the correlation was consistent with the postulated relationship. The second approach was the one that produced data counter to this postulated relationship. In retrospect, the relationship could only have been supported if the rate of mechanization for any unit of analysis was higher when the level of mechanization was higher. Mechanization is a process and if causality is to be established by measuring change over time, then mechanization should be measured in the same way as the dependent variable. The third approach was fully processual and supported the relationship.

Acreage is not the only measure of farm size (Krause and Kyle, 1970; Rodefeld, 1974, pp 117-122). Farm size can be measured by output, or capital investment. In economic

models farm size is generally treated as "scale of operation." Given that farmers are economically rational decision-makers attempting to maximize profit, then these models indicate they will pursue increased scale of operations (Krause and Kyle, 1970; Breimyer and Barr, 1972) and capital-for-labor substitution is a means to that end. For different types of agricultural production, for different regions and for the nation as a whole, there has been a concentration of agricultural production output and capital investment (Krause and Kyle, 1970; Ball and Heady, 1972; Breimyer and Barr, 1972; Kyle et al., 1972).

Concentration in Farm Size. The decrease in farm number, like in workforce number, is not a random process. Firstly, rate and pattern varies with type of agricultural production and by region (Krause and Kyle, 1970; Kyle et al., 1972). Secondly, there has been a dramatic change in the distribution of farm size; substantial concentration of land and capital into a small proportion of total farms. Consequently, the category of largest farms comprises an increasingly larger share of the productive resources (Krause and Kyle, 1970; Ball and Heady, 1972; Breimyer and Barr, 1972; Kyle et al., 1972) (Table 6).

MECHANIZATION HAS CAUSED A CONCENTRATION OF PRODUCTIVE RESOURCES TO FAVOR THE LARGEST FARMS
(McMillan, 1949// Krause and Kyle, 1970; Ball and Heady, 1972; Breimyer and Barr, 1972; Kyle et al., 1972)

In summary, mechanization has been responsible for:

increased farm size
concentration of productive resources
in largest farms

However, although mechanization is postulated as a necessary condition for these changes, it is not sufficient. There are two dimensions to farm size: (1) the amount of production per unit of operation (yield); and (2) the number of units in the operation (size). Mechanization contributes mainly to the second dimension whereas biological advances contribute to the first. Hence, biological advances are also a causal factor to increased farm size.

Table 6. Average Farm Size and Distribution of Land Area by Farm Size, United States, 1935-1969.

Date	Average Farm Size (acres)	Percentage Distribution of Land in Farms by Farm Size Category (%) 0-139 acres	140-259 acres	260-999 acres	1000+ acres	(2000+ acres)
1935	155	23.7	20.5	26.4	29.4	
1940	175	21.0	19.0	25.7	34.3	
1945	195	17.8	17.1	24.8	40.3	
1950	216	15.8	16.2	25.4	42.6	
1954	242	13.3	14.9	25.9	45.9	
1959	303	10.3	13.3	27.0	49.4	
1964	352	8.6	11.3	27.4	52.7	(42.2)
1969	390	7.5	10.2	27.9	54.4	(42.8)
Percentage change in acreage 1935-1969		-68.0	-50.1	+88.7	+86.8	All farms +0.84

SOURCE: U.S. Bureau of the Census, 1973, pp 55, 61.

Increased Farm Income

Adoption of mechanization by economically rational farm decision-makers has enabled them to increase the size of operations. At the same time there has been a dramatic increase in agricultural production per farm. The result has been an increase in farm sales and income.

MECHANIZATION HAS CAUSED AN INCREASE IN FARM SALES/INCOME (McMillan, 1949; Bertrand, 1951; Bertrand et al., 1956 // - / Heady, 1960; Rasmussen, 1962; Hall, 1963; Tweeten, 1965; Constandse et al., 1968; Krause and Kyle, 1970; Ball and Heady, 1972; Kyle et al., 1972; Donaldson and McInerney, 1973; U.S.D.A.; 1973; Rodefeld, 1975)

Concentration in Farm Sales. The concentration of land and capital into a small proportion of the largest farms is also reflected in farm sales. The category of farms with annual sales of $40,000 or more has expanded most rapidly in number and proportion of total sales (Ball and Heady, 1972) (Table 7). Although there is no direct evidence for a causal link to mechanization, the relationships with increased farm size, increased farm sales/income and concentration in farm size combined with tend data would support the following generalization.

MECHANIZATION HAS CAUSED A CONCENTRATION IN FARM SALES/ INCOME TO FAVOR THE LARGEST FARMS
(- // - / Ball and Heady, 1972)

In summary, mechanization has caused:

increased farm sales/income
concentration in sales/income among the largest farms

Table 7. Number of Farms and Percentage Change by Value of Sales Classes, United States, 1960-1968.

Economic Class by Farm Sales ($)	Number of Farms (thous.)		Percentage absolute change	Percentage change in proportion of total
	1960	1968	1960-1968	1960-1968
40000 +	113	194	+71.7	+3.5
20000-39999	227	332	+46.3	+5.2
10000-19999	497	495	- .4	+3.7
5000- 9999	660	420	-36.4	-3.0
2500- 4999	617	327	-47.0	-4.9
0- 2499	1848	1286	-30.4	-4.5
Total	3962	3054	-22.9	...

SOURCE: Ball and Heady, 1972, p 54.

The two components of increased production per farm have been previously described - yield and size - and their main causes - biological advances and mechanization. Again, biological advances have also been responsible for these changes.

It was concluded earlier that the greatest single stimulus to mechanization was the cost-price squeeze and that farmers responded with economic rationality. These responses have resulted in the three primary or first-order consequents: (1) decreased number of farm workers; (2) increased size of farms; and (3) increased farm sales and income. The causal relationships with mechanization have been substantiated with reasonable confidence. If such relationships are accepted and that mechanization has been a main causal factor, then a large number of other consequences can be included in this process, by logical argument, trend data

and limited empirical explanation. These consequences are not only economic, but also social and environmental. They are discussed in the following sections.

Farm Characteristics

Mechanization, and biological advances, have been largely responsible for increased farm size, production and sales in U.S. agriculture. These are intervening variables to a range of consequences for the farm, and have the common denominator of "division of tasks."

> Technology means the systematic application of scientific and other organized knowledge to practical tasks. Its most important consequence, at least for purpose of economics, is in forcing the division and subdivision of any such task into its component parts. Thus, and only thus, can organized knowledge be brought to bear on performance (Galbraith, 1967, p 24).

As firms get bigger there is the tendency for increasing division of tasks. This may be reflected in a more specialized type of production, increased differentiation of status-roles for the farm workforce, a tendency for more structured farm organization types, and increased economic interdependence with the nonfarm sector.

Specialization of type of production might also be called commercialization. It is the tendency for farms to concentrate on production of specific commodities for market. The farm may have only one, or at most a few enterprises, and other food and fiber products for consumption by farm people must be brought in. The result has been regional

specialization such as cotton in the South, fruit and vegetable production in the South-west. Structural differentiation is the cleavage of the status-role of the family farmer into more specific functions such as land owner, farm manager and laborer. The family farm traditionally had the same person filling all three status-roles, but the large corporate farms have different people in each position. The land owner may not live on or even near the farm; the farm manager is chosen for entrepreneurial skills; and the labor is hired. Farms can be classified into organizational types according to the amount and type of structural differentiation. The family farm has been historically undifferentiated. The tenant-type farm has manager-laborers differentiated from owners. The larger-than-family farm has owner-managers different from laborers, the latter being hired rather than supplied by the managing family. Corporate farms have different people filling the status-roles of land owner, farm manager and laborer. These larger, more specialized farms require an interdependence with the nonfarm sector. Marketing is done away from the farm. An increasing proportion of farm inputs are supplied by nonfarm sources. And there has been a shift of managerial functions to off-farm control such as vertical integration, land and/or capital ownership and government programs. Mechanization may not be the sole cause nor even the major cause of these changes, but it is important through its effect on intervening variables such

as farm size, production and sales.

Specialization in Types of Production.

> Specializing implies restricting the scope of activities participated in. Thus we would expect a more specialized farm to participate in fewer production activities than a less specialized one (White and Irwin, 1972, p 193).

The most usual form of specialization in farming is to restrict the number of different commodities being produced but not necessarily changing the number of processes performed in their production. There has been increasing product specialization in the U.S. for vegetable, poultry, dairy and livestock production, and continued high specialization for fruit and nut, and cotton farms (White and Irwin, 1972). However, if specialization is a dependent variable of mechanization, there must be a relationship direct with mechanization or indirectly through farm size. There is adequate evidence on both counts.

MECHANIZATION HAS CAUSED INCREASED SPECIALIZATION IN TYPE OF FARM PRODUCTION
(McMillan, 1949; Bertrand, 1951 // - / -)

In Oklahoma, the highly mechanized farms made shifts in crop production contrary to the statewide trend, to concentrate on wheat and cotton production (1919-1945). In both Oklahoma and Louisiana the proportion of farm products (value) consumed by the farm household was lower for the more mechanized areas. White and Irwin (1972) found that increased farm size and increased specialization are strongly linked for some types of enterprises, and that economic theory indicated

that a third common factor was operating. This was probably mechanization, or at least technological change in general.

Structural Differentiation. Structural differentiation is not a widely used concept in assessment of changes in land tenure and farm organization. More commonly measurements are made of parameters such as number of owner-operated farms, tenant farms, managers, absentee-owned farms. Extrapolations are then made as to the numbers and proportions of family farms, corporate farms and tenant farms. The inconsistencies of this approach are alleviated by the notion of structural differentiation (Rodefeld, 1974-1975).

> Farms are conceptualized as 'production systems.' The system status-role of (land, capital) owner [O], manager [M] and laborer [L] and their interrelationships were postulated as the major dimensions of farming occupations and farm organizational structure (Rodefeld, 1974, p 110).

> Historically, U.S. farm numbers have been dominated by relatively small farms with low levels of differentiation between (land and capital) ownership, management and labor. (Such farms are) managed on a daily basis by an individual or family who simultaneously: owned all or most of the acres providing the land base of the farm; owned all or most of the capital (nonland resources) used in the production of agricultural goods; and provided for all or most of the physical labor expended in the production process (Rodefeld, 1975, p 2).

A convenient notation for these family farms is O-M-L.

> In the South and West and in areas of cotton, vegetable and fruit production and ranching, the economic significance of larger farms with higher levels of structural differentiation has been great. While the number of these farms has never been large, their average size is many times larger than for (family-type) farms. Structural characteristics common to all these farms are high levels of differentiation between: labor and . . . ownership, and

labor and management (Rodefeld, 1975, p 3).

The labor of these farms is mainly hired workers with limited involvement in management decisions, and such differentiation can be noted as M/L.

Tenant farms generally have low levels of differentation between management and labor, but high levels between ownership and management-labor. Most often the land owner is a retired farmer and/or a relative of the managing worker although some are nonfarmers. This differentiation is represented O/M-L.

The traditional family farms with low levels of differtiation have the notation O-M-L, and the most highly differentiated farms have the notation O/M/L. The most important divisions in status-role that have occurred are between ownership and management [O/M] and between management and labor [M/L] (Rodefeld, 1975). For structural differentiation to be a dependent variable of mechanization, there should be a linkage between occurrence of O/M, M/L and O/M/L, and mechanization, either directly or through the intervening variable farm size. There is evidence for both.

MECHANIZATION HAS CAUSED INCREASED STRUCTURAL DIFFERENTIATION OF STATUS-ROLES IN FARM PRODUCTION
(McMillan, 1949; Bertrand, 1951; Bertrand et al., 1956 // - / -)

The evidence from comparative studies does in general support the postulated relationship but there are inconsistencies. For Oklahoma (1920-1945), the number of owner-operated farms

decreased in high mechanization counties, and increased in low mechanization counties. Although farm tenancy declined generally, the decrease was less where greater mechanization had occurred (McMillan, 1949). Both findings support an increased tendency for differentiation between land ownership and management [O/M]. Yet for 1930-1945 in Louisiana the number of owner-operated farms increased with mechanization, and the number of more differentiated tenures decreased. The findings support less differentiation [O-M] (Bertrand, 1951). The five state study (1940-1950) gave the strongest support. When the independent variable was a cross-sectional index score for 1950, there was inconsistent support for increased O/M according to changes in tenure groups. However, dividing farms by rate of tractor adoption (1940-1950), the faster mechanization adopters showed a tendency to part-owners and managers rather than full owners (Bertrand et al., 1956). There was increased O/M. Farm areas that had attained a higher level of mechanization in the five state region also had higher expenditures for hired labor and had a higher proportion of farms employing hired labor (Bertrand et al., 1956). This would suggest increased M/L.

The comparative studies give weak support to increased differentiation between ownership and management, and between management and labor, for more mechanized farms. Trend data give additional support. Rodefeld (1975, pp 45-46) was able to substantiate that in the U.S.:

> levels of differentiation on all dimensions of farm organizational structure should be increasing and (number of) farms with low levels of differentiation on the various dimensions of structure should be declining relative to those with high levels.

This completes the evidence for a direct relationship between mechanization and increased structural differentiation.

Assuming a relationship between mechanization and farm size, then a relationship between farm size and structural differentiation would substantiate the generalization. There is a positive association of farm size (as measured by sales) and structural differentiation (Rodefeld, 1974, pp 243-246; 1975, p 17). However, the nature of the relationship is not so simple. Increased farm size could only occur following removal of uncertainties in production, prices and management that had constrained size of operations in the past. For example, advances in cultural practices reduced the vagaries of weather, pests and diseases. Similarly, farm insurance programs and increased availability of professional advice reduced the risks in farming and permitted the pursuit of economies of scale and specialization. Also more specific causal variables operated to increase structural differentiation. For example, as farms became larger and more specialized, the traditional non-routine nature of farmwork gave way to specific and repetitive tasks. This favored increased M/L differentiation (Rodefeld, 1974, pp 124-146). Also as farms got bigger and capital requirements increased, farm acquisition or transfer or expansion became more difficult

for the traditional O-M arrangement to finance. Prospects for O/M differentiation were enhanced (Rodefeld, 1974, pp 159-173). The relationship between mechanization, increased farm size and increased structural differentiation are complex but never-the-less are supported.

Farm Organization Types. The characteristics of farm size, specialization in production and structural differentiation are the major ingredients of a highly emotional issue in farm trends. This is the "family" farm versus "corporate" farm debate. The divergent factions disagree on whether family farms, which have dominated U.S. farm numbers and sales historically, are being replaced by corporate farms.[6] This treatment of consequences will not focus explicitly on the issues of this debate nor speculate on future trends. However, given the changes in farm size, specialization in production and structural differentiation, there appears to be a propensity for a relative increase in corporate farms; and if such a change is occurring then mechanization is implicated.

A major reason for the debate continuing unresolved is the inconsistencies in conceptualization of farm organizational types. Family farms, corporate farms and tenant farms are defined in many ways and even the Census of Agriculture has not maintained consistency across time. However, the preceding notion of structural differentiation offers a way of categorizing farm types according to status-roles of

the human component of the production system (Rodefeld, 1974, 1975).

O-M-L Family-type farm
O-M/L Larger-than-family-type farm
O/M-L Tenant-type farm
O/M/L Corporate-type farm

This conception demands an arbitrary cut-off point between low and high levels of differentiation, and these could be:

+/- 50 percent of labor performed by resident farm manager and family
+/- 50 percent of land and capital owned by resident farm manager and family

Thus the family-type farm is where the resident manager and family own most of the land and nonland resources and do most of the work. Alternatively, the corporate-type farm has a resident manager, but mainly owned by other people and mainly worked by hired labor, each of whom have limited involvement in daily management decisions. Farm organization types have thus been defined in terms of their levels and types of structural differentiation.

There is no research that links increased mechanization with increasing incidence of corporate-type farms. Indeed, the trend data are hotly disputed. However, there is the evidence that farm structural differentiation is increasing and that mechanization is involved. Therefore, to the extent that the traditionally low levels of differentiation exceed these cut-off points for O/M and M/L, then changes in farm types will occur. The results would be decreased proportion of family-type farms and increased proportions of larger-

than-family-type and/or tenant-type and/or corporate-type farms. There is evidence that this is occurring but as an interaction with farm size. There has been little change in the proportions of farm number to each farm type, but consistent trends in proportions of farm sales to favor larger-than-family-type and corporate-type farms (Rodefeld, 1975). Such a movement from family-type farms to corporate-type farms in terms of farm organizational type could legitimately qualify as consequences of mechanization.

There remains a farm type that warrants further consideration. The incidence of part-time farms[7] has increased steadily since 1935 both in proportion of total number of farms and proportion of total income coming from nonfarm sources. However, individual motivations and career patterns for part-time farmers differ. The three important stimuli for part-time farming are: (1) economic gain, (2) economic survival, and (3) bio-social adjustment. The career patterns fall into two distinct types: (1) farmers who take a non-farm job to supplement farm work and income; and (2) nonfarm workers who become farmers while continuing nonfarm work. There are regional differences in amount of part-time farming, according to opportunities for off-farm employment. Most part-time farmers are within commuting distance of industrial centers (Bertrand, 1967).

Part-time farming is a complex situation with different classes of part-time farmers subject to different causes.

For example, the process of mechanization places pressure on smaller farms to "get big or get out." Part-time farming may be an alternative to both. Small farmers attempt to earn more money to adopt new technology, or to take an off-farm job as an initial step to leaving farming altogether. Either way this would indicate that less mechanized farms may have a higher incidence of part-time farming (McMillan, 1949, p 12). Alternatively, the more mechanized, larger, specialized and differentiated farms are more likely to have strong economic ties with the nonfarm sector. These farms may have substantial income, particularly dividends coming from off-farm sources (Kyle et al., 1972, p 7). Given the diversity of motives and patterns for part-time farming, it is not surprising that significant relationships have not been found with mechanization (Bertrand et al., 1956).

Interdependence with the Nonfarm Sector. Mechanization of agriculture is suspected of having changed the input balance of farms to greater reliance on off-farm sources (Donaldson and McInerney, 1973); and it has coincided with similar changes in entrepreneurial and financial structure (Harris, 1969; Lee, 1968), land prices (Herdt and Cochrane, 1966) and marketing (Breimyer and Barr, 1972; Rhodes, 1972). Comparative studies have not demonstrated that mechanization is a causal force in this trend of increased interdependence with the nonfarm sector. However, mechanization does increase farm size, production and sales; it does increase

specialization in type of production; and also increases structural differentiation. It would seem consistent that it plays a role in the changing relationship with nonfarm institutions. If there is a link between increased interdependence and increased farm size, specialization or differentiation, then mechanization is implicated.

That mechanization is associated with increased reliance on nonfarm suppliers is logical. The adoption of mechanization necessarily adds machines, fuels, lubricants, etc. to the nonfarm input list. The biological advances that have occurred have expanded the demand for fertilizers, pesticides, hybrid seeds and livestock requisites all from off-farm suppliers. The complexity of this new technology requires greater use of expert services for machinery maintenance, diagnosis of plant/animal problems, etc. And, as asserted earlier, one of the main on-farm inputs - labor - is decreasing (Donaldson and McInerney, 1973).

There have been changes in the managerial and financial structure of farming that have been linked with increased farm size, specialization and differentiation (Harris, 1969; Lee, 1968). Traditionally, U.S. farms have had a low level of differentiation of status-role not only between ownership, management and labor, but within management. The "independent farmer" held almost complete organizational and operational control of the farm, making the decisions and bearing the risks. Production was coordinated with many off-farm

buyers in an open market. The only restrictions to this freedom had been societal reservations such as the right to tax, police and acquire land for public purpose, and control over spending power. However, further changes have occurred in institutional arrangements:

(1) Formal organization - increased structural differentiation resulting in less of the family-type farms and more of the tenant-type and/or larger-than-family-type and/or corporate-type farms.

(2) Credit arrangements - increased use of lending agencies allowing encumbrances on farm property by nonfarm sources.

(3) Lease agreements - increased use of rented land, particularly as a means of getting access to more land.

(4) Vertical coordination - the formation of contractual arrangements with off-farm firms for supply and marketing functions.

(5) Government programs - diverse programs controlling land use, production and pricing in farm production.

This increased participation of the nonfarm sector in entrepreneurship of the farm is linked to increased structural differentiation (Harris, 1969).

Financial structure relates to the pattern of ownership of financial resources both money and capital. Structural change has been evident by the growing separation of use and ownership of financial resources. Indications of this change have been the increased capital intensity of farming, increased farm debt, increased part-ownership of land, separation of land-extensive and land-intensive farm operations.

Increased farm size and increased specialization in type of production, have been at the heart of changes in financial structure (Lee, 1968). These changes in balance of inputs, managerial structure and financial structure have all been associated with greater involvement of off-farm institutions. Farms have become more interdependent with the nonfarm sector as they have increased in size, specialization and differentiation. Mechanization is a contributing factor.

U. S. agriculture has been dominated by a dispersed system of farm production and marketing. However, it "is being transformed into a new and strange pattern" - concentrated agriculture (Kyle et al., 1972; Breimyer and Barr, 1972). The features of concentrated agriculture are: (1) large farm size, and (2) an agricultural production system that includes "both farming operations and firms that formally supplied inputs or marketed products in a single management complex" (Breimyer and Barr, 1972, p 16). Thus, there are two dimensions - horizontal and vertical integration. The horizontally structured farm is the corporate-type farm. The vertically structured firm encompasses input, agricultural production and management, and marketing often by contractual arrangements. The involvement by agribusiness is the extreme case of interdependence with the nonfarm sector. Independent market firms and the open market are replaced by sales under contract negotiated over long terms and for greater volume. The agribusiness firms handling, processing

and merchandizing the raw farm product will have a large influence.

There is circumstantial evidence that mechanization has played a role in the increasing interdependence of farms with the nonfarm sector, through increased farm size and other changes in farm level characteristics.

Efficiency of Production. By common measures of productivity there have been dramatic improvements in U.S. agriculture. Total farm production and production per acre have doubled since 1935, due mainly to biological advances; and, production per farm worker and production per farm have increased six times in the same period (Table 8).

Table 8. Changes in Agricultural Productivity, United States, 1935-1974.

Date	Total Farm Production Index 1935 base	Production per Land Unit Index 1935 base	Production per Worker Index 1935 base	Production per Farm Index 1935 base
1935	100	100	100	100
1940	115	113	134	128
1945	134	124	170	156
1950	142	129	182	179
1954	153	139	225	218
1959	172	157	297	316
1964	182	170	379	393
1969	200	194	556	454
1970	198	189	550	457
1971	213	205	609	499
1972	217	209	638	514
1973	225	218	662	540
1974	220	213	647	531

SOURCE: U.S. Bureau of the Census, 1973, p 14.
U.S.D.A., 1972, pp 523, 537; 1974, pp 420, 435.

These larger increases are due to a combination of biological advances increasing the yield dimension (production per land) and mechanization reducing the number of farms and farm workers. If labor or prospective farmers were the limiting resources to agricultural production then the six-fold increase per worker and per farm would be a highly desirable consequence of mechanization. There is evidence that neither were scarce. An increase in the ratio of production to surplus resources is not as desirable as increased productivity for scarce resources.

One of the main reasons for adopting mechanization has been the cost-price squeeze. Appropriate decisions were made to increase farm income, decrease farm costs and/or increase profit margins. The main feature of mechanization and other decisions to increase net income has been the pursuit of economies to scale. According to economic theory there is an optimum size, or proportion of output to factor input. The critical question is: Has the process of mechanization and its consequences for the farm firm approached, reached or exceeded the optimum scale? When farms grow very large there are possible diseconomies such as problems of coordination and uncertainty. However, most measurements of economies have been of technical economies using either synthetic or case study analyses. But most diseconomies are in terms of political or social welfare, and typically are intangible. The conclusion would be that larger farms are

technically still taking advantage of economies to scale. However, nonempirical diseconomies are suspected (Madden, 1967; Raup, 1969; Madden and Partenheimer, 1972; Milk, 1972). Thus, mechanization has improved the economic efficiency of the surviving farms, but may have "already transcended optimum 'societal' returns." No postulate can be made with regard to mechanization and economic efficiency of production. The optimum farm size is not known, and there have been no studies linking mechanization to such dependent variables. Mechanization by its effect of decreased number of farms and farm workers has contributed significantly to the parameters of production per farm and production per farm worker.

Energy is a particular resource that is being used with decreased efficiency in agriculture (Cottrell, 1955; Perelman, 1972; Pimental et al., 1973; Carter and Youde, 1974). The major forms of energy input are solar, human and machine fuel; and the energy required by off-farm manufacturers of machines, fertilizers, chemicals, etc. The crop plant converts solar energy to grain. Mechanization substitutes machine energy for human energy. Technological advances require off-farm inputs at an energy cost. Efficiency of energy use in this case is the ratio of energy output to energy input (other than solar). This ratio has declined for corn production since 1945 (Pimental et al., 1973) Table 9).

Table 9. Energy Input/Output for Corn Production, United States, 1945-1970.

	Energy Input/Output (thous Kcals)					
	1945	1950	1954	1959	1964	1970
Input						
labor	12.5	9.8	9.3	7.6	6.0	4.9
%	1.35	.81	.60	.40	.27	.17
mechanization	785	980	1193	1375	1574	1717
%	85	81	77	73	70	59
Biological advances	128	216	345	507	662	1175
%	14	18	22	27	30	41
total	926	1206	1548	1889	2242	2897
Output						
total	3427	3830	4133	5443	6854	8165
Ratio						
output per input	3.7	3.2	2.7	2.9	3.1	2.8

SOURCE: Pimental, 1973, p 445.

The substitution of machine power for human power increases the energy costs of agricultural production and with little or no increase in yield (Cottrell, 1955).

1. More energy is required because the work is done more quickly. It will be recalled that the energy required to do a job varies not only with the mass and the distance involved but also with the time consumed. The amount of energy is not directly proportional to the increase in speed; rather it varies as the square of the velocity. Thus, decreases in time are purchased at greater and greater penalties in the form of the amount of energy used.

2. The tools which permit the great increase in the power used must themselves be larger,

heavier, and more complex than the hand tools which they replace. Therefore, they take more energy for their production, maintenance and repair.

3. The greater area per production unit involved requires that more energy be used getting to and from the work site, and in transporting the product to the place where it will be consumed (pp 134-135).

Cottrell (1955, p 135) also lists the energy cost of the mechanization process itself: (1) the energy required to overcome the inertia of human sentiment and habit, to bring about the change; (2) the energy cost of farm size expansion, both initial costs of the new systems and physical losses of obsolete equipment, buildings, etc.; and (3) the energy cost of displaced farm labor finding new employment. There is a logical connection between increased energy cost and mechanization.

MECHANIZATION HAS CAUSED A DECREASE IN AGRICULTURAL OUTPUT PER UNIT OF ENERGY INPUT
(- // Cottrell, 1955 / Perelman, 1972; Pimental et al., 1973; Carter and Youde, 1974)

Mechanization is not the only cause of this decreased energy efficiency; biological advances also incur energy costs. Production of fertilizers, pesticides and other chemicals uses substantial amounts of fossil fuels (Perelman, 1972; Pimental et al., 1973).

Changes in farm characteristics as a result of mechanization are selective processes. The very notions of specialization and differentiation denote that particular farms and people are favored over others. Under these circumstances it

is insufficient to refer to a change in level of a dependent variable, and it is more meaningful to examine the change in distribution of that variable. That is, to measure a change in some index of specialization or of differentiation is not as informative as categorizing into types of agricultural production or into status-roles of farm workers, and measuring the frequencies in each.

In summary, the consequences of mechanization on the farm characteristics have been:

increased specialization in type of production
increased structural differentiation of status-roles in farm production
decreased energy output per unit of energy input

and mechanization appears to have been partly responsible for:

decrease in family-type farms by number and sales
increased interdependence of farms with the nonfarm sector

Farm Workforce Characteristics

The preceding sections have dealt with farm level changes. This section deals with the consequences of these changes for the individuals residing and working on those farms. Trend data indicate that a multitude of changes have occurred for people in the farm sector from 1935 to now, and there is evidence to support that some derive from these farm level changes or from mechanization directly.

Direct Consequences of Mechanization. The previously analyzed first-order consequents of decreased farm workforce,

increased farm size and increased farm sales/income are key intervening variables for this consequences process. Yet there are two direct consequences for individuals working on farms: (1) reduced drudgery of work; and (2) new hazards to health and safety.

MECHANIZATION REDUCES DRUDGERY FOR FARM WORKERS
(Bertrand, 1951, p 45)

Although there is little empirical support for this generalization, it would seem logical that the use of machine power for such operations as plowing fields, harvesting grains, milking cows should reduce the physical exertion required of workers. Certainly, this was an argument used by change agents for mechanization (Hibbs, 1941) and was the opinion of farmers in the Louisiana study (Bertrand, 1951).

MECHANIZATION HAS CREATED NEW HEALTH AND SAFETY DANGERS FOR FARM WORKERS
(Donaldson, 1968 cited in Donaldson and McInerney, 1973)

It would seem logical that increased machine-human contact would create new risks to the well-being of farm workers. Besides injuries to limbs from moving parts of machines, there has also been impairment to the hearing of tractor operators. However, farming has always been a high risk occupation. According to Donaldson (1968, cited by Donaldson and McInerney, 1973) "Studies have revealed both acute and chronic effects, in the form of accidental injuries and health damage respectively, which are increasing not only in proportion to the farm population but in absolute terms

as well." However, support has not been found for an increase that coincides with mechanization, and so it is postulated that only the nature of the risks have changed.

Consequences of Increased Farm Size, Sales and Income. Rational decision-makers responded to the cost-price squeeze by pursuing capital-for-labor substitution and increased size of farm operations. Farm sales and income increased markedly, but population per farm remained about the same. Consequently, increased per capita income was to be expected. Comparative studies have not linked increased average income to mechanization although income has increased over time (Holt, 1969; U.S.D.A., 1973). However, there is evidence that mechanization has resulted in increased level of living of farm families.

MECHANIZATION AND ITS INTERVENING VARIABLES HAVE CAUSED INCREASED LEVEL OF LIVING FOR FARM FAMILIES
(McMillan, 1949; Bertrand, 1951; Bertrand et al., 1956 // - / Loftsgard and Voelker, 1963)

More specifically, farms with a higher degree of mechanization were more likely to have had amenities such as electricity, automobiles, telephones, radio and television. This increased level of living indicates that mechanization should also have caused an increase in level of income. Increased income would have allowed farm people to consume additional conveniences.

The per capita disposable income has increased continuously for the farm population (U.S.D.A., 1973), the average

daily earnings have increased for the farm workforce (Holt, 1969), and so has the median income for farm families, 1949 to 1970 (Gardner, 1969, 1974). Gardner found farm population decline to be associated with this incease in income and suggested farm outmigration to be a factor. It has already been established that mechanization has caused decreased farm workers and increased farm income. The decline in farm workers and in farm numbers has proceeded at about the same pace, and the number of workers, people or families per farm have remained relatively constant. Hence, increased farm income has been shared among the same number of people. Some studies also supported the trend that mean total income per farm worker, per farm family and per farm person has increased (Boyne, 1965; Coffey, 1968; Gardner, 1969, 1974; Lianos and Paris, 1972).

MECHANIZATION AND ITS INTERVENING VARIABLES HAVE CAUSED INCREASED PER CAPITA INCOME FOR THE FARM POPULATION (-// - / Boyne, 1965; Coffey, 1968; Gardner, 1969; Holt, 1969; Lianos and Paris, 1972; U.S.D.A., 1973; Gardner, 1974)

Distribution of Income: Agricultural economists have been concerned with personal income of farm people, particularly its distribution. The results of one study (Miller, 1963) are shown in Table 10. The solution to labor displacement and underemployment and low income, was seen as a matter of economic rationality and social mobility for migration to better paid jobs in the cities. Not only was this claimed to improve the welfare of the migrants (McDonald,

Table 10. Median and Distribution of Total Money Income for Families and Unrelated Individuals by Place of Residence, United States, 1947-1960.[8]

Date		Median Income (1959 dollars) and Gini Ratio of Income			
		Rural Farm	Rural Nonfarm	Urban	Total
1947	families	2585 (.493)	3688 (.348)	4383 (.344)	3957 (.378)
	individuals	877 (.560)	927 (.531)	1568 (.548)	1325 (.568)
1952	families	2452 (.478)	4090 (.353)	4668 (.347)	4277 (.374)
	individuals	759 (.586)	1077 (.502)	1790 (.461)	1566 (.479)
1956	families	2560 (.448)	4968 (.351)	5608 (.335)	5129 (.355)
	individuals	879 (.441)	1034 (.541)	1785 (.466)	1544 (.487)
1960	families	2838 (.456)	5547 (.360)	5836 (.350)	5547 (.369)
	individuals	941 (.523)	1134 (.548)	1960 (.469)	1694 (.491)

SOURCE: Miller, 1963, pp 36-45.

1955-56) but also that of the farm workers and their families remaining behind (Gardner, 1974). However, labor displacement is a selective process; thus, it seems likely that mechanization caused an alteration in distribution of farm income among farm people.

Farm people have traditionally had lower per capita incomes than nonfarm people (Miller, 1963). U.S.D.A. (1973) trend data shows that the absolute differential has closed a little for 1960-1972, and farm income has increased from 55 percent of nonfarm income to 83 percent in that time. However, Boyne's (1965) study found relative decline in farm family income compared to all U.S. families, 1948-1960. Within the farm sector, the distribution of personal income has been a contentious issue. Firstly, the inequality of income distribution has traditionally been higher for farm people, than

for all people (Miller, 1963; Boyne, 1965; Coffey, 1968). Some reasons for this have been distribution of farm sales and real wealth gains; government research, extension and programs (Coffey, 1968; Gardner, 1969). There are inconsistencies in the pattern of this inequality over time. Miller (1963) and Coffey (1968) found that income inequality among farm people declined 1948-1964. However, Lianos and Paris (1972) using a Marxian analysis of hired and family labor exploitation, found the workers share of the income relative to the capitalists, had declined markedly 1949-1968. These inconsistencies are probably due to differences in definition of income, the index of distribution chosen and regional differences across the farm population. A postulated relationship for mechanization and income distribution is not possible.

Occupational Composition. Rodefeld (1974, Ch. 5) identified a key intervening variable between increased farm size and changes in farm workforce characteristics: occupational composition. Mechanization was earlier linked to structural differentiation of status-roles in farm production. By definition, any changes in this differentiation will result in farm workforce occupational change (Rodefeld, 1974, Ch. 5; 1975, pp 18-20). Hence, mechanization has affected occupational composition by the increasing separation of the owner, manager and laborer status-roles (McMillan, 1949; Bertrand, 1951; Bertrand et al., 1956, Rodefeld, 1975, pp 25-40).

Further supporting evidence comes from the changing relationships between occupational groups. Friedland and Nelkin (1972) speculated that technological trends in agriculture had created the stability, stratification and expectations of migrant farm workers that was conducive to unionization. This was consistent with the findings of Holt (1970), Lianos and Paris (1972) and Steeves (1972).

MECHANIZATION AND ITS INTERVENING VARIABLES HAVE CAUSED INCREASED DIVISION OF STATUS-ROLES IN FARM STRUCTURE
(McMillan, 1949; Bertrand, 1951 Bertrand et al., 1956 // Rodefeld, 1975, pp 25-40)

Consequences of Changing Occupational Composition: In the rural social change literature there have been a number of reviews of changing individual characteristics of farm and rural society (e.g. Bertrand, 1958, pp 402-409); Larson and Rogers, 1964; Rogers and Burdge, 1972, pp 3-10, Ch. 7) linked to technological change in agriculture. A frequent claim has been that farm (and rural) people are becoming more urban-like in personalities, composition, family relationships and participation in the community. While not denying the importance of the trend and cross-sectional data on which these assertions are based, they do not satisfy the criteria for causality, whether the independent variable is

technological change or mechanization. The treatment of individual-level characteristics in comparative or case studies has been spasmodic and the implication of mechanization is inconclusive or inconsistent.

However, such consequences may be linked to mechanization via the intervening variables described previously. Rodefeld (1974) found relationships between changes in occupational composition and changes in socioeconomic characteristics, family structure and behavioral integration into social system for the farm population of Wisconsin. Thus, increasing occupational differentiation in farming is associated with a younger, less educated and more transient workforce that is less family oriented, with lower levels of local community participation (Rodefeld, 1974, Ch. 7) (see Table 11). It could be postulated that mechanization caused increased farm size which has caused increased structural differentiation, which in turn caused changes in occupational composition and finally the changes in socioeconomic, family and integration characteristics.

However, such changes seem in conflict with the popular notion of "farmers of today" and certainly these changes in occupational and other individual characteristics are relatively recent whereas mechanization and farm-level changes have occurred for some time. Perhaps counter-balancing forces have operated historically. For example, the increasing proportion of hired labor would indicate a lowering

Table 11. Relationship Between Degree of Occupational Differentiation and Farm Workforce Characteristics, Wisconsin, 1970.[9]

FARM WORKFORCE CHARACTERISTIC	RELATIONSHIP TO OCCUPATIONAL DIFFERENTIATION	CONFIRMATION FROM OTHER SOURCES
Occupational Composition		
Non-owning managers	+	
Non-owning laborers	+	
Socioeconomic Characteristics (owners, managers, laborers)		
Age	-	0
Farm background	-	
Education	-	
Job stability	-	
Residential stability	-	+, 0
Family Structure		
Marriage	-	
Fertility	-	-
Local Participation and integration support for:		0, -
Voluntary organizations	-	
Businesses	-	
Schools	-	
Churches	-	
Politics	-	

SOURCE: Rodefeld, 1974, Ch. 7.

+ denotes a positive association and
- denotes a negative association

The confirmation is in terms of the relationship between these individual characteristics and mechanization (occupational differentiation as an intervening variable), from the studies of McMillan (1949), Bertrand (1951) and Bertrand et al., 1956).
+ denotes support,
- denotes contradiction and
0 means neither for these relationships

of socioeconomic status, and the decrease in total workforce would indicate less local participation. Yet those remaining in agriculture have higher levels of income which indicates higher socioeconomic status and participation. More recently, changes in farm size and structural differentiation may have surpassed these counter-forces and then caused the net changes in individual characteristics of farm workforce members and their families, that have tended away from the "traditional" conception of background socioeconomic status, family structure and integration with the local community.

MECHANIZATION AND ITS INTERVENING VARIABLES HAVE CAUSED A NET CHANGE IN BACKGROUND SOCIOECONOMIC CHARACTERISTICS, FAMILY STRUCTURE AND BEHAVIORAL INTEGRATION FOR THE FARM WORKFORCE AND FAMILIES (-// Rodefeld, 1974, Ch. 7/ -)

There have been a large number of changes in the characteristics of farm population, but the critical question is the role of mechanization in causing these changes. Despite the little evidence for asserting such causation, the following generalizations were made. Mechanization, and its direct farm-level consequents have caused:

reduced drudgery for farm workers
increased health and safety dangers for farm workers
increased level of living for farm families
increased per capita income for farm population
increased division of status-roles in farm structure
changes in socioeconomic characteristics, family structure, behavioral integration into local community

Rural Neighborhood and Community Characteristics

There is a wealth of literature dealing with change in population and other characteristics of rural communities and neighborhoods. Many causes have been postulated for such changes: (1) mechanization and decrease in number of farms and farm people (Chittick, 1955; Bertrand, 1958; Raup, 1961; Loftsgard and Voelker, 1963; Fuguitt, 1965a; Field and Dimit, 1970; Bollinger, 1972; Beale, 1973); (2) changes in transportation and communication technology (Chittick, 1955; Loftsgard and Voelker, 1963; Fuguitt, 1965a; Field and Dimit, 1970)[10]; (3) metropolitan dominance and rural industrialization (Raup, 1961; Fuguitt, 1965a; Field and Dimit, 1970)[11]; and (4) residential preferences for smaller places but close to metropolitan areas (Dillman, 1973; Zuiches and Fuguitt, 1972). The objective is to isolate consequences of mechanization in U.S. agriculture, but having shifted from on-farm effects to the rural population, other causes are also very important. In general, one could expect that the greater the dependency of a community on farming as an economic base, the more dominant is mechanization as a causal force. Hence, in examining indirect effects of mechanization for communities, the following procedures must be employed. Firstly, ceteris paribus (all other things being equal) will control out other possible causes of community change so that relationships can be postulated between mechanization and these dependent variables. Secondly, only those communities with a sizeable dependency

on farming as the economic base will be considered.

Rural outmigration will be considered in the next section. Meanwhile, the concern is for the chain of relationships that link mechanization to decline of community population and of community functions. Firstly, brief description of the traditional agriculture-based community is warranted.

Change in Agriculture-based Communities. Slocum (1962, Ch. 6) has identified three predominant farm settlement patterns in the U.S.: (1) agricultural village, (2) plantation, and (3) isolated farmstead/farm trade center. The village pattern along European lines was introduced to the New England region with the earliest settlers but was not well suited to the larger farm sizes. Village patterns also occur among Mormon, Louisiana French and Spanish American farmers. The plantation system mainly occurred in the Southeast. The isolated farmstead was the dominant form of settlement, particularly in the Midwest and Great Plains. Distributed among the farms were trade centers that served as the primary market for farm produce, as the supplier of farm inputs, as the site of professional and artisan services, and of meetings of farm related organizations. They differed from the village pattern because they did not fulfill the residential function for farm families. The typical rural community then was a geographic area with which most of its members identified themselves. It would normally consist of

several farm neighborhoods and one or more trade centers (Ensminger, 1949; Kolb, 1959). The community contained about 80-500 farm families and as many again in the trade center. Its function was to provide a full range of economic and social services to members. Neighborhoods were smaller socio-geographic areas with perhaps 20-80 families in the Plains and 15-30 families in the South. They were a symbol of local personal identity, and were characterized by intimate, personal relationships. Farm trade centers were the focal point of the community for most of its economic and social services.

The traditional community, neighborhood and trade center has changed greatly. Particularly since 1935, there has been attrition in their number, population, autonomy and function. The farm population has declined about 70 percent since 1935. Given the limitations of National level data,[12] more than half the population places with less than 250 people declined in population for decades 1930-1970 (Brunner and Smith, 1944; Ratcliffe, 1942; Brunner, 1952; Beale, 1969, Fuguitt, 1971) and about 30 percent of places 250-2500 declined in population (Brunner and Smith, 1944; Ratcliffe, 1942; Brunner, 1952; Fuguitt, 1971). Population decreases have been greater for the 1950-1970 period. Beale (1974) measured population change in nonmetropolitan incorporated towns for the North Central Region, 1960-1970 (Table 12).

Table 12. Population Change in Nonmetropolitan Rural Towns, North Central Region, 1960-1970.[13]

Size of Town 1960	Number of Towns 1960	Population of Towns 1960 (thous)	Percentage Towns with Population Loss 1960-70	Percentage Change in Population 1960-1970
Total	5566	3339.3	50.4	4.8
1000-2500	1063	1640.1	36.0	6.7
900-1000	150	142.5	33.3	4.4
800- 900	217	183.7	41.9	3.7
700- 800	261	195.5	38.7	5.2
600- 700	289	186.9	40.8	9.0
500- 600	334	182.3	43.7	3.6
400- 500	505	227.0	47.7	2.9
300- 400	605	210.6	53.6	1.1
200- 300	828	204.4	59.5	0.7
100- 200	933	140.4	64.2	-4.4
0- 100	381	25.9	67.5	-7.7

SOURCE: Beale, 1974, p 6.

The ability of rural places to retain population is enhanced by a larger initial size (Ratcliffe, 1942; Anderson and Miller, 1953; Harden, 1960; Anderson, 1961; Loftsgard and Voelker, 1963; Fuguitt, 1965b; Fuguitt, 1971; Beale, 1973; Lybecker, 1974) and is also enhanced by proximity to larger places (Hassinger, 1957a; Harden, 1960; Fuguitt, 1965b; Butler and Fuguitt, 1970; Field and Dimit, 1970; Lybecker, 1974; Rodefeld, 1976). However, the traditional farm trade center tended to be smaller and more distant to larger places.

Given the evidence for a declining farm population and for a declining population in farm trade centers, it seems valid to postulate a declining population for agriculture-

based rural communities. What remains to be demonstrated is the link between mechanization and community population decline.

Decreased Farm Population. The farm population has declined by about 70 percent since 1935 (U.S. Bureau of the Census, 1975, p 457) (see Table 13). One would expect mechanization of agriculture to be a significant cause of this change, given its role in decreasing the farm workforce.

Table 13. Farm Population, United States, 1935-1970.

Date	Farm Population (mill.)	Percentage of Total Population
1935	32.16	25.3
1940	30.55	23.2
1945	24.42	17.5
1950	23.05	15.3
1955	19.08	11.6
1960	15.64	8.7
1965	12.36	6.4
1970	9.71	4.8

SOURCE: U.S. Bureau of the Census, 1975, p 457.

MECHANIZATION HAS CAUSED A DECREASE IN THE FARM POPULATION (McMillan, 1949 // Chittick, 1955 / Lofstgard and Voelker, 1963; Beale, 1964; Field and Dimit, 1970)

McMillan (1949, pp 7-8) found in his studies of Oklahoma that higher mechanization counties had experienced greater losses in farm population, 1925-1945. Bertrand (1951) and Bertrand et al. (1956) studying Louisiana and the five state Southern region respectively, found no such relationship despite a decrease in the total farm population. Bertrand

(1951) identified "mitigating circumstances" that prevented support for such a relationship, and recognized other support for mechanization causing decreased farm population. Correlations between increasing mechanization and decreasing farm population have been found for the U.S. (Beale, 1964; U.S.D.A., 1973), for South Dakota (Chittick, 1955) and for North Dakota (Loftsgard and Voelker, 1963). Anderson (1961) found mechanization, other technology, specialization and commercialization of agriculture in one county of Nebraska to have contributed to decreased farm population.[14]

Decreased Population of Agriculture-based Communities. It is tempting to postulate that mechanization and its intervening variable (farm population) have caused a decrease in the population of agriculture-based rural communities. However, there is no support from comparative studies. Beale (1974) speculated a relationship between mechanization and rural population, using indirect data (see Table 14). Assuming that counties entirely rural and with high proportions of agricultural workers have been more influenced by agricultural mechanization, and that nonmetropolitan county population reflects rural community population, Beale's data do support his claim. Beale has also documented changes in population of nonmetropolitan counties since 1920 (1964, 1975). For the period 1940-1970, about half of these counties were losing population, particularly in the Great Plains, western Cornbelt, southern Coalfields and Southern

Table 14. Nonmetropolitan Population Change by County Characteristics, United States, 1960-1973.

County Characteristic in 1970	Population Number (mill) 1960	1970	1973	Population Change (%) 1960-70	1970-73	Migration Number (thous) 1960-70	1970-73
With city 25000 +	8.92	9.94	10.35	11.4	4.2	-74	-148
With city 2500 - 25000	43.85	44.36	46.25	1.2	4.2	-2922	998
Entirely rural	4.47	4.27	4.40	-4.5	3.0	-551	123
Over 40% employed in manufacture	8.06	8.65	8.94	7.3	3.3	-294	73
Others	48.14	49.01	51.15	1.8	4.4		
Over 35% employed in agriculture	1.04	.92	.92	-11.5	-.4	-201	-12

SOURCE: Beale, 1975, p 8.

Costal plain. In addition, Anderson (1961), Raup (1961), Loftsgard and Voelker (1963) and Field and Dimit (1970) support a relationship between decreased farm population and decreased place population. Brunner (1951) found no such relationship for U.S. towns 1000-2500 in size, but indicated a possible relationship for smaller places (Brunner, 1952).[15]

The process by which mechanization would cause decreasing population in rural communities is complex. Firstly, mechanization has caused a decrease in farm population. Secondly, these farm people were members of open-country rural neighborhoods, and so one would have expected the decline in the size of neighborhoods, and in the number of neighborhoods (Kolb, 1959, Ch. 3). Thirdly, farm people and open-country neighborhoods had an intimate relationship with the trade center(s) and accounted for a significant proportion of the community population. The decline in persons in the hinterland creates a decline in size of the community and/or a decline in number of communities (Kolb, 1959, Ch. 6). This population decline so far has been a direct consequence of decreased farm population. However, farm trade centers and rural communities exist to provide certain functions to their constituents. A decrease in the farm segment of the population reduces the demand for such functions, and hence the need for nonfarm persons responsible for those functions (Anderson, 1961).

Change in Community Functions. Again it is tempting to postulate that mechanization through decreased farm population

and decreased community size, has caused alteration in community functions. Unfortunately, no comparative studies are available. However, a number of studies support causal relationships between changes in community populations and changes in community functions. Further, many more studies have established correlations between population change (places and counties) and selected community characteristics.

The population change in farm trade centers is directly related to the number of retail businesses (Chittick, 1955; Anderson and Miller, 1953; Hasinger, 1957b; Fuguitt and Deeley, 1966; Brunn, 1968; Folse and Riffe, 1969; Bollinger, 1972), the variety of retail businesses (Chittick, 1955; Anderson and Miller, 1953; Hassinger, 1957b; Brunn, 1968) and the volume of retail trade (Loftsgard and Voelker, 1963). In declining places, the economic system enters a declining spiral of decreased variety of goods and services, and decreased patronage from local people (Bauder, 1962; Bollinger, 1972). The requirements of trade centers have changed as consumers of their economic functions become more specialized in demands. The previously mentioned farm changes of mechanization combine to drive up the minimum volume of business needed to support supply and market agencies (Raup, 1961). Farm equipment and automobile dealers have been among declining businesses in declining towns (Bollinger, 1972). Individual consumption patterns have also changed. Farm and nonfarm shoppers, being able to travel greater distances

with improved transportation, have tended to bypass smaller centers for more specialized goods and services at larger places (Anderson, 1961; Brunn, 1968; Yoesting and Marshall, 1969; Raup, 1970; Bollinger, 1972).

A similar pattern exists for schools and churches. Initially, a high proportion of rural neighborhoods had elementary schools and churches. As neighborhood populations declined so did these institutions (Bertrand, 1958; Kolb, 1959). Schools underwent a reorganization following World War II, with closure of small schools in neighborhoods and small trade centers, and building of consolidated elementary and high schools at larger places (Anderson, 1952; Kolb, 1959; Klietsch, 1962; Loftsgard and Voelker, 1963). The number of churches has declined with the decrease in farm population and decrease in number and size of neighborhoods and smaller trade centers (Anderson, 1952; Kolb, 1959; Kenkel, 1962; Loftsgard and Voelker, 1963; Hassinger and Holik, 1970). Government and political institutions have not been so responsive to this declining trend (Bertrand, 1958; Kolb, 1959; Doerflinger and Robinson, 1962).

An important characteristic in this change in the economic and instiutional system is the source of public funding. As might be expected, communities of declining population generate less funds per capita for educational and municipal facilities (Bollinger, 1972; Bills and Barkley, 1973; Erickson, 1974). Bills and Barkley found that for a town

declining in population there was heavy reliance on fund transfers from Federal and State governments. The growing town, however, could raise the funds locally using special property taxes and bonded indebtedness.

This change in the economic system of agriculture-based rural communities is a complex process, and a specific problem is isolating the role of farm mechanization from other causal forces. The decline in numbers and size of communities and their goods and services cannot be considered in isolation of the consolidation and concentration of these functions at larger expanding centers. This process has been variously described as functional differentiation (Anderson, 1961), increasing economies of scale (Raup, 1961, 1970) and structural differentiation (Wilkinson, 1974). In effect, the minimum size at which a trade center can provide a comprehensive range of goods and services to its constituents is increasing. The population of smaller centers is falling. Hence, researchers have often referred to a separation of trade centers into those expanding with increased economies and specialization, versus those smaller places which are declining (Anderson, 1961; Loftsgard and Voelker, 1963; Wilkinson, 1974). While mechanization in agriculture can be postulated as a direct or indirect cause of the decline in population of rural communities, its importance is reduced when the changing pattern of economic functions across centers of different population size is considered.

Other possible causes have been mentioned: changes in transportation and communication technologies; urbanization and metropolitan dominance; rural industrialization.

Changes of a sociological nature are even more difficult to clarify with respect to indirect consequences from mechanization. There has been consensus for a loss in local autonomy and of traditional leadership roles for communities of declining population (Bollinger, 1972; Erickson, 1974). Although Wilkinson (1974) saw the "passing of the small town" as a threat to informal aspects of social organization and a sense of community, there has been no empirical support. There is not the support to generalize a causal relationship between mechanization of agriculture its intervening variables of population changes, and sociological consequences for agriculture-based communities. However, it is a hypothesis worthy of further testing.

In summary, comparative studies support the relationship between increased mechanization and decreased farm population; and the following consequences can be hypothesized:

decrease in population of agriculture-based communities
decline in community functions, such as retail business, schools, churches and other institutions

Economic and social change in the rural sector is a complex process, for which mechanization is one of a myriad of causes. Nevertheless, mechanization of agriculture is likely to have contributed to population changes and hence

changes in community functions. It also is important to note rural neighborhood and community changes in the distributional dimension. The pattern of growth and decline in population and functions is strongly related to such characteristics as dependency on agriculture, community size, and proximity to larger centers. Community functions have been increasingly concentrated in a smaller number of rural communities.

Farm and Rural Outmigration

Farm Outmigration. It has been established that mechanization of agriculture has caused a decrease in the farm workforce and a decrease in farm population. The logic of this role of mechanization in labor displacement indicates that it has caused farm outmigration.

MECHANIZATION HAS CAUSED NET OUTMIGRATION OF THE FARM POPULATION
(- // Guither, 1963; Hill, 1962; Reeder and LeRay, 1970 / Beegle, 1961; Bishop, 1961; Bogue and Beale, 1964; Fuller, 1970; Morrison, 1972; Sjaasted, 1961)

The comparative studies of McMillan (1949) and Bertrand (1951, 1956) did not investigate rates of farm outmigration. However, cross-sectional surveys by Guither (1963) for Illinois and Hill (1962) for Iowa identified certain characteristics of those leaving farming as an occupation, versus those still farming. A higher proportion of the leavers were tenants, but with little difference in gross income or farm size. A sizeable proportion of each group were retiring. Of the

remainder, economic reasons were most often given as cause for migrating. This is consistent with previous findings that mechanization has occurred largely in response to economic incentives. Traditionally, the majority of owner-operated farms have been passed on to other members of the family. The important question would have been who took over the farm following retirement. For instance, the easiest mode of adaptation to decreased numbers and farm population, would be intergenerational (Reeder and LeRay, 1970). The children leave the farm after high school for further education or for nonfarm jobs, and the parents sellout on retirement. Should this be the important mode of adaptation to consequences following mechanization, these studies could not explore it.

A more comprehensive study was one county in New York state, 1949-1962 (Reeder and LeRay, 1970). Their findings were largely supportive of Guither and Hill. Again the major reason for changing occupation was financial. Further, they investigated the factors favoring and opposing such shifts and modes of change. The results indicate that changing occupation is an extremely important event with a whole cluster of forces affecting the decision. There are still strong forces binding people to the farm. However, the net result has been fewer farms, reduced farm population and farm outmigration. Mechanization has played an important part (see Table 15).

Table 15. Net Farm Outmigration, United States, 1935-1972.

Date (5 year period)	Net Outmovement from Farm Population (mill.)	Cumulative Outmigration (mill.)
1935-1940	3.54	
1940-1945	8.01	11.55
1945-1950	3.39	14.93
1950-1955	5.57	20.51
1955-1960	4.55	25.06
1960-1965	3.97	20.03
1965-1970	2.97	32.00
1970-1972	.43	32.43

SOURCE: U.S.D.A., 1973, p 55.

Rural Outmigration. It has been hypothesized that the decline in farm population creates underemployment in the nonfarm population of rural communities. This pressure to decrease nonfarm population is realized only in the absence of incentives to increase population, such as new industry, bedroom community functions, tourism and recreation, etc. Again the condition of ceteris paribus is important.

The rural population has been relatively stable 1930-1970, but because the farm component has decreased by about 22 million people in this time, the nonfarm population has grown (see Table 16). However, there has been net rural outmigration including the nonfarm segment, for areas more dependent on agriculture and distant to large metropolitan centers. Beale (1964) found that for the 1950-1960 decade: (1) 50 percent of all counties in the U.S. lost population;

Table 16. Changes in Farm, Rural and Urban Population, United States, 1930-1970.[16]

Date	Total population (mill.)	Urban population (mill.)	Rural population (mill.)	Rural Nonfarm population (mill.)	Farm population (mill.)
1930	122.78	68.95	53.82	23.66	30.16
1940	131.67	74.42	57.25	27.03	30.22
1950	150.70	88.93	61.77	38.69	23.08
1950	150.70	96.47	54.23	31.18	23.05
1960	179.32	125.27	54.05	40.47	13.47
1970	203.21	149.32	53.89	45.59	8.29
Percentage change 1930-1970	+65.5				-72.5

SOURCE: U.S. Bureau of the Census, 1975, p 12, 457.

(2) 63 percent of all counties lost rural population; and (3) 73 percent of entirely rural counties lost population. Counties experiencing heavy losses were concentrated in the South coastal plain, the Great Plains and the Cornbelt. Beale (1975) found that for nonmetropolitan counties there was greater retention of population in 1960-1970 and an increase in population for 1970-1973. About 44 percent of all counties lost population in 1960-1970 and this declined to about 20 percent for 1970 -1973. These declining counties were found mainly in the Great Plains, and had a high ratio of employment in agriculture.

Unfortunately, rural-urban migration data that are comparable over time periods are difficult to get. In addition, the quantitative importance of mechanization and farm outmigration is declining because not only has the farm

population decreased to a small proportion of rural population, but several factors are operating to increase rural population. To the extent that these factors are controlled:

MECHANIZATION AND ITS INTERVENING VARIABLES HAVE CAUSED RURAL OUTMIGRATION
(- // - / Beale, 1964, 1975)

Effect of Outmigration for Farm-dependent Communities: Whether the effect of mechanization on community characteristics is mediated through the "change in population" variable or through the "net outmigration" variable, the consequences are the same. Hence, postulated changes in community functions have already been reviewed. However, one important group of consequences was omitted - demographic changes - because it is specifically related to the selectivity of migration rather than population decline per se.

It is tempting to postulate that mechanization through its intervening variables farm/rural outmigration, has caused a change in the population composition of agriculture-based communities. Migration is selective with distributional consequences. The concern here is not so much with the number of people that leave the farm and rural population, but their characteristics. Bollinger's study (1972) of rural depopulation in Idaho revealed that migrants were younger, better educated, more likely to be professional/technical workers and consequently the remaining population was older, less educated and undertrained. Selectivity of migration is well documented (Suval, 1972; Price and Sikes, 1975).

The largest single age group of rural-urban migrants is 16 to 25 years old (Taves, 1961) and included among these is a large proportion of high school leavers (Bollinger, 1972; Reiger et al., 1973). The age structure of the remaining population is changed. The median age increases and so does the dependency ratio (Bollinger, 1972; Beale, 1974; Price and Sikes, 1975). As the reproductive age group declines, so does the birth rate which results in further aging of the population (Bollinger, 1972; Beale, 1974). Once the median age exceeds about 35 years the community experiences natural decrease, and many Midwestern places are in this situation (Beale, 1974).

Rural outmigrants have received more education than nonmigrants, even when controlled for age (Price and Sikes, 1975). Also men have tended to have aspirations for academic achievement and women were more socially aggressive (Price and Sikes, 1975). Yet rural areas are still required to educate the young, despite the returns on this investment in human capital being realized in the urban market (Morrison, 1972; Flora, 1976). Rural communities lose their more capable individuals in terms of education, aspiration, skills and leadership (Taves, 1961; Bollinger, 1972; Morrison, 1972; Price and Sikes, 1975).

Rural-urban migration is most commonly interpreted as an economic adjustment process. There has nearly always been an economic incentive for people to migrate to urban

areas (McDonald, 1955) and many underemployed have responded (Bishop, 1961; Miller, 1969). The expected result should be improved job opportunities in the rural communities with less underemployment and a relative increase in per capita income. There is no strong evidence that this has happened. One reason may be depletion in the economic base of the rural sector, not merely as a consequence of declining population, but also from the change in composition of population. Older people are more likely to be on fixed income and invest less in the community (Zuiches and Brown, 1976). Property values decline reducing the tax base (Raup, 1961; Bills and Barkley, 1973). The number of persons per household declines and per capita costs of delivery of services increases (Beale, 1974; Zuiches and Brown, 1976). In sum, the depletion of population and selectivity of this migration, place the farm-based community at an economic disadvantage.

Effect of Outmigration on Farm/Rural Migrants: There has been a lot of research on the effects of outmigration for farm and rural outmigrants, but the results have been inconsistent. There have been no comparative studies testing a relationship between mechanization of agriculture and these consequences. Given the state of current research and the tenuous chain of relationships that would link these two variables, a postulated relationship cannot be made at this time. The effects of outmigration on migrants are merely reviewed here.

The major problem confronting such research has been how to assess such consequences. One can interview the migrant to obtain a self-assessment versus collecting objective data and making an external assessment. One can compare the rural migrant with urban nonmigrants in the destination area, with rural nonmigrants in the source area, or a before-and-after comparison for the migrant (Fuller, 1970, pp 61-62). Self-assessment by rural outmigrants have generally been positive. Most consider themselves to be happier and better off financially in their new environment. This has been particularly true for Blacks and Mexican-Americans (Fuller, 1970, pp 66-67; Morrison, 1972). External assessment of farm and rural migrants in their new setting versus the conditions in the area of origin, indicates that migration has been beneficial for the individual. The migrant has improved employment opportunities and the prospect of occupational mobility, has improved earnings and living standards, and there is a lower incidence of poverty. These differentials are greater for minority groups. However, where the comparative assessment is between rural migrants and rural nonmigrants, these consequences may be as much due to the personal characteristics of the people migrating as to migration itself (Morrison, 1972).

External assessment of farm- and rural- reared urban dwellers versus urban-reared dwellers shows that the migrants are overrepresented in the lower status, lower income and

and blue-collar groups (Shannon, 1961; Fuller, 1970, pp 63-66; Price and Sikes, 1975). Farm migrants generally have lower participation rates in their new environment than their urban counterparts, but the gap does close over time. They may be quickly integrated into their immediate group, often consisting of old friends and relatives, but not into the broader community. There may be relatively smooth job assimilation but not cultural assimilation. The degree of participation and assimilation varies across subcultures, being greatest for Blacks and Mexican-Americans, and least for Southern whites (Zimmer, 1955; Fuller, 1970, pp 68-74; Morrison, 1972; Price and Sikes, 1975). There has been little consideration of the social costs of severing old relationships and relocating in a new environment; possibly because of the strong emphasis on economic adjustment rather than social adjustment.[17] Certain adaptive mechanisms have eased this stress because much of the outmigration has been integenerational with children leaving after high school, and many follow in the same "stream" as friends and relatives (Abt Associates, 1970). However, there are substantial rates of return migration which may indicate this cost is judged too high (Abt Associates, 1970).

Effect of Farm/Rural Outmigration on Urban Areas: In examining consequences of mechanization perhaps "one of the most dramatic relationships is that hypothesized between agricultural mechanization and ghetto riots. The explosions

of Watts, Detroit, Newark, and Chicago in recent years (are) traced to roots in rural poverty and displacement" (Fujimoto, 1969, p 335). This conclusion was reached by National Commissions on Rural Poverty (1967), Civil Disorders (1968), and on Causes and Prevention of Violence (1970). The implication is that mechanization in the South, particularly cotton, displaced large numbers of Black tenant farmers in the 1940s and 1950s, who migrated to the industrial centers of the North creating the situation for racial conflict. While not denying that this chain of events occurred, there has been no empirical support for a cause-effect relationship between mechanization in agriculture and racial violence. However, the suggestion of such a link serves to make two important points. Firstly, if such a relationship did exist then it demonstrates how consequences ramify from the intended client system to the larger social system. Secondly, there are many propositions blaming social ills on mechanization and often with the support of trend data but no studies capable of supporting or rejecting such a hypothesis.

Recent reviews of literature on rural-urban migration indicate that the negative effects have been exaggerated. The farm population has declined to a point where continued migration must also decline. In any case the contribution of migration to urban growth has been decreasing. There has not been a disproportionate number of Blacks among rural-urban migrants, but there has been a greater redistribution

of the Black population because counter-stream migration has been relatively small. The increase in Black population in ghettoes has mainly come from natural increase rather than migration. Rural-urban migration has not been merely a transplant of rural poverty to an urban setting (Morrison, 1972; Price and Sikes, 1975).

Given these contrasting perspectives on the indirect consequences of mechanization of agriculture for the urban sector, no generalizations are possible. The major difficulty in exploring such relationships would be implementing the condition of ceteris paribus. Regardless of the possible importance of mechanization as an independent variable, there are many other causal variables at work that would have to be accounted for. Any postulated relationship would be tenuous.

In summary, there has been empirical support for mechanization of agriculture indirectly causing:

net outmigration of farm population
net rural outmigration

and the following consequences may be hypothesized:

changed demographic characteristics of rural communities
benefits and costs to rural-urban migrants
changes in urban sector characteristics from migration.

Societal Characteristics

The consequences of mechanization in U.S. agriculture for the farm sector have been generalized with considerable confidence. Consequences for the rural sector are more

tenuous but nevertheless, some generalizations were possible. Consequences of agricultural mechanization for U.S. society in general are even less direct and there have not been satisfactory studies to support cause-effect relationships. However, it seems reasonable to assume that mechanization and its more direct consequences have affected societal characteristics to some degree. Some of the frequently speculated consequences are reviewed.

Two such consequences have been discussed in some detail. Firstly, there has been a continuous net outmigration from the rural sector, 1935-1970, which has changed the locational composition of U.S. society. As recently as 1910 more than half the national population was rural, and most of them were farm people. The U.S. is now highly urban and highly metropolitan. With this change has come "problems, which are increasingly troublesome in the major cities . . . financial difficulties, high unemployment, poverty, crime, pollution, and service delivery problems . . ." (Stockdale, 1976a, p 7). Secondly, farming is becoming increasingly inefficient in energy input/output. "The use of tractor fuel alone on U.S. farms has surpassed the energy conversion of sunlight for a given unit of agricultural land" (Clark, 1974, p 171; see also Clark, 1975; Stockdale, 1976a).

A technologically advanced agriculture (mechanization and biological) has been blamed for high resource consumption and for environmental problems. The use of resources for

manufacture of machinery, fertilizers, and other chemicals requires not only energy but other mineral resources. U.S. agriculture consumes a disproportionate share of the world's resources and has outbid developing countries who rely on such scarce resources for increased food production (Stockdale, 1976a). Environmental problems from a highly specialized mode of agricultural production have included soil erosion; residual toxicity from insecticides; and pollution of ground water by nitrogen and phosphate fertilizers, and by cattle manure (Headley, 1972' Commoner. 1974. Ch. 5; Clark, 1975; Stockdale, 1976a).

The availability, quality and cost of food is a controversial issue. National agricultural production has increased rapidly although due more to biological advances than to mechanization. The U.S. now dominates the world's grain exports, which has earned it the title of "breadbasket of the world" (Brown and Eckholm, 1975; Frundt, 1975, p 94, 272a; Lerza, 1975). In this decade of increased food scarcity, this surplus production is being used as a political means of gaining compliance from dependent countries (Balz, 1975; Frundt, 1975, Ch 2. and 6; Lerza, 1975). Nationally, the export of primary produce offsets the huge deficit in the trade balance for the secondary sector of the economy (Frundt, 1975, pp 267-287; Shuh, 1976). The U. S. Department of Agriculture claims modern agriculture produces cheaper food in terms of food expenditure as a proportion of

per capita income (Hightower, 1975, p 71). Although the average person spent 16 percent on food in 1973, the poorer groupings spent as much as 35 percent of median family income (Blakeley, 1974; see also Pollack, 1975). Other research shows that the cost of food has risen considerably in recent years (Robbins, 1974, Ch. 11; Consumer Reports, 1975; Hightower, 1975, Ch. 3). There are a number of publications blaming a reduction in food quality on the rise of a technologically sophisticated agriculture (Hightower, 1975, Ch. 4; Jacobson, 1975; McCarthy, 1975).

This review of societal-level characteristics variously attributed to mechanization again demonstrates the pervasiveness of such consequences should relationships to mechanization be verified, or demonstrates the tendency to blame mechanization for undesirable impacts on the environment and food quality. It would seem likely that a technologically advanced system of agriculture with specialization of enterprises and dependency on off-farm inputs, has contributed to increased national food production and to political and economic influence of the U.S. in the international sphere. However, there have probably been costs to the environment, for resources and to food quality. Societal consequences of mechanization in U.S. agriculture have yet to be substantiated empirically.

Conclusion

The consequences of mechanization have been considered at three levels: (1) farm; (2) rural, and (3) societal (see Figure 12).

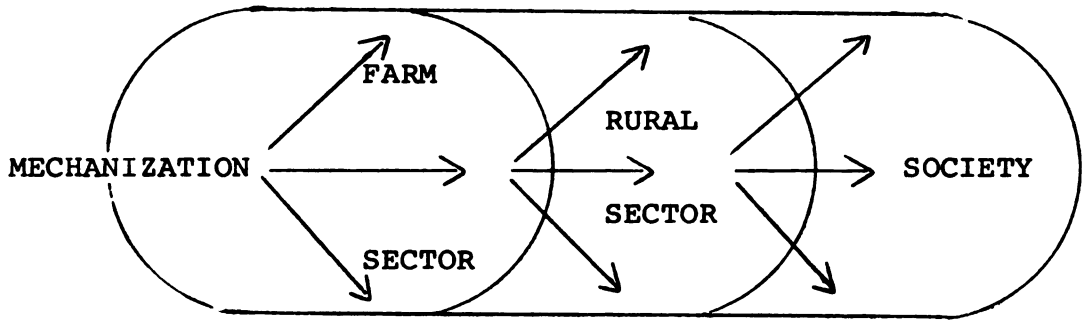


Figure 12. Segments Experiencing Consequences of Mechanization

The degree of empirical support for cause-effect relationships between mechanization and its consequences is greatest for farm-level changes, less for rural changes and absent for societal characteristics. Correlatively, direct consequences of mechanization have mainly affected the farm sector, while those affecting the larger social systems have been mainly indirect consequences. Certain key intervening variables were identified: increased farm size and production, and decreased farm workforce. Relating mechanization to possible indirect consequences is a difficult methodological task because of the need to control (i.e. ceteris paribus) for other possible causal variables. That no generalizations could be made for societal consequences does not mean that such have

not occurred, but merely that confirmation or rejection was not possible with available data.

Given this limitation to stating generalizations, the following consequences of mechanization were postulated (or hypothesized):

decrease in size of total farm workforce
decrease in hired farm labor
decrease in farm family workers
selective decrease in minority group workers
selective decrease in seasonal hired laborers

increase in average farm size
concentration of productive resources on larger farms

increase in average farm sales and income
concentration in sales and income on larger farms

increased specialization of farm production
increased structural differentiation of status-roles in farm production
(change in farm organizational type)
(increased interdependence with nonfarm sector)
(increased productivity)
decreased agricultural output per energy input

reduced drudgery for farm workers
new health and safety dangers for farm workers
increased average level of living for farm families
increased per capita income for farm population
increased division of status-roles in farm structure
changes in background socioeconomic characteristics, family structure and behavioral integration for farm workers and families

decrease in farm population
(decrease in population of agriculture-based neighborhoods and communities)
(decline in functions of agriculture-based neighborhoods and communities)

net outmigration of farm population
rural outmigration
(change in demographic characteristics of rural communities)
(selective benefits and costs to rural-urban migrants)
(changes in urban sector characteristics from rural inmigration)

(change in societal characteristics)

These consequences are shown diagrammatically in Figure 13.

Thus, even with the deficiency of qualitatively adequate research and the excess of speculation from trend data, mechanization has caused a diversity of consequences.

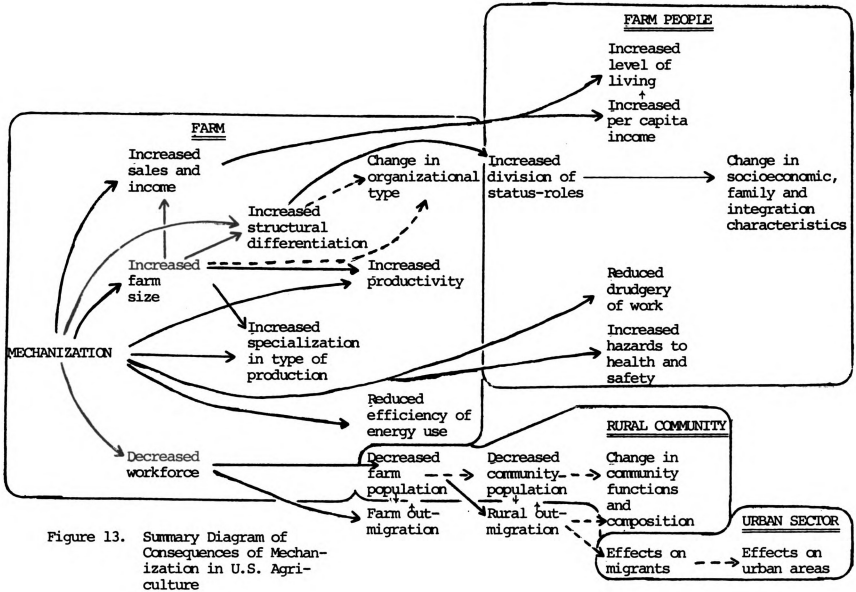


Figure 13. Summary Diagram of Consequences of Mechanization in U.S. Agriculture

FOOTNOTES

[1]The relevant details of these studies are:

Author	Period	Area	Unit of Analysis
McMillan (1949)	1920-1945	Oklahoma	multi-county groups
Bertrand (1951)	1930-1945	Louisiana	multi-parish groups
Bertrand (1956)	1940-1950	Southwest Region (five states)	grouped state economic areas
Constandse (1968)	1944-1964	Louisiana	multi-county regions

The McMillan and Bertrand analytic units were grouped according to level of mechanization; the Constandse study used regions according to major agricultural enterprise.

[2]The relevant details of these studies are:

Author	Independent Variable in Case Study
Metzler (1964) Dillingham and Sly (1966) Vandiver (1966)	Mechanical cotton picker
Rasmussen (1968) Schmitz and Seckler (1970)	Mechanical tomato harvester
McElroy (1969a) E.R.S. (1969) Grise et al. (1975)	Mechanical tobacco harvester
Cargill and Rossmiller (1969)	Mechanical harvesting of fruit and vegetables

[3]Bertrand et al. (1956) analyzed 25 separate census items considered to be indicative of mechanization, and selected six of them to comprise an index equation through multiple regression. Multi-county regions were then assigned farm mechanization scores.

[4]The question of distribution of consequences was raised in Chapter II in response to Merton's "net balance of an aggregate of consequences." It is an important concept in this thesis.

[5]Generalizations for consequences of mechanization will be specified in upper case lettering, and supporting studies listed in parentheses. Those references before the // are longitudinal, comparative studies each capable of supporting the postulated relationship. References between the // and / provide only partial support for such postulates but are qualitatively superior to mere trend data. References appearing after the / are trend data.

[6]For a comprehensive review of this debate see Rodefeld (1974, pp 1-2, 15-20; 1975, pp 1-2).

[7]The part-time farm is where the operator reported 100 or more days of work off the farm and/or the nonfarm income received by him/her and members of the family was greater than the total value of farm products sold.

[8]"The median income is the amount which divides the distribution into two equal groups, one having incomes above the median, and the other having incomes below the median" (p 30). The Gini Index is a measure of income concentration, ranging from 0 for perfect equality of income to 1 for maximum concentration of income in one family or individual (p 26). Families are "Two or more persons related by blood, marriage, or adoption and residing together . . ." (p 28). Unrelated individuals are "Persons who are not living with any relatives . . ." (p 28).

[9]This information is based on measurements of two groups of farmers and farm workers, controlling for size of farm: (1) low occupation differentiation [O-M-L], and (2) high occupation differentiation [O/M/L].

[10]For further studies of the impact of transportation and communication changes on rural communities see Rodefeld et al. (n.d., section IV C 1).

[11]For further studies of the impact of urbanization and industrialization on rural communities see Rodefeld et al. (n.d., sections IV D 1 and IV E).

[12]Interpretation of national data on population change for places is difficult because of partial enumerations and different criteria for inclusion. The relevant details of studies used in this section are listed here:

Author	Period Studied	Criteria for Inclusion of Places: Size of Place	Type of Place
Marshall (1946)	1920-1940	-2500	Unincorporated
Ratcliffe (1942)	1930-1940	-2500	Incorporated
Brunner and Smith (1944)	1930-1940	1000-2500	Census
Brunner (1951)	1940-1950	1000-2500	"Nonsuburban"/ census
Brunner (1962)	1940-1950	-1000	"Nonsuburban"/ census
Fuguitt and Thomas (1966)	1940-1960	1000-10000	Incorporated
Fuguitt (1965b)	1950-1960	-1000	Unincorporated
Beale (1960)	1950-1960	-25000	Census
Fuguitt (1971)	1950-1970	-50000	Nonmetropolitan/ incorporated

Ideally, a total enumeration of all farm trade centers is required. Census data includes all places of 1000 persons or more whether incorporated or unincorporated, and only incorporated places of less than 1000. Many farm trade centers are unincorporated and less than 1000. Using Census places or incorporated places as a sample of farm trade centers is valid only if incorporated places of less than 1000 are representative of all places in this size category. Data for Michigan indicates that this is not the case (Rodefeld, 1976, Tables 10-11). For further discussion see Rodefeld (1976, pp 2-8).

[13]The source was U.S. Census data. Recent analysis for Michigan incorporated and unincorporated places 75-2500 indicates that inclusion of the latter would increase the proportions of rural places losing population (Rodefeld, 1976, Table 21).

[14]The relevant details of studies with farm population as a variable are listed here:

Author	Sample	Time Period
Chittick (1955)	South Dakota	1921-1951
Anderson (1961)	Nebraska	1930-1960
Field and Dimit (1970)	South Dakota	1940-1960
Loftsgard and Voelker (1963)	North Dakota	1940-1960
Beale (1964)	U.S.	1940-1963
U.S.D.A. (1973)	U.S.	1960-1973

[15]The relevant details of studies with place population as a variable are listed here:

Author	Sample	Time Period
Anderson (1961)	Nebraska (36 towns, 6 counties)	1930-1960
Raup (1961)	U.S. (no empirical data)	1930-1960
Brunner (1951)	U.S. (nonsuburban census places, 1000-2500)	1940-1950
Brunner (1952)	U.S. (nonsuburban census places, 0-1000)	1940-1950
Loftsgard and Voelker (1963)	North Dakota (no empirical data)	1940-1960
Field and Dimit (1970)	South Dakota (incorporated places, 0-50000	1940-1960
Beale (1964)	U.S. (counties with rural population)	1950-1960
Beale (1974)	North Central (all counties)	1960-1970
Beale (1975)	U.S. (nonmetropolitan counties)	1960-1973

[16]The urban-rural definition was changed in 1950.

[17]A classic illustration of this economic determinism appears in McDonald (1955). A counter-argument can be found also in economics (Ford, 1973, pp 59-68). For an excellent review see Fuller (1970, Ch. 4).

CHAPTER V

CONCLUSION

Guidelines for the Study of Consequences

The systematic treatment of consequences of mechanization in U.S. agriculture confirmed the guidelines set earlier in Chapter II.

Framework for Consequences

Diffusion	Consequences
independent variables	dependent variables
individual innovation-decision (innovativeness)	consequences
collective innovation-decision (rate of adoption)	consequences

The independent variable, mechanization, is the manifestation of the innovation-decision of farmers, individually and/or collectively, in a specific diffusion process. The dependent variables are consequences of that diffusion process. They may occur for individuals, families, or communities and for their agglomerates: farm people, rural population or society in general. The proposed framework has utility.

Definition of Consequences

> Any changes that occur to a social system or any member of it, as a result of diffusion of an innovation that achieves at least one adoption or rejection.

The consequences of mechanization not only effect farm decision-makers, but their families, their employees, rural nonfarm people, and the urban population. To consider the impact on only the adopters and rejectors of agricultural machinery means an extremely narrow focus on this very important change process. The definition of consequences should account for non-participants in the innovation-decision; for example, small town merchants who face a dwindling farm population, a reduction in clientele and a less than viable demand. The definition of consequences of diffusion of innovations must include those individuals, groups, organizations, etc. that experience changes that would not have occurred if the diffusion process had not taken place.

Classification of Consequences

Anticipated-unanticipated
Desirable-undesirable
Direct-indirect

As recognized by Merton (1936) the anticipated-unanticipated distinction is not clearcut because of the problems "of ascertaining the actual purposes of a given action." Also as the working knowledge of the change agency accumulates, its ability to anticipate consequences improves. What may have been unanticipated consequences at the start of the social change process, are anticipated later on. For example, articles in Agricultural Engineering in 1940-1941 (Davis, 1940; Merrill, 1941) denounced any claims that adoption of new machinery in agriculture would displace labor from the

farm. More recently, however, the manpower implications of mechanization have been recognized and the major question has not been whether labor displacement will occur, but how much displacement will occur. Such "impact statements" have been done for tobacco harvesting (McElroy, 1969; E.R.S., 1969; Grise et al., 1975) and fruit and vegetable harvest mechanization (Cargill and Rossmiller, 1969). If labor displacement was unanticipated in 1940 but anticipated in 1970, this would represent a significant advance in understanding of the mechanization process. The notion of unanticipated consequences is very important because it delineates the area for further research.

Equally problematic is the division between desirable and undesirable consequences. For instance, that mechanization had increased farm size would seem desirable because each farmer on the larger farm can generate more production and hence more income. However, given a limited total acreage, the number of farms and farm workers had to decrease. For many displaced farmers the result is probably undesirable. Desirability is not specific to the consequent variable per se, but to the individual, group, organization, etc. affected by that consequence. Probably every diffusion process has some undesirable consequences for some elements of the social system. This is important because agencies of planned social change normally decide on goals and strategies based on anticipated desirable consequences, while mostly overlooking

undesirable consequences.

The direct-indirect dichotomy is useful. The effects of mechanization did not stop with just increased farm size and decreased farm workforce. Labor displacement was a key factor in reduction and outmigration of the farm population, which contributed to rural outmigration, which in turn added to the urbanization process. It is the indirect consequences that spread the impact of a diffusion process beyond the intended client system. Indirect consequences would more likely be unanticipated, and undesirable.

Dimensions of Consequences

Level
Distribution

The outcomes of diffusion processes have tended to be evaluated in the levels dimension. For instance, most would agree that mechanization has contributed to the increase in farm income. That is, the mean income per farm has increased. There is the tendency to interpret this as economic improvement for most or all farms, ranging from large corporate operations to small part-time farms. However, the higher income farms accounted for most of the increment in income and the lower income farms were relatively worse off. The inequality of distribution of income had increased. Thus, mechanization may have caused a (desirable) increase in the level of farm income, but at the same time contributed to (undesirable) anti-social distribution of that income. The distribution-redistribution of life chances is of increasing concern to

welfare and development policy.

These guidelines for the study of consequences of diffusion are helpful for structuring an analysis in such a way that certain biases, particularly change agency orientation (versus client orientation), are minimized.

Methodology for the Study of Consequences

Generalizations concerning consequences of selected diffusion processes can only come from satisfactory evidence that certain cause-effect relationships do occur. Causation cannot be definitively established from case studies. One "case" means there is only one unit in the analysis. The independent and dependent variables each have one value at one point in time, and correlation cannot be determined. Causation cannot be established from cross-sectional studies. The causal process is time-ordered, and so processual data is needed for testing the direction of a hypothetical cause-effect relationship. Causation cannot be established from trend data. Although trend analysis is longitudinal, there is no tracking of specified units in the analysis across time periods. For example, in the U.S. the number of farm tractors has increased across census periods and the average size of farm has increased across the same periods. However, these measurements were not made by farm, by county nor by state, but were for the nation. In this way trend data are merely longitudinal case studies. Yet, most of the data available

for determining consequences of mechanization is of the case study and/or cross-sectional type.

Qualitatively adequate studies of consequences of diffusion of innovations must be comparative and longitudinal. Comparative studies have at least two units in the analysis, such that at least two paired observations are made. Association can then be determined. Longitudinal studies include time as a variable. The direction of cause-effect can then be determined. Time also allows calculation of rate of change in variables. Comparative, longitudinal data for the relationship between mechanization and farm size, gave no support when the level of mechanization was measured for one point in time, yet gave support when the rate of mechanization was measured between two points in time. Rate of change can create consequences over and above the amount of change.

Besides establishing association and directionality, the causal analysis must also account for the possible influence of other causal variables. For example, competent study of consequences of mechanization should also measure biological advances in agriculture. Many consequences derive from both. To determine the extent that mechanization contributes to a specific change, the extraneous variables such as biological advances need to be "held constant" with empirical control or the ceteris paribus assumption.

The discovery or testing of causal relationships between mechanization and consequences requires longitudinal,

comparative studies with controls on extraneous causal variables.

Theory of Consequences

The experience of cross-cultural application of the classical diffusion model, and of the considerable number of unanticipated and/or undesirable consequences from agricultural mechanization indicates that there is deficiency in the theory of consequences. Firstly, an increase in qualitatively adequate research should reduce the unanticipated component of consequences. Secondly, an explanation for the role of extra-individual factors in social change should ameliorate the amount of undesirable consequences. Individual-level theorizing has generally resulted in models of action that preserve the status quo. Inevitably, structural gaps between segments of a social system are further widened as a consequence of that action. Yet the blame for the relative lag in less-advantaged segments is placed on those segments themselves. Consequences of individualistic theories are inequitable because of structural constraints. This thesis has described an extra-individual approach to diffusion of innovations in which the notions of distribution of consequences and substructural rates of change are important.

The goal of this thesis was to elaborate on a sociological perspective to diffusion of innovations and to develop guidelines for future work on consequences of innovations.

Critical review of diffusion and consequences of innovations has provided justification for further research with the sociological approach. The review of theory construction and research methods specified the need for comparative, longitudinal studies in causal analysis. Systematic review of consequences of mechanization in U.S. agriculture confirmed this need for advancing a theory of consequences of diffusion of innovations. The next phase should be further substantive research in the quest for knowledge of consequences from specific diffusion processes. Principles for such research have been explicated.

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