A PRELIMINARY TECHNOLOGY ASSESSMENT OF LARGE FARM TRACTORS AND COMBINES

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ABSTRACT

A PRELIMINARY TECHNOLOGY ASSESSMENT OF LARGE FARM TRACTORS AND COMBINES

by

Francis Kent Walton

Present governmentally influenced economic policies and conditions make the purchase of large machines attractive on an individual enterprise basis; however, when considered from an overall societal standpoint, many secondary and higher-order consequences must be evaluated to determine if society has actually benefited from increased size of farm machines. Externality costs may exceed by many times the total economic benefit derived from the technology modification of the current high-horsepower farm tractor and combine.

In the research study, externality costs became manifest in farm structural changes which were measured by levels of structural differentiation for each of the five farm structural characteristics investigated. High levels of farm structural differentiation have been shown, by sociologists and economists, to be socially and economically undesirable for society.

Farm structural data associated with large tractors and combines were obtained from computer records of the Michigan State University Cooperative Extension Service's

Francis Kent Walton

TelFarm record service and an investigation was completed of selected structural changes associated with the technology modification of the purchase of highest-cost tractors and combines.

Farms which purchased highest-cost tractors decreased family labor participation and increased hired labor differentiation over twice the amount of the other farms in the study from 1974 to 1975. The increase in capital differentiation on highest-cost tractor purchase farms was twice that of all other farms over the same time period. Land and machinery differentiation increased significantly on the all-farms category; however, a decrease was found for highest-cost tractor purchase farms thus indicating a possible concentration in land ownership and a decreased need for leased machines or hired-machine work on those farms which purchased large tractors.

The second part of the research study developed the nucleus for a comprehensive technology assessment relating alternative agricultural technologies to major societal problems. Techniques of inquiry of problem-driven technology assessment led to controversial issues. Educational aids and inquiry into professionalism were additional subject areas where problem-oriented technology-assessment techniques could likely prove useful.

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A PRELIMINARY TECHNOLOGY ASSESSMENT OF LARGE FARM TRACTORS AND COMBINES

by

Francis Kent Walton

A DISSERTATION

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INTRODUCTION

Within the last century, the technology of mechanical power has revolutionized agricultural food production in the United States. Petroleum products coupled with innovations in metallurgy in conjunction with automotive assembly-line techniques created an agribusiness industrial complex unsurpassed in labor-efficient primary food production. The change from the vast surplus of land with a scarcity of labor during the 1800's to the present adequacy of land with high rates of unemployment, illustrates the need for evaluation of the labor-resource supply in relation to the appropriate application of technology for farm production.

The technological change from animal draft power to mechanical power, derived from cheap fossil fuels, was accentuated only slightly by the wars and slowed only temporarily by the depression of the thirties. Few would argue that the agricultural technological transition from draft power to fossil fuel power was detrimental to the evolving industrializing society up to 1950; however, the adoption of labor-efficient technologies has not been without a large number of associated externality costs. Since 1950 there has been no significant technological ch

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change in mobile farm power sources of the farm tractor and combine, but there has been a twenty-fold increase in the availability of technological modification through increased tractor size. The availability and utilization of large-scale tractors and combines may be of much greater total cost to society as a whole than the economic benefits derived by a select few.

Buchele (1975) emphasized that the primary reason for the utilization of high levels of technology was the reward of individual economic gain. Buchele further pointed out that individual gains from the use of the technology have been shown to rapidly diminish as the majority of possible users acquire use of the technology. The economic gain of the early adopter was then lost, but the technology remained. The possibility of returning to a previous intermediate level of technology was financially nonviable and the externality costs remained.

With the decline in the number of workers involved in direct farm production of food and fiber, there has been an associated increase in the capital requirements necessary for viable commercial agricultural production units. Gulley (1974) considered large capital requirements to be among causal factors which created structural changes that required large measures of agricultural adjustment for those individuals involved with agricultural production. In addition to Gulley, Harris (1974) indicated that traditional family-farm functions have been, in many respects, absorbed

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by agribusiness in varying degrees depending upon type of enterprise and location. Recent vertical integration in the southern poultry industry illustrates structural change from low to high levels of differentiation. Such differentiation has been researched by sociologists such as Rodefeld (1975), Stockdale (1976), and Goldschmidt (1972). The sociologists found specific farm structure with high levels of structural differentiation to be detrimental to the social institutions of society. The economist, Heady (1975), illustrated the economic decline of rural areas associated with large increases in farm size.

Statement of the Societal Problem

For various reasons, specific individuals and clientele groups in the United States value or desire commercial agricultural production farm structure to be similar to one of the following: traditional family farm, current family farm, larger-than-family farm, other-than-family farm, or agribusiness-factory farm. Such farms differ significantly in farm structure, thereby providing a widely varying environment for the individuals associated with each farm structure, and imparting distinctive characteristics upon the communities in which they are located.

It is known that technology change and modification have played a key role in the creation of distinctive farm structure. Yet the exact impact imposed upon farm structure

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by the technology modification of the large tractor and combine is not known. The change from draft horses to total tractorization was a giant shift for agricultural production in the United States. Technology modification in the size of the farm tractor and combine has likely created an even greater change in the structure of farms in the United States than the shift from horses to tractors. The transition from a large hitch of horses to a two-bottom size tractor likely had only a small effect on farm structure compared with the modification from a two-plow tractor to a tractor capable of pulling more than twenty plows.

The available technologies for agricultural production are becoming increasingly capital intensive. Power units required to maintain viable agricultural production enterprises are being manufactured and placed into service in ever-increasing size. The economic viability of purchasing larger machines under present economic policies and conditions makes such purchases financially attractive on an individual enterprise basis. When viewed from an overall societal standpoint, in place of the individual standpoint, many secondary and higher-order consequences of the increasing size of agricultural production technology must be evaluated in order to determine to what extent society has benefited from increased machine size. Externalities or shadow costs may exceed manyfold the initial purchase price of the largest machines. Some se

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secondary costs can be evaluated by economic measures. Other secondary costs to individuals and to society such as losses of components of Freedom, Justice, Environment, and Quality of Life are not measurable by standard specific economic measures; however, they may be systematically identified, evaluated, and estimated.

The problem then, at the societal level, is to determine which technologies and technology modifications best serve the needs of society when all costs and benefits are considered.

Statement of the Research Problem

The first part of the research problem consisted of the need for information regarding the relationship between increased size of farm machines and sociologically relevant farm structural changes. The research approach used in the technology-driven part of the study was to investigate the impacts of the technology modification of size of tractor and combine purchases upon the sociologically relevant farm structural characteristics of family-labor participation, hired-labor differentiation, capital differentiation, land differentiation, and machinery differentiation.

The second part of the study utilized technology assessment which was defined by Coates (1975) as "the systematic study of the effects upon society that may oc

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occur when a technology is introduced, extended, or modified with emphasis on the impacts that are unintended, indirect and delayed." The establishment of an analytical framework for a comprehensive technology assessment related to agricultural technologies and societal problems was the second part of the research problem. Agricultural technologies, societal problems, clientele groups, and references which could be used as the initiation of a comprehensive problem-driven technology assessment were elements selected for inclusion in the research study.

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REVIEW OF LITERATURE

Purpose of Technology Assessment

An aid to decision makers

Technology assessment was developed as an aid to decision makers at the congressional level by Congressman Daddario in 1966. Government funding and interest continued the political orientation of technology assessment until a wider array of interest groups began utilizing the methodology for different types of investigations with the results being used to educate a spectrum of decision makers. The George Washington University assessment group headed by Coates (1975) carried significant impact on the early development of technology-assessment methodology. The technology-assessment process was not to make decisions, but to illuminate and expand associated information so the decision makers could make a decision based on as much accurate information as possible.

Secondary consequences and externalities were the major considerations of technology assessments, and stress was placed upon the fact that information was to be made freely available to decision makers and interested members of the public. In accordance with the definitional nature of technology assessment, this research study gave little attention to the primary economic considerations associated with the technologies in question.

Preliminary Aspects of Technology Assessment

Black (1975) wrote, "Orientation to the future is the major attribute distinguishing technology assessment from research. Technology assessment entails development of hypotheses or statements of prospective future conditions arising from new technology, which could be considered a stage of research, but it does not allow for completion of the research process by testing the validity of such statements of hypotheses which have to be considered plausible possibilities, not certainties or even probabilities. Policy decisions necessarily reflect a subjective or judgmental weighting of the set of hypotheses, or possible consequences of new technology. To have this much illumination of the future is better than no analysis of future consequences of technology, or an analysis restricted to the intended beneficial effects." Black later wrote, "All technology assessments, however sophisticated and detailed, must remain "preliminary." Knowledge of complex social processes and interactions, especially of the future, will forever remain incomplete." In justification for technology assessment, he also wrote, "These estimates are based upon scanty and inadequate data, and must be

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considered rough approximations at this time, but they do not need to be highly accurate for the purpose of illuminating potentially significant long-run consequences."

Back (1975), in referring to the technology assessment of minimum tillage wrote, "This study was undertaken by the Office of Planning and Evaluation as a part of a continuing effort to provide better information for USDA policy officials on significant agricultural and related issues of national importance." Back further wrote, "Knowledge of the past is not useful to policy officials unless it provides foresight of (1) likely future consequences of continuing technological advance, and (2) opportunities to influence the nature, magnitude and direction of future technology. Analysis intended to give a future perspective to policy officials on technology-related decision options and consequences is a part of a recently emerging type of policy analysis called technology assessment." "The purpose of technology assessment is to assist in the management of technological processes including research and development as well as technology transfer and application, not to hamper these processes."

Mayo (1975) wrote, "The purpose of technology assessment is to clarify policy and project options in terms of their full social implications in order that intelligent choices can be made by responsible public and private-sector decision makers." Black (1975), in describing technology assessment wrote, "The function of technology assessment is

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is not advocacy, but to give decision makers a larger and better hand from which they can select their trump card."

Coates, according to Chen and Zissis (1975), also emphasized the preliminary nature of technology assessment when she wrote, "after the initial effort, a monitoring and surveillance program must be set up to update and implement the results of technology assessment on a continuing basis."

Technology Assessment Methodology

Some practitioners of technology assessment have made statements which relate only to a specific type of methodology and would tend, upon interpretation, to be in conflict with an alternative methodology. Black (1975) wrote, "Technology assessment must not attempt impossible precision." Yet Finsterbusch (1975) includes technical feasibility, economic feasibility, and profitability as segments in his complex methodological assessment procedure. Several of Finsterbusch's assessment components did not appear consistent with the definitional characteristics of the secondary effects of technology assessment as defined by Coates which was previously quoted in this paper. Determination as to whether a specific rigorous assessment technique or a generalized assessment methodology would be appropriate for a given assessment would be influenced by factors such as the type of problem to be addressed, the special interests of clientele groups, and the personal cha

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characteristics of the decision makers.

Chen and Zissis (1975) characterized the most important part of technology assessment as "policy-and-action-oriented. The results of technology assessment are expected to change or influence policy decisions." "The effort of technology assessment in the near future should be focused on those technologies which are likely to exert very significant impacts on society and which are in a sufficiently early stage of development still subject to effective control." Chen and Zissis divided the technology assessment methods into those which were "technology-driven" and those which were "problem-driven" as previously used by the Committee on Public Engineering Policy of the National Academy of Engineering and presented to the U.S. House of Representatives in 1969.

In further describing technology assessment methodology, Chen wrote, "technology assessment is policy-and-action-oriented. This makes technology assessment itself more a technology than a science, with all the implications of the difference between science and technology. The conclusions of recent methodological studies are similar and congruent in terms of the general steps taken and the general considerations to be included. However, the specific methods for determining the unintended, indirect, and delayed social effects of a given technology are diverse, unrigorous and judgmental."

Tracing methods were described by Chen as a chain of events or identified impacts. Each impact was made explicit. Tracing methods included the impact-tree method of assessment in which each branch represents a course of events or an alternative for policy decisions. Such a method may be considered a technology-driven method of assessment.

Chen described scanning methods as having possible components of: apparently enormous impacts, major societal problems, major social values, disciplinary aspects, and checklists. Such components were characteristic of problem-driven assessment.

In describing one methodology for technology assessment, Mayo (1975) listed the following steps:

Step 1 - Define the Assessment Task

Establish scope (breadth and depth) of inquiry

Develop project ground rules

Step 2 - Describe Relevant Technologies

Describe major technology being assessed

Describe technologies competitive to the major and supporting technologies

Step 3 - Develop State-of-Society Assumptions

Identify and describe major factors influencing the application of the relevant technologies

Step 4 - Identify Impact Areas

Step 5 - Make Preliminary Impact Analysis

Step 6 - Identify Possible Action Options th

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Step 7 - Complete Impact Analysis

Analyze the degree to which each action option would alter the specific societal impacts of the assessed technology discussed in Step 5

Black (1975) wrote, "it has often been observed that there are linkages between many current social problems and the rapidly advancing agricultural technology of the past three decades." This statement gave a direct awareness of the relationship between social problems and agricultural technology. Many studies such as Cargill (1972) and Hightower (1973) have shown the labor or work displacement aspects of technology. Most such technology-labor substitution aspects were of first-order consequences and were the desired goal of the technology implementation. Such labor-substitution studies are not material for inclusion as principal components of technology assessment until such components are or become second or higher-order consequences.

Problem-driven assessments which were initiated from a list of commonly accepted societal problems were described by Chen and Zissis (1975). The technology or alternative technologies were then evaluated to find whether the societal problem was alleviated or aggravated because of the technology or technologies in question. Various schemes such as that described by Montgomery (1975) have been used to quantify the desirability of the various technologies with respect to goal variables.

Montgomery and the Michigan State University Group for the Analysis and Assessment of Technology developed the components of provision of physical necessities (P), environment (E), freedom (F), and justice (J) as all-encompassing components for technology assessment. In making the quality of life concept operational, the components were placed in a matrix array or cross-tabulation table against technological alternatives. An estimated value judgment ranging from +2 to -2 for each matrix space was then determined. The rows or columns were then summed for the various technologies and an aggregate value obtained for each.

It was the opinion of the author that in the United States, the commercial agriculture production sector of the economy has maintained a relatively steady condition during the past two decades and that the provision of physical necessities, (P), with respect to food and fiber through agricultural production in the United States, has not been a major issue. Therefore, with the provision component (P) satisfactorily fulfilled from the agricultural sector, components of environment (E), freedom (F), and justice (J) were emphasized for the latter part of the research study.

Related Studies Which Used Technology Assessment Methodology

Back (1975), along with others in the Office of Planning and Evaluation of USDA, published Minimum Tillage: A

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Preliminary Technology Assessment, in September, 1975. This was one of the first technology assessments dealing specifically with a technology within the area of agriculture mechanization and will be reviewed in methodological detail.

Back prefaced the study with technology assessment definitions. A page of "highlights" followed containing the following material. "The purpose is to provide policy officials and program managers with information useful for managing the process of technological change in ways to enhance beneficial effects while avoiding potentially adverse effects." Projections were prepared through the year 2,000 and summarized as follows: annual harvested acreage up 20 million, crop production up 5 percent, labor savings of 350 thousand man years at an estimated value of $1.6 billion, energy savings of 850 million gallons of fuel or $275 million per year, increased use of chemicals with a cost of $300 million per year, soil losses reduced by 50 percent, environmental pollution from pesticides and herbicides may become a major social concern, and the impact on numbers and sizes of farms remains in doubt. More research is required to accelerate beneficial impacts or reduce adverse consequences.

Back's "Introduction" provided a definition of the technology within a conceptual framework rather than specific typological farm practices. The technology under study was then related to the complementary technology of chemical weed control.

The previously stated conceptualization as to content was then listed as principal variables or "impacts" related to production increasing conditions (yield, multiple cropping, etc.); conservation and environmental quality; energy, machinery, labor requirements; and farm size. Implications for public policy and recommendations also followed in the report and were presented as follows:

1. The extent of the technology adoption was given. (Acres covered by the technology, 1963-1974).

2. Factors affecting the technological concept "Each farmer makes these kinds of production decisions on the basis of the agronomic and economic information available to him." Market and price factors were assumed not to be major constraints. Yields and multicrops may increase due to the enhancement of timeliness and moisture considerations. Lower machinery and labor costs enhanced adoption. Conservation tillage relates to the environmental factors.

3. Projected expansion of the technology to the year 2,010 was divided into levels of the technological concept and crop specific estimates. The adoption of the pure technology of zero tillage was compared to reduced tillage. Adoption curves were estimated.

4. Impacts; farm labor estimates for the year 2,000 were estimated at 2 percent of the national workforce. The impact of the technology in question on national labor is negligible. "However, reduced tillage may be a major contributor to further significant reductions in farm-labor

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requirements." Feed grains, wheat, rye and soybeans produced with the new technology could save 200 thousand man years of labor by year 2,000 or a 7 percent reduction in labor. "For some farms, labor saved may encourage expansion in crop acreages and farm operations." "Because most of the pre-harvest operations are performed by farm-operator families rather than hired labor, a substantial amount of this saving could be diverted to increased leisure time of members of farm families."

In production costs, labor was valued at $3 per hour and minimum tillage saved 52-58 percent of preharvest labor. Machine costs were expected to decrease as the minimum-tillage technology was adopted over a long time span; however, immediate cost reductions were not expected.

Concerning energy costs, future supplies of fuel were in question. With higher energy prices, farm costs and consumer prices for food could rise. Conservation tillage could save 50 percent of total production of energy requirements. By 1980 a 20 percent reduction in tillage could save 425 million gallons of fuel per year. Twice this much could be saved by the year 2,000. Pesticide use would increase 2 lb/acre by 2,000 and would be equivalent in energy requirements to an additional 0.6 gallon of fuel per acre.

As to number and sizes of farms, Back wrote, "available data are inadequate for fully assessing the impacts of further reductions in tillage on numbers and sizes of farms."

Soil losses due to erosion can be cut 50 percent by the adoption of the technology. Pesticide pollution of the environment would likely increase with the adoption of the technology. Back's summary was adequately covered in the preceding comments. Research implications which followed the summary included specific technology research needs and monitoring requirements to follow the developing technology. Policy and Program Implications included the USDA's promotion of the technology based upon conservation, environmental, and production impacts. The technology assessment was ended by a list of needed monitoring functions to make the assessment more useful in future years.

Back's technology assessment was written within the institutional framework of the USDA and therefore did not deal with controversial issues. Most issues considered were of primary consequence rather than the investigation of second-order consequences which was the material considered by most technology assessments. As an example, Back listed the savings of 350,000 man years at a value of $1.6 billion. He did not list the possible societal costs attached to that savings such as displacement, relocation, unemployment, and decline of community institutions.

In considering relevancy, Guy Black (1975) wrote, "In short, technology assessment directed to mission-oriented agencies must be restricted to the scope of agency interest and responsibility; otherwise it loses relevance to that agency. But from a public point of view, assessment in these terms is too narrow."

Cargill and Rossmiller (1970) recommended studies be undertaken of a technology-assessment-like nature. They recommended that "Studies be undertaken to develop appropriate policies whereby the losers who are required to make substantial social and economic adjustments due to technological change can be compensated, out of the rewards flowing to the gainers from those changes." They also recommended the development of a parallel system of social accounts in which measurements of the non-market costs and benefits of alternative programs and policies may be assessed.

The following study which used methodology similar to technology assessment was included even though the words technology assessment were not used by the authors. Fridley and Holtman (1974) in Predicting the Socio-Economic Implications of Mechanization by Systems Analysis used confidence levels to compute an expected value of system merit. A rating of from 4 to 10 was used. The value of 4 represented marginal acceptability and 10 represented high achievement of desired outputs. Various technologies and clientele groups were selected. A realized output index was also introduced into the calculation as a measure of technology performance. Summation techniques were used to find composite desirability indexes. Fridley and Holtman concluded, "Engineers are responsible for dramatic changes in our way of life, and agricultural engineers will continue to have a very important impact on farmers, farm workers, and consumers of farm products. It is our responsibility to do all we can to ensure that our efforts provide the best possible overall benefits. This goal can be met best by a systematic effort at clearly defining the real need and identifying both the positive and negative aspects of proposed changes."

Gill (1971) in Economic Assessment of Soil Compaction wrote, "This physical, compactible soil system, however, is not an isolated entity since it interacts with the social and economic components of the agricultural system. The importance of soil compaction as a physical phenomenon must be evaluated in relation to the complete system, and the cost of compaction must be established to provide a basis for national as well as individual decisions." "Intuitively we may believe that compaction induced by mechanization may reduce crop yields, but that these reduced yields may be offset by more economical forms of cultural operations. As a result, viewing the practical system in terms of "net" costs may provide a means of "living with" an agricultural system which has an inherent controlled compacting capability." Gill assumed a 1 percent loss in crop value due to compaction for freeze depths of over 25 cm and a 10 percent loss for depths of freeze less than 25 cm. With the previous assumptions, Gill estimated crop value loss at $1.18 billion annually for the U.S.

Gill also wrote, "the economics of the agricultural system appear to dictate the adoption of equipment that has a greater compaction potential rather than less."

Donaldson and McInerney (1973) examined unanticipated structural and societal changes which were due to the tractorization of sectors of India. They found enlarged land holdings; tenants had been eliminated, and there was no increase in production intensity.

McMillan (1949) found a .97 correlation between tractors per 100 farms and the average value of farm machinery and implements per farm in Oklahoma. McMillan determined the tractors per 100 farms to be a valid and reliable measure of farm mechanization. In the study, he found population decreases greatest in counties with the greatest number of tractors per 100 farms. From 1925 to 1945, McMillan found a 3 to 4 rural-farm-person decrease for each tractor added. Also for each tractor added there was a decrease of 0.5 farm.

Bertrand (1951) found mechanization to be the significant change factor in rural Louisiana. An increase in tractors was correlated with an increase in cropland per farm, a decrease in the number of farms, and a decrease in rural farm population. Bertrand and others (1956) researched mechanization and social consequences in the Southwestern United States.

Finch (1951) related the United States economic, farm, and social structural problems associated with farm production to the advance of mechanization. Overproduction through mechanization and subsidization were the factors which displaced many farm enterprises.

Esmay (1973) considered the social costs of reduced employment to be a major consequence of most large-scale mechanization efforts in developing countries. Appropriate or intermediate technology was considered the desirable alternative for a wide-based income distribution.

The President of Yale, Griswold (1948), in Farming and Democracy wrote, "Meanwhile agricultural machinery and technology, applied on a constantly expanding scale, increased the productive capacity of agriculture, depressing prices and wages, creating a labor surplus, and accelerating the flight from the land." "These were the true causes of distress of agriculture." Griswold went on to illustrate the total cost of food purchased by American consumers to be the price paid by the consumers plus that paid by the taxpayers in subvention of existing methods of producing it and the social institutions surrounding them.

Gulley (1974), in Beliefs and Values in American Farming, described freedom by encapsulating it in terms of presocial freedom. He wrote, "The concept of freedom that has been a part of an agrarian view of agriculture is inadequate for farming in the present and future." "Freedom for the farmer in the latter part of the 20th century will not square with the concept of independence of the Agrarian Ideal." "The rugged individualist has been given his due credit, but perhaps it is time to lay his weary bones to rest." "The type of structure desired for agriculture is one that is capable of achieving society's goals." "There will be fewer farmers in the traditional sense of the word; that is, owner-operators." "Of necessity, the farmer must increase his output in order to increase his income." "He is not able to improve his income appreciably but finds it necessary to expand his operation simply to stay even."

Schwarzweller (1975) portrayed the changes which occurred in a German village due to tractorization. Schwarzweller indicated a high degree of over-mechanization had occurred in recent years in the German village which he studied.

Buchele (1975), in Social Costs of Large Machines/Farms, assessed a variety of societal problems such as unemployment costs and conservation. The temporary advantages, gained by early adopters of technology, were discussed along with the long-term benefits gained by society. Limitation of farm size was considered as a control measure to counter the effects of technological change. Buchele developed a concept of "A new view of rural America" and described "A plan for rural America" based on a long-range plan for U.S. agricultural conservation.

Statement of the Current Status of the Art

Technology assessment is a relatively new area of study; the topic was placed in a position of national view in 1966 by Congressman Daddario in a report to the Subcommittee on Science, Research and Development. A wide variety of methodology has developed from the detailed technology-specific outline listed by Finsterbusch (1975) to the broad conceptualization developed by the Michigan State University Group for the Analysis and Assessment of Technology as described by Montgomery (1975).

Each methodology has its specific advantages and limitations. Such advantages and limitations depend upon the objectives of the individual or individuals who are to carry out the assessment and the clientele groups who will be served by the assessment. Time and cost limitations may also enter into the methodology selected for the study.

The previously considered definitional papers and related studies gave insight into the topics considered and methodologies used in this study. Considerable time passed since studies were completed which related mechanization to various sociological consequences at the onset and after completion of tractorization in the United States. The technology-driven assessment part of this research was an inquiry into sociologically relevant components of farm structure as affected by the technological modification of the large farm tractor and combine.

Approximately thirty years has passed since the completion of tractorization. Although many sociological studies have been completed over this time period and it has been known that tractor and combine size has been increasing, no major attempts have been made to interrelate the technology modifications considered in this study with sociological components of farm structure and changes in farm structure which have been shown by Rodefeld (1974), Goldsmith (1972), Heady (1975), and others to be sociologically relevant.

The diversity of techniques and variety of approaches to problems used by practitioners in the field of technology assessment, illustrate the newness and diversity of the field of technology assessment. With the characteristic of technology assessment being investigative toward second and higher-order consequences of technology, the methodology was quite appropriate for studying sociologically-related variables.

Reese (1973) in Candidates and Priorities for Technology Assessment found, from a survey of Federal Executive Agency Professionals, mechanization of farming and the resultant displacement of people from the land to be considered as a candidate technology for assessment. Although several components of labor were considered in this research study, such components were evaluated from sociologically-related structural relationships rather than from an economic-displacement viewpoint. This research study was undertaken from a broad holistic approach rather than from myopic, special-interest considerations.

Conceptualizations and Definitions

Farms

The explicit definition of farm types was of critical importance in understanding the various structural concepts presented by the different authors in previous studies. The general definition of a farm as a land-based unit producing food and fiber was a beginning point for many authors. This definition gave little indication of any structural or classification-type information, and most authors could agree thus far on the definition of a farm. Traditional legal definitions of land ownership were proprietary in the definitions of farms. Such definitions rapidly became incomplete as new land-use and ownership patterns developed. Such traditional definitions were considered only as they applied to specific issues in this research study.

As enumerated elsewhere in the study, the Agricultural Stabilization and Conservation Service (1973) set explicit land ownership and use categories in establishing equitable and generally acceptable just distributions of government funds toward land owners and tenants who maintained farm operations upon land owned by others. Such definitions were based upon parcel ownership or on farm operatorship.

This type of farm definition was based on ownership of the land resource, and there could have been as many farms as there were owner parcels, plus the additional category of farms as operational units which were operated by tenants upon land owned by individuals other than the tenant. The primary measurement used in classification was the physical dimension of size in acres.

The Census of Agriculture adopted classifications for farms based on acres operated, acres of land owned, acres of land rented, and legal status of corporations. As economic trends and political objectives changed, so changed the definition of a farm. As explained in detail by Rodefeld (1974), such definitions were inappropriate for the study of changes in structural differentiation.

Larson (1974) wrote, in Economic Class of Farm; and the Farm-Family Welfare Myth, of the inadequacy of using size of farm business and other economic measures as indicators of farm and family well-being. Traditional definitions of a farm were covered in additional detail in the section which conceptualized farm structural differentiation.

Family farms

Much rhetoric, considerable popular writing, and some economic writing has been devoted to the idealization of the family-farm concept. Most authors agreed that there were elements beyond economic considerations associated with the concept of the family farm. The agreement that there were associated elements was as far as the authors agreed.

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Nikolitch (1972) contributed significantly over recent years toward adding elements of farm structure, both economic and elemental such as labor, into the definitions of farm types. Nikolitch defined the family farm as "a primary agricultural business in which the operator is a risk-taking manager, who with his family does most of the farm work and performs most of the managerial activities." The remaining farms which failed to meet the preceding conditions were then called "other-than-family farms."

Gulley (1974) in Beliefs and Values in American Farming developed historical perspectives into definitional frameworks. Such definitional frameworks were covered in detail elsewhere in the study.

Nair (1969) traveled the world searching for common elements of farm characteristics and compiled the findings in the book entitled, The Lonely Furrow. Definitional elements were found throughout the writing. The invisible ladder, the national dream, farm indebtedness and the work ethic were considered with respect to technology and other related factors.

Slack (1970) was one of the initiates in recent agribusiness farm-type definitional writing. In Defense Against Famine: The Role of the Fertilizer Industry, Slack wrote, "In the early days of agriculture--the manure and ashes era--the cost of farming was not given much thought. There was little or no outlay of cash; the farmer grew his own seed, supplied his own fertilizer, and provided motive power in the form of horses (or bullocks) and his own muscles. The farm was a family operation, a self-contained enterprise." "In some areas of the world this is still the rural way of life, but it is fast passing away, even in the less-developed countries. In the more advanced areas, much of the crop production is on large farms operated on a "food-factory" basis. Seed is bought from specialty growers; tractors, combines, and other machines make it possible for one or two men to farm hundreds of acres, and large amounts of fertilizer are bought and used to give high yields per acre."

Other agribusiness elements, particularly the machinery manufacturers, have entered writings and other media as definitional interpreters of what should be considered family farms. Henkes (1976) and Nelson (1975) illustrated the concepts desired by the machinery industry. Another agribusiness, the largest so-called "farm organization", Farm Bureau, which claims to represent the largest block of farmers, avoids using the words family farm for reasons described by Olson (1973). Olson showed that such a vast conglomerate as Farm Bureau could not justly represent the conflicting interests of the family farmer and agribusiness.

Paarlberg (1974) defined the family farm as "one on which the majority of the labor and decision-making are supplied by the farmer and his family." Kyle (1973) wrote, "It is still going to be a long time, 25 to 50 years, before public corporations control much of our agriculture, but it doesn't mean that commercial farms will be the "family farm" in the old sense of the word." Ottoson (1963) wrote, "The family farm still dominates the rural scene but the old definitions are outmoded." From such statements it was evident that the definition was an evolving definition which required more than the two words "family farm" to convey a specific meaning.

Harris (1974), in Entrepreneurial Control in Farming, wrote, "About 1/2 of selected elements of entrepreneurship have been shifted to off-farm firms. The overall trend is toward acceleration of such shifts brought about by the quickening of change in agricultural technology." Such elements of current definitional nature add complexity to an operational definition needed for the research study.

Other farm types

Wunderlich in Ottoson (1963) suggested farming has "moved through the Domestic Stage characterized by largely self-sufficient units and motivated by self preservation; and through the Commercial Stage characterized by off-farm contact with the product markets and motivated by family income. We have now entered the Industrial Stage characterized by close interdependence with both resource and product markets and motivated by firm profits."

Nikolitch (1972) used the concept of other-than-family farms. This concept was effective as long as the definitional characteristics did not require further elaboration for the study at hand. Factory farms as used by popular

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writers carry significant connotations but very little definitional characteristics useful for research type classification.

Rodefeld's (1975) classification of farm types was useful, as his conceptualizations were explicitly based on various farm structural characteristics. Rodefeld's definitions of family, tenant, larger-than-family, and large-scale-industrial type farms were useful in that the farm legal organization (proprietorship, partnership, corporation) was viewed separately from structural type. Rodefeld's research findings on the present and changing status of family and nonfamily type farms have been markedly different from those of the United States Department of Agriculture. These latter studies have classified farms according to their legal organization or in terms of other census definitions.

Thompson (1976) added dimensions of rural resident, supplemental-income farmers, senior-citizen farmers and full-time small-farm operators in his research work concerning small farms in Michigan. Thompson's dimensions were further categorized by off-farm employment, farmer age, and level of farm income. Consistency with census classifications was maintained.

For purposes of this study, Michigan TelFarm farm type classifications were unified under the three categories of crop, livestock, and specialty as shown in the following list.

Crop: Saginaw Valley Cash Crop
Cash Grain

Livestock: Cattle Feeding
Hog
Beef-Hog
Beef-Cow
Southern Dairy
Northern Dairy
Southern Dairy Mixed
Southern Mixed
Northern Mixed

Specialty: Unclassified
Fruit
Vegetable
Potato
Poultry
Forest Products
Flower
Nursery
Mushroom

As stipulated by definition, TelFarm crop farms received less than five percent of their income from livestock or livestock product sales.

Structure and structural differentiation

As was previously noted under the definitions of farm and family farm, structure became a component in the definition as the definitions were expanded and conceptualized into modern terminology. Nikolitch (1972) included labor and management in the definition of the family farm. Paarlberg's (1974) definition also contained the resources of labor and management. In the study and writing of Structural Changes in West European Agriculture 1950-1970, Breitenlohner (1975) used macro-level structural characteristics of: agriculture in the economy, agricultural labor force, agricultural productivity, agricultural output value, land utilization, average farm size, distribution of agricultural holding by size, fragmentation, land tenure, mechanization inputs, chemical inputs, and irrigation inputs.

The United Nations, Economic Commission for Europe (1967) also used macro-level structural characteristics of: labor-force decline, management resources, vocational education of operator, capital investment, income, part-time farming, type of institution, tenure, type of ownership, sales, output-input, gross sales, pattern of farming, level of technique or mechanization, costs, level of yield, return to capital, family farm income, labor requirement and rent.

Donaldson and McInerney, (1973) (2) wrote, "The primary impact of mechanization on agriculture can be seen through the changes in its input structure." "Certainly mechanization has been the critical enabling factor in the process of farm amalgamation."

Weelock (1969) related structural differentiation to sectors of the national economy and suggested that structural differentiation could be used as a predictor of productivity.

Ball and Heady (1971) described the traditional family farm as a farm where all of the factors of production were owned and provided for by the farm family. The North Central Public Policy Education Committee (1972) in Who Will Control U.S. Agriculture described structural components of hired labor and hired management along with rented land and rented machines (capital) noting that they have recently entered into the farming economy in large scale.

Harris (1974) analyzed entrepreneurial control in agriculture by describing the traditional family farm in the United States whereby the operating manager and his family owned and controlled all of the factors of production. In such a traditional family-farm structure there would have been no differentiation. The direct contrast to such a traditional family farm was the totally differentiated factory-type farm in which hired management had no structural connection with land, capital, or management; land owners had no structural connection with labor, capital, or management. And finally, the owners of the capital would have no structural connection with land, labor, or management. Rodefeld (1974) labeled these farms with the highest levels of differentiation on all dimensions as the "corporate/industrial type."

Gulley (1974) went to considerable detail in describing and diagramming differences in the traditional farm structure and the current commercial farm structure. Difficulties were encountered with conceptualizing farm structure as Harris and Gulley's definitions lead from a traditional family-farm structure to the current factory-type commercial farm structure. Their definitions were not at the true endpoints but in the middle of the definitional structural continuum between the two pure endpoints.

Nickolitch (1972) gave some insights into structural definitions by his explanation of the current commercial family farm. By his definition, if a farm employed a hired non-owning manager or if more than 50 percent of the total labor was hired, the farm was classified in the other-than-family farm category. This type of conceptualization, however, gave little understanding of farm structure between the exact definitional points on the continuum. Rodefeld (1974) overcame the structural definitional problem by using a differentiation scale which was suitable for mathematical analysis. After analysis the scale was divided into high, medium, and low levels of structural differentiation, and was used by Rodefeld to classify farms according to structural type and investigate the relationship between farm type and rural community characteristics and change. Structural differentiation as defined by Rodefeld was used as the starting concept for the independent variables of farm structure employed in this study. This differentiation concept may be thought of as losses of parts of entrepreneuership of the farming operation. (Harris, 1974) Differentiation may be considered as a loss of entrepreneuership functions from the totally owned and managed traditional subsistence type family farm as described by Gulley (1974).

In the present research, the level of farm structural differentiation will be defined as the extent to which the farm manager is separated from the ownership and/or provision of the remaining factors of production (land, labor, and capital). The level of differentiation between the factors of production may be thought of as the level of non-ownership and/or non-provision of the production factors.

Structural differentiation concepts were used to describe the interrelatedness of the traditional production factors of land, labor, capital, and management. The definition of family farm as defined by Nickolitch (1972) was combined with the conceptualization of farm structure and structural differentiation as used by Rodefeld (1974). The family-farm structural base, where the operator provided most of the management and the operator and family provided the majority of the labor for the farm operation, gave a starting point for farm structural consideration which was consistent with current commercial farm operations in the midwestern United States. In current commercial farm operations structural differentiation may be thought of as infringements between measures of concern, associations, or ownership between the farm operating manager and the other factors of production. Putting it simply, differentiation was used as a measure of who owns and who controls the factors of production on a farm operation.

High levels of differentiation between the factors of production of a farm enterprise may be considered as either desirable or undesirable depending upon the specific party at interest. For example, the interests of absentee owners wishing to extract maximum immediate monetary returns from a given farm enterprise with high levels of structural differentiation would likely be opposed to local area residents who have economic interests which would be best served by low levels of structural differentiation of the given farm enterprise as described by Heady (1975).

The objectives of the technology-driven part of the research were to empirically determine the types and levels of farm structural differentiation and determine if levels of structural differentiation were increasing or decreasing, and determine if changes in technology might be responsible for changes observed in levels of structural differentiation.

The differentiation variables were designed to range from zero to one. In unique cases, however, differentiation could become greater than one due to unusual farm structural characteristics.

Technology selection

From James Watts' early experiments in England through the steam-power era of mobile power devices to modern tractors of current production, the unit of power has been horsepower.

The Nebraska Tractor Test Law of 1919 was the first significant large-scale effort at establishing uniform tractor-test procedures. The test was based on various performance horsepower output measurements and has proved useful from 1920 to present, with very little change.

Owing to the various homestead acts and settlement patterns, the large farms which could utilize large equipment did not predominate in most areas of the United States. The manufacture of small gas-powered tractors provided an alternative to draft animal power for small farmers.

Gray (1956) illustrated in his history of the development of the agricultural tractor in the United States that very large tractors were in use as early as 1909. Gray stated that by 1925, the low-priced Fordson represented 60-75 percent of the total domestic tractor production. The Fordson and other mass-produced two-plow tractors initiated a two-plow tractor-size era in U.S. agricultural production history. By the mid-thirties most companies had introduced three-plow tractors. Four-plow tractors were introduced in the 40's and 50's. The 60's saw the five- and six-plow sizes and by the 70's the horsepower race was full speed ahead.

Early large tractors described by Gray were the Reeves 40-horsepower steam tractor which pulled sixteen 14-inch plows and broke 160 acres in 24 hours, the Gaar-Scott steamer of 25 horsepower which plowed at the rate of 1 acre in 7 minutes 58 seconds, and the largest Best tractor which weighed 41 tons and had drive wheels each 15 feet wide by 9 feet diameter. The horsepower ratings reported by Gray were likely not based on current methods of calculating horsepower.

Gray also illustrated the close association between mobile power sources and plowing. To many individuals the concept of tractor size was based on the number of plows a tractor could pull in a satisfactory manner. The general acceptance of the plow size classification was illustrated by Farm Equipment Red Book as late as 1959. Farm Equipment Red Book listed the number and size of plows as the first specification for each type of tractor. Back (1975) referenced Rask's use of two-plow and four-plow size tractors in labor-utilization studies.

With the recent advent of the chisel plow and the introduction of the adjustable-width moldboard plow, which adjusts from 12-inch cut to 22-inch cut, hydraulically on the go, the concept of number of plows a tractor can pull will likely disappear as a measure of size in the larger tractors. From the standpoint of the present technology assessment, the tractor-size categories were selected and classified as (1), the two-to three-plow-era size, (2), the four-to six-plow-era size, and (3), the current trend of tractors sized by 100's of horsepower.

The Farm and Industrial Equipment Institute (1976) utilized one-size breakdown in power-take-off (PTO) horsepower for two-wheel-drive farm tractors, and another for four-wheel-drive farm tractors. The two-wheel-drive small tractors were size-categorized as under 35, and 35 and under 40, PTO horsepower. From 40 to 100 horsepower, the interval was in increments of 10 horsepower. Higher horsepower categories were 100 to 120, 120 to 130, 130 to 140, 140 to 150, and 150 and over. The four-wheel-drive

categories were under 170, 170 to 200, and 200 and over horsepower.

Sohne (1975) graphically illustrated the trends in tractor size by graphing sales of various sizes of tractors over time for the U.S. and the Federal Republic of Germany. The graph illustrated a loss in sales of from 60 percent to 8 percent of tractors of less than thirty-four horsepower in only 11 years from 1953 to 1964. In contrast, tractors of over 100 horsepower in 1964 had only 3 percent of the market, and 11 years later had 54 percent of the market. From Sohne's graphic data, the new tractors sold appeared to double in horsepower every 11 years. In contrasting this technology modification with the decline in farm workers, it must be considered that the numbers of tractors used or tractor use per year may have changed significantly.

The same interpretation was made from Sohne's graph of the Federal Republic of Germany of tractor size doubling twice over the last 20 to 22 years. Implement and Tractor (1976) reported a 7.1-horsepower increase from 1974 to 1975 for the average new tractor sold. This represented an increase of 7.9 percent over the year or over twice the mean increase over the past 10 years. The annual sales of tractors over 100 horsepower increased 2,036 percent over the past 10 years. During the same 10 years, the horsepower sold in size units over 100 horsepower increased 2,798 percent.

Bowers (1975) indicated 10 years to be the useful life of a tractor. When this use period was connected with the size of tractor sold, it appeared as though each new tractor sold had the size capability of accomplishing twice the amount of work of the tractor which it replaced. From the labor standpoint, such would be the case only if the number of tractors remained the same. Implement & Tractor (1976) reported that the number of new-tractor sales declined from 196,994 in 1973 to 173,801 in 1974 and to 161,147 in 1975. The total horsepower sold over the time period remained relatively consistent, the values being 16,839,000; 15,706,400; and 15,704,900, respectively. A great deal of the increased tractor horsepower was used to improve timeliness of field operations according to Bowers (1975). Harrington (1975) graphically illustrated the use of increased horsepower per given unit of land in the United States; the horsepower increase was nearly linear over the period of his study.

Back (1975) referenced the Ohio study in 1967 by Norman Rask (Cost-Analysis of No-Tillage Corn", Ohio Report January-February, 1967, p. 14-15). Preharvest labor for two-plow equipment was reported to equal 3.47 hours per acre of corn produced, and for the four-plow size equipment, the labor reported was 1.86 hours. The same figures for no-till were .70 and .50 respectively. The study was interesting in that the labor would have been expected to have been cut in half when the tractor size was doubled. In the case of no-till, only a 28 percent reduction in labor was given for a doubled tractor size.

In considering multiples of a technology and tractor purchases, the purchase of smaller tractors was likely to have been of a replacement nature on a one-to-one basis. Medium-size tractors may have been purchases for a one-to-one replacement basis, or may have been purchased to replace several small tractors. It was unlikely but entirely possible that a medium-size tractor of 100 horsepower was purchased to replace four tractors of the 25-horsepower size. Such a replacement as the hypothetical one-for-four technology modification would likely have had a large effect on farm structure, especially the farm-labor structure. If this trend were carried further to include the largest tractors of 300 to 600 horsepower, then it would have been possible to conceptualize a technology modification of a tractor purchase where one tractor purchased replaced at least twelve smaller tractors. It was highly unlikely that a change of this order of magnitude had occurred on any one farm at any one time.

In relating the tractor to farm production, Gill (1971) wrote, "Even though many special-purpose machines are self-powered, a large number of machines draw auxiliary power from the tractor; hence the power of the farm tractor determines the capacity of the entire crop-production system."

Combine technology selection was similar to tractors with respect to size and time. Several large combines were constructed and pulled by horses or mules in the late 1800's. Holbrook (1955) reported a 42-foot-wide cutting header on a combine drawn by 40 horses in the year 1828. The combine had an auxiliary engine powered by a steam hose. The Furrow (1975), in its Bicentennial issue, pictorially illustrated a similar combine pulled by over 30 horses and mules.

Gasoline-powered combines (requiring three men in place of the 20 to 30 for steam threshing) appeared as early as 1912, according to Holbrook. Steam threshing machines predominated in harvesting until the late 1930's and early 1940's, when small combines of 5 to 6-foot-cut width harvested the majority of sown grain crops. The small mass-produced combines were power-takeoff-driven and required only one operator. By the late thirties a self-propelled combine was manufactured and popularized through use by the harvest brigades running from south to north with the ripening grain during the war years. After the war, the size or capacity of these machines began the same increase as tractors. The combines became a multipurpose harvesting machine in the midwest as corn heads were added. Capacity or size was measured in the number of rows of corn that the specific machine would handle. Combines were usually manufactured in multiples of two rows. With the advent of the 6-row, 30-inch planter, however, many 3-row corn heads were manufactured for the smaller model machines. Row models of 2, 3, 4, 6, and 8-row sizes dominated the market. Official Guide, Tractors and Farm Equipment, (1976 and earlier) listed the four basic sizes of combines offered by most full-line companies. The sizes were based not on the grain-platform head width, but on the corn head carrying capacity. The Official Guide (1976) listed only one power-take-off combine capable of multipurpose harvesting, and it required a 1,000 RPM power-take-off. The size capacity on the machine was equivalent to a six-row corn head which placed the available power-take-off combine in the next-to-largest size category. The company manufactured two smaller size models in the self-propelled line, but no smaller power-take-off model. The conclusion was that no multipurpose least-cost machine alternatives are available today to fulfill the needs of the small farmer.

Since the framework of agricultural structural thought has shifted from an individual-human concept (the self-sufficient family farm) to a business-oriented commercial-production (agribusiness) concept, it seems relevant to base a study of farm structure on economic technological capacity rather than on individual farm-machine size. It was decided to use the level of investment in the machines as a continuous variable to study farm structure. The disadvantages, such as inflation, in using the price paid for various technologies are considered elsewhere in the paper.

This study was not one of what technology modification had occurred on the farms. It was a study of the technology modification of tractor and combine purchases and the effects of such purchases on the structure of the farms studied.

There was the possibility that a tractor or combine purchase was not a technology modification but a direct machine replacement. This would seem unlikely as the number of years of useful machine life is relatively short and the rapidity with which new models of tractors and combines were introduced. These and other factors (such as repair down time and average tractor size of purchases and number of trade-ins), taken in aggregate, illustrate how few tractor purchases were made to replace a tractor with the identical tractor technology.

Even if a tractor purchase resulted in the same technological replacement as would a trade-in for an identical tractor, then the technological effect from the purchase would have been a null effect from the standpoint of farm structure excepting any secondary causal forces upon farm structure due to the economic considerations from the purchase. Without investigation, here, it would appear that such economic impact would cause very little if any effect on the farm structure due to secondary infrastructural changes resulting from economic forces.

PRELIMINARY TECHNOLOGY ASSESSMENT

Methodologies Followed in Research

Two major methodologies were followed in the research. The first was the technology-driven assessment; the second was the problem-driven assessment.

The technology-driven assessment part of the research study was initiated by a demographic search of possible areas where sufficient numbers of the technology for study would be located. Potential areas were then narrowed by limitations imposed by financial resources available for the study. Various information sources were investigated which linked the technology for study with components of societal structure. The information source which provided the largest amount of data of types required for the study, at the least cost, was found to be the Michigan State University Cooperative Extension Service, TelFarm records. As the TelFarm record-system data were structured for tax and economic analysis, a large number of procedures were necessary to arrange data into forms useful for the study of various technologies and agricultural structural characteristics.

The second methodology followed in the research was that of the problem-driven assessment. Several of the techniques used, such as the analysis matrix and quality-of-life components, were developed by Montgomery (1975) and the Michigan State University Group for the Analysis and Assessment of Technology. The author developed technological alternatives and technological modifications associated with the agricultural-production technologies in question. Also developed were societal problems, clientele groups, and reference lists which connected and associated the technological alternatives and modifications with the societal problems.

An example was given using technology-assessment techniques as an educational aid, and an inquiry into professionalism was developed.

The application of assessment methodologies was preceded by the author's selection of clientele for research findings as suggested by Montgomery (1975). As indicated earlier, the primary objective of technology assessment was to provide information as an aid to decision makers. The first requirement would therefore follow that the decision makers or clientele must be first identified in order that data could be structured to produce maximum educational impact on the decision makers. The clientele list follows.

Clientele for Research Findings

1. Farm Machinery Industry

    Management

    Design Engineers

    Labor

    Sales - in-house industry, advertising, retail

    Primary Consumers (farmers)

2. Food Policy Makers (generalists)

    Congressional members

    Congressional hearings

    Consumer protection groups

    Individuals

3. Educational Institutions

    Agricultural Engineering and Physical Systems in Agriculture

    Agricultural Education - College level

    Agricultural Education - High School Vocational Agriculture

    Extension

    Rural Sociologists

4. Groups

    Organic farmers

    Jeffersonian Agricultural Idealists

    Farm Organizations

    Public Interest

Technology-Driven Assessment

Research procedure

Information sources--The technology-driven part of this technology-assessment investigation was initiated by examining demographically the agricultural crop-producing areas of Michigan, Indiana, and northern Ohio. Concentric circles were drawn in less-densely populated areas on state highway maps in order to determine farming areas with the least amount of urban influence. Several areas were found with no populating centers larger than 20,000 persons. Crop-production areas were found in Indiana with 50, 60, 80, and 86-mile diameter open areas without major population centers. Michigan areas of low population density were found with diameters of 46, 54, 56, 68, and 100-miles. One Indiana-Michigan non-urban area was found with a 96-mile diameter.

As alternative research techniques were examined for viability, the questionnaire survey technique for any of the above selected areas was discarded owing to the distances and time requirements needed to research the subject adequately. Areas closer to urban centers were then considered. Several Lansing-area farm-implement dealers were contacted with regard to locating farms having the technologies to be studied, and with regard to the content of information collected and sent to the company's main office for warranty registration. It was anticipated that warranty registration information for new-tractor and combine owners would supply the necessary leads to find farms which were using increments of the technologies to be assessed. Some reluctance to allowing access to records was encountered, and incomplete warranty records soon proved the technique of inquiry to be of questionable value.

Sales personnel turned out to be a good source of information as to owners and locations of the technologies for study. Tony Warnke, Agricultural Sales Representative for Case Power and Equipment, Holt, Michigan, cooperated by providing model numbers, owner's names, and locations for Case large-tractor owners within the area covered by his company. This information was plotted and coded for tractor size and location. In addition, tractor-owner locations were marked on detailed county road maps which were obtained from the Michigan State Highway Commission, Department of State Highways. The owner list plus the county road maps would allow for efficient follow-up of personal interviews if the method of inquiry was to be followed.

The Agricultural Stabilization and Conservation Service was investigated as a potential information source for farm structural data. Specific types of data were available at individual farm, township, county, district, and state levels of aggregation. Number of farms, acreages of farmland, cropland, various crops, subsidy payments, farm transfers, farm divisions, and farm combinations were the major statistics available. Problems associated with the various data sets were accessibility to longitudinal data, time lag, and incompleteness of farm transfer, combination, and division data. Significant measures of farm structural change could have been obtained; however, the incompleteness and therefore, accuracy of the data would not have been desirable for a comprehensive research study. The reason that the data were not complete was that in recent years very few farmers had participated in any government farm programs, and that data were updated by farmers voluntarily visiting the local Agricultural Stabilization Office to change farm records. Recently, there has been no incentive nor requirement for any farm record updating. It was significant to note that farms in the USDA governmental institution were defined on an ownership-and-producer (tenant) basis and that a land area as small as one-tenth of an acre could have been called a farm. The statistics of farm numbers with this type of ownership definition could not be compared with farm-numbers data from the Agricultural Census, which used a different economic definition of a farm.

A similar method to obtain land ownership and transfer data was found in public legal records maintained by each county property-taxation unit. These records were accurate and maintained up-to-date; however, contractual obligations regarding ownership and future transfer of land would have necessitated an individual search for each record from a different location. Measures of value of farmland, improvements, and personal property were available; but they were not in aggregate form. These types of governmental legal data would have been valuable in case-study research for land farm-structure determinations. Each of the previously listed data collection techniques would have necessitated personal follow-up questionnaires.

The major source of data for the technology-driven part of this research study was obtained from Michigan State University Cooperative Extension Service, TelFarm records with cooperation from William Dexter and James Mulvany.

An initial investigation was undertaken to determine if sufficient data were available to justify TelFarms use as a primary data source for the technology assessment. Farm structural and depreciation data were found to be available for approximately 1600 Michigan farms. A change in the computer-tape data-storage system used for storing previous years' data made older data of certain types accessible only by expensive tape-conversion processes.

The preliminary study to determine the feasibility of using TelFarm data was initiated by a hand search of the hard copy of summaries compiled from the first nine-months reports of depreciation schedule transactions which were returned to TelFarm by the participating farmers. The reports were a noncomplete set of data for two reasons. First, all participating farmers did not turn in the specific reports, and second, of those farmers who did turn in the reports, there was no assurance that actual purchases were all included.

A list was compiled from the depreciation schedule transactions of new and used tractor and combine purchases amounting to $10,000 or more. The items which were compiled were: county number, farm number, farm type, cost, new or used machine purchased, and machine description. From the data set of 89 purchase entries, two types of information were generated. The first was a listing of tractors and the second a listing of combines. The listing of tractors having power-take-off (PTO) horsepower exceeding 130 was compiled by eliminating smaller tractors as listed in the depreciation-schedule description received from the farmers. This information was then used to determine the horsepower from the model identification given and to find the model's horsepower in Implement and Tractor (1976), "Farm Wheel Tractors on the U.S. Market." This technique identified the make and model of 33 tractors, leaving only one tractor which cost $19,307 unidentified. From the price and horsepower data and Official Guide: Tractor and Farm Equipment (1975), it was possible to determine that a tractor at that price was over 130 PTO horsepower. The tractors were then plotted by tractor-manufacture make by use of coded map tacks on a Michigan county-outline map. The largest number of TelFarm large tractor purchases per county was four in both Lenawee and Lapeer Counties. Missaukee and Isabella counties had three purchases each.

St. Clair, Monroe, Jackson, Ionia, and Saginaw had two each. One purchase each was accorded the counties of Emmet, Clare, Ottawa, Sanilac, Montcalm, Gratiot, Ingham, Kalamazoo, Calhoun, and Hillsdale. The number and make of tractors were 3 Allis Chalmers, 4 Case, 12 John Deere, 1 Ford, 5 International, 3 Massey Ferguson, 2 Steiger, and 3 White. One make was unknown from the description, TRACTOR.

Approximately the same procedure was followed to determine the two largest models of each make of combine with the exception that only the Tractor and Implement Blue Book was used in size determinations. Of the 9 combines identified, 2 were Allis Chalmers, 3 John Deere, 2 International and 2 Massey Ferguson. Lenawee county had 2 purchases; Monroe, Kalamazoo, Ingham, Allegan, Ionia, Bay, and Schoolcraft had 1 purchase each. From the above information, which covered part of the purchases for nine months, it was determined that the TelFarm record system contained many farms which had purchased large tractors and combines, and that the TelFarm information source should be investigated further as a data source.

Computer-aided selection of technologies for study--The 1975 TelFarm depreciation schedules were selected as a technological data base for this part of the study. The 1975 depreciation schedules carried tractors of various ages. The oldest tractor which had been purchased new, was a 1935 International F-20.

The data were collected from depreciation summary tapes by selecting all machine categories associated with tractors and combines, and by recording information pertinent to the depreciation purchase entry. The information recorded included: county number, farm number, farm type, farmers item entry number, machine description, trade-in value, cost, year of purchase, new or used, and machine classification. The columns containing this information were placed on the left of the print-out page for tractors, and the columns for combines were placed on the right-hand side of the page for ease of identifying machine type. Even though the machine classification column contained a further breakdown or description of the technologies, the data were unusable owing to the number of incorrect entries in the machine-classification breakdown. As an example, diesel tractors were entered indiscriminately between the tractor entry code and the diesel-tractor entry code.

The purpose of obtaining the information was to enable the location of farms using large tractor and combine technology. Several problems were encountered with respect to the full accomplishment of this goal from the raw data. It was evident from examining the data that a large number of partnership purchases were made where the cost indicated only a fractional share of the total cost of the machine purchase for the farm.

From the sociological standpoint, the author considered partnerships to be extended family-type arrangements where decisions were entered by mutual agreement. In using a sociological approach to this technology assessment, it was not of significance whether the large machine was owned in partnership but whether the machine was available for use on the farm or farms. Along with the above, an assumption was made that if an item was listed in the TelFarm record for tax purposes that it would likely be used. Machines purchased through partnership were increased in cost to reflect the fractional share paid by the farmer. The computer was able to identify identical entries for approximately 225 machines and make corrections in the cost. Manual corrections and deletions were made on 280 entries which the computer could not discriminate as being partnerships. In addition, several semi-trailer truck tractors were deleted from the data. Several unisystem tractor units were also deleted from the tractor section. Used tractor and combine entries under $500 were deleted. New tractor and combine entries under $1,000 were deleted. Plots were then made of the tractor and combine purchases in new and used categories for 1955 through 1975. The purchase price or cost was plotted against the year of purchase. The plots clearly illustrated the increasing costs of machinery due to inflation and the availability of larger machines. Machine-size groupings were evident in the new-combine plot where the cost distribution was between $1,000 and $46,000. Combine headers were also distinguishable from the combines in latter years. The highest machine-cost values for each year were checked for validity

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by using Official Guide; Tractors and Farm Equipment for various years. From the plots, only one value was found to be outside the expected price range. That value of $23,000 was in New Tractors 1968 and was approximately twice the price of any new conventional farm tractor. The value could have easily been a crawler tractor of large size. However, since the second highest-cost tractor for that farm was $7,000, the $23,000 entry was deleted.

The highest-cost tractor and highest-cost combine for each farm having made a tractor or combine purchase for a given year was selected by computer. From 6,831 tractor entries, 1,526 were selected as the highest-cost tractor entries. From the 1,441 combine entries, 870 were selected as the highest-cost combine entries on each farm. Although there were 6,831 tractor entries, it would have been incorrect to have assumed that all entries were tractors, as some farmers had entered major repairs and tire purchases which were higher than the $500 and $1,000 minimum for entry classification. A similar situation occurred in the combines, as farmers entered combine crawler tracks ($8,000 in one case) and combine headers in the combine category. Since the highest-cost technology farm-number selection was based on highest single-purchase cost, the non-combine and non-tractor items were eliminated from the new listings.

Technology and structural methodology

If all machine purchases per farm were included as a method of dispersion for analysis of farm structures, then

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the structure associated with the small machine purchased by the owner of another large machine would have been weighted equally against the structure where a small machine was the only machine on a given farm. This type of analysis would have been valid; however, it would not have isolated the structural differences as vividly as a system designed to bring out the structural differences associated with the given technology. To find and illustrate the structural differences and changes due to the technologies it was necessary to identify the highest-purchase cost of each type machine which had been purchased on each farm at a specified point in time. This was accomplished by selecting a subset of farms which purchased a new or used highest-cost machine in 1975 and measuring farm-structure change from 1974 to 1975. This would have given structural change due to the addition of the technology if the effects of the technology were isolated. If the structure were plotted or correlated for each year against the purchase price of the machine, the structure relative to purchase price would have been identified and compared with other structures at different purchase price levels.

Structure at various time periods could have been compared; the difference in structure having been made up of structural change due to the technology modification or change plus other factors. If structural change due to other factors was assumed on all farms to have been equal, then total structural change minus structural change due to other factors would have left remaining the amount of structural change due to the purchase of the technology in question.

Owing to the structural makeup of the TelFarm depreciation schedule, the most accurate information concerning exact tractor and combine technologies in service on the TelFarm farms were for the year 1975. For this reason, machine purchases made during 1975 (those entered onto the TelFarm depreciation schedules) were used in the study of the effect of machine purchases on farm structure and structural differentiation.

The method which TelFarm used to allocate labor to crop enterprises was consistent over the time of the study. The TelFarm labor allocation system was developed by using information from different university departmental and farm record sources to establish mean time requirements for the production of each unit of each farm product. On farms which reported a variety of products or enterprises, the labor was divided proportionally according to the prepared computer program. The validity of the allocation system and the variables involved could have added possible errors to the labor data reported; however, the continuity of the allocation system remained the same for the entire study. The labor reported in the study was the labor allocated to crops owing to the primary use of tractors and combines in crop production functions.

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A case study of ten farms with highest-cost tractor purchases was completed for 1969 and 1975. Farms were selected on the basis of descending order of highest-cost tractor purchase and those which had reported records sufficient for structural study over the 1968-to-1969 and the 1974-to-1975 time intervals. Five farms were eliminated out of the first fifteen in order to obtain sufficient records for analysis. The structural change over the one-year time period was determined by taking the latter-year structure and subtracting the similar earlier-year structure for each selected variable.

Computer-aided selection of farm structural characteristics

Farm structural conceptualization--The farm structural characteristics for the farms for this study were obtained from TelFarm Business-Analysis Summary Tapes. The farm-structural data-information system was conceptualized in a manner similar to that used by Rodefeld (1974). The concepts of farm structural differentiation (as applied to farm structure related to management function, ownership, and labor) were the primary relationships measured. The concept of differentiation may be thought of as a measure of non-ownership or non-provision of the resources needed for assured farm production and continued enterprise viability. A detailed description of the concept of differentiation was covered elsewhere in the study, under "Structure and structural differentiation."

Conversion of raw data to farm structural indicators--TelFarm business analysis summary tapes were used as a data base for the indicators of farm structure. Tapes for the years 1968 through 1972, as originally used with the CDC 3600 computer, were searched by one program. Tapes of the years 1973 through 1975, designed for use with the current CDC 6500 computer, were searched by a separate program.

Information was extracted sequentially beginning with the individual farm number. The first part of each farm number was the standard reference code number for the Michigan county where the farm was located. The county code system was a list of alphabetically arranged Michigan counties coded with number 1 for the first county and progressively numbering each county. The farm number was used as the common element for combining information from the depreciation tapes concerning technologies with farm structural information from the business analysis summary tapes. Thus, the specific technologies were connected with specific farm structural information on an individual farm basis.

Tractor and combine purchases were then arranged according to increasing year of purchase and decreasing cost. The farm structural data were filed by year for each farm for which it was available. To the structural data, which were two rows deep on hard copy, were added the highest and next-to-highest-cost tractor and combine purchase, for each year, if any such purchases were made during that year.

The structural data were then combined with the largest tractor and combine purchase data for each year. Several of the largest tractor and combine purchase farms were then evaluated for structural change with respect to time of major tractor or combine purchases by using hand computation methods. The year of major purchase and the preceding year were selected as the years to be considered for determining the structural changes associated with the machine purchase. Differences in structure were determined for each farm that had reported sufficient data to make the calculation. If values were missing, no entry was made in the statistical compilation for analysis.

Family-Labor Participation--Family-labor participation was considered as family labor involvement (other than the operator) in the farm enterprise. The ratio measure was actually a measure of differentiation between the operating manager and total labor control; however, to most individuals considering differentiation, the concept of family farm or extended family farm would place family labor differentiation in a special category separate from other differentiation types. The cooperative family decision-making characteristics of the family farm placed the family labor input in a unique relationship with the operating manager. Such a relationship would add measures of control over family labor which would not exist for hired labor.

When considered from the family enterprise viewpoint, the family labor involvement was a measure of family labor efforts of integration or the bringing together of individual family labor efforts toward the common family goal of an adequate, least-cost labor supply for the farm enterprise.

The family-labor involvement indicator of differentiation was derived by taking the hours of labor reported in the non-paid family-labor category (other than operator) of TelFarm records and dividing that amount by the total labor utilized in the farm operation. The previous calculation gave an indicator of family-labor involvement, other than operator, which varied from zero to one. A zero (0) was an indication that there was no family-labor involvement reported, other than operator, and a one (1) was an indication that family members (other than operator) did all of the work, and that the operator reported no labor for self or hired labor. In such a case, the operator would have been serving a management function only.

Even though the actual number of hours of different types of labor was considered as a measure of farm structure, the ratio was required to remove the effect of the component of size. The same method of removing the component of size was used in calculating the other differentiation ratio indicators. The concept of size (in hours of labor) was used as a variable in another part of the study.

Hired-labor differentiation--Hired-labor differentiation was calculated as the ratio of hours of hired labor divided by the total hours of labor reported on TelFarm records. This variable was similar in respect to size when compared to the family-labor involvement variable as it varied from 0 to 1. However, the concept of structural differentiation was applied to this ratio value because of the wider acceptance of the structural definition of a farm with respect to hired labor than with the structural definition of a farm with respect to family-labor involvement. The concept of labor differentiation, as used by Rodefeld (1974), and developed here by the above ratio, could have been considered as any possible operational barriers or restrictions which could infringe upon the enterprise between the operating manager and the full accomplishment of the labor factor of production. The ratio could have been considered a measure of the non-control which the owning manager had over the labor inputs into the farm enterprise.

The ratio was set up as a measure of non-provision (not provided by manager) rather than provision (provided by manager) so that the measurement of differentiation could be cumulated into sociologically relevant terms as used by Rodefeld (1974), and to allow individuals not familiar with farm structural termininology a more clear understanding of the concept of infringement upon total entrepreneurial function.

Capital differentiation--Capital differentiation was calculated as the ratio of cash interest paid divided by the sum of cash interest plus non-cash interest for each individual farm in the TelFarm accounting system. The non-cash interest was a measure of interest which might have been paid to the owner-operator if the owner-operator had his assets invested elsewhere than his own farm enterprise. The non-cash interest data were used by TelFarm as a means of determining enterprise accounting returns to the management function of the farm enterprise, as contrasted to the returns to equity reserve within the farm enterprise. The differentiation ratio of capital used in this study was the same as the differentiation between owner-operator and capital as used by Rodefeld (1974). Capital differentiation as viewed by the author was a measure of non-control of the capital resources of the farm enterprise. Capital differentiation could have been viewed as equity differentiation.

Land differentiation--The land differentiation ratio was obtained by dividing rented acres farmed by total acres farmed. If all land farmed was rented land, then the land differentiation would have been 1. If no land was rented, the land differentiation ratio would have been 0 divided by the total land farmed or 0. The land differentiation ratio was designed as a measure of the non-control (non-ownership) which the farm operator maintained over the land used in the farm enterprise.

Machinery differentiation--Machinery differentiation was calculated by dividing the expenditures for custom-hired services plus expenditures for the leasing of equipment, for the year, by the farm's reported machine depreciation for the year. If the farm operation hired and leased a large amount of services and machinery and had a low investment in owned machinery, then the machinery differentiation ratio could have gone above 1.

Results of investigation

Two important criteria of measurement were considered when farm structure was analyzed. The first criterion was the absolute value of each of the various types of farm structural differentiation. The second criterion of measurement was the rate of change, on a year to year basis, of the various structural differentiation components. The analysis included all farms, crop farms only and subsets of the first two groups. One major subset of farms selected consisted of the group of farms which, in 1975, had purchased the highest-cost tractor ever purchased by that farm. These farms were designated highest-cost tractor purchase farms. The structural differentiation analysis was based on the 1975 structural data minus that for 1974. The subset included 122 tractor cases. A similar subset involved 104 highest-cost combine purchase farms. The theoretical base for the analysis of these subsets was developed in the section of this study entitled Technology and structural methodology. The result of the above analysis was placed with each appropriate structural characteristic.

The results of two separate case studies of ten farms with highest-cost tractor purchases for 1969 and 1975 were placed with the results of the different structural characteristics. For 1969, the highest-cost tractor purchases varied from a high of $15,000 to $9,000 for the ten farms selected. The 1975 highest-tractor costs varied from $47,000 to $30,000.

Owing to computer-storage costs for the quantity of data processed, the longitudinal components of the research study were handled by hand-computation methods. Tables I through VII were prepared on a single-variable basis from the computer run for each year. The mean structural values were determined for all farms, crop farms only, and other subsets of these two groups.

The 1968 data were prepared by conversion of a previous data-base system. Several of the 1968 variable values which were reported in the tables were not used in further analysis owing to a large error found in the computer conversion of labor information on one farm in the all-farm category. No error was found in the crop-farm category.

Results and discussion

Family-labor participation--Family labor participation was the ratio of family labor (other than operator) divided by the total labor input to the farm enterprise. From Table I a structural decrease of 35 percent for crop farms over the seven-year period, and a 4.5 percent decrease for all farms over the 1969-to-1975 time period was calculated.

Figure 1 illustrates the structural changes. For the respective farm types, family-labor participation decreased 12 and 4.4 percent from 1974 to 1975.

From the set of all farms, a subset of highest-cost tractor purchase farms was computer selected as described previously. This subset of farms (Big Tractor Purchase Farms in the Figures) decreased mean family-labor participation .028 with a standard deviation (SD) of .0942 and cases (c) which numbered 122 from 1974 to 1975. A mean decrease of .0132 (SD .1176) (c 1175) was found for the subset of all other farms. Mean ratio values were evaluated to have a significance (s) of .01. The respective decrease for the subset of highest-cost combine purchase farms was .012 (SD .0994) (c 104).

In the ten-case study subset of farms, which was described in a previous section, the computer was not used in the selection of the farms. The mean family-labor participation for this group of 10 farms decreased .03 between 1968 and 1969 and .06 between 1974 and 1975.

Figure 1 illustrates the overall and specific decreases in family-labor participation on all farms and on crop farms. From Figure 1 it is evident that Big Tractor Purchase Farms decreased family-labor participation over twice as much as all other farms when the decrease was plotted from the all-farms mean for 1974.

TABLE I

FAMILY LABOR PARTICIPATION RATIOS

	Year	Mean	Standard Deviation	Cases
All Farms				
	1968	.1651	.2018	1,781
	1969	.1985	.2036	1,544
	1970	.1995	.2073	1,382
	1971	.1962	.2054	1,273
	1972	.1939	.2092	1,281
	1973	.1916	.2075	1,389
	1974	.1979	.2113	1,415
	1975	.1896	.2117	1,424
Crop Farms				
	1968	.1849	.2182	141
	1969	.1786	.2177	168
	1970	.1804	.2110	142
	1971	.1593	.1877	128
	1972	.1530	.2101	117
	1973	.1426	.1982	147
	1974	.1375	.2026	183
	1975	.1206	.1898	201

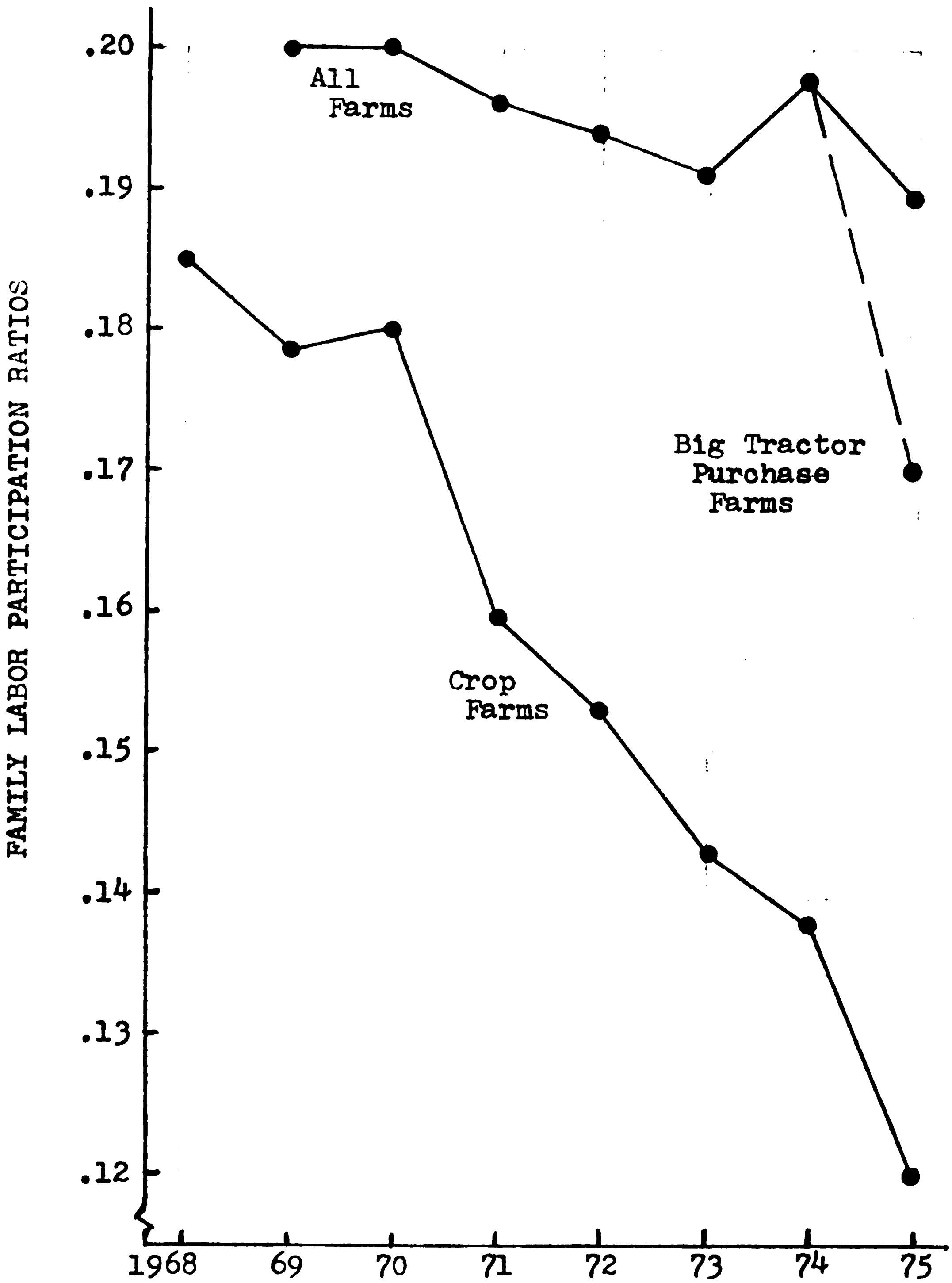

FIGURE 1

FAMILY LABOR PARTICIPATION, 1968-1975, ON ALL FARMS, CROP FARMS, AND BIG TRACTOR PURCHASE FARMS.

Hired-Labor Differentiation--Hired-labor differentiation was calculated as the ratio of hours of hired labor divided by the total hours of labor used in the farm enterprise. From Table II the mean hired-labor differentiation increase was calculated to be 29 percent from 1969 to 1975, and 8 percent from 1974 to 1975 on all farms. The mean crop farms labor differentiation increased 53 percent over the 7 years from 1968 to 1975 and 15 percent from 1974 to 1975. From 1974 to 1975, hired-labor differentiation increased .072 (SD .1756) (c 107) on highest-cost tractor purchase farms and .048 (SD .1705) (c 92) on highest-cost combine purchase farms. The mean ratio values were evaluated to have a significance of .02.

The data would, at first appearance, seem contrary to the traditional concept that large machines replace hired labor. When considering the concept of labor displacement by machine, it must be kept in mind that the differentiation ratio indicator was designed to remove components of farm size. The hired-labor differentiation ratio measured the farm structure of the reported labor and was not an indicator of the specific quantity of labor used. Several reasons for the large increases in hired-labor differentiation found by this study were explained in detail by Rodefeld (1974).

The mean hired-labor differentiation in the ten-case study of highest-cost tractor purchase farms increased .13 from 1968 to 1969 and .15 from 1974 to 1975. This

TABLE II

HIRED LABOR DIFFERENTIATION RATIOS

	Year	Mean	Standard Deviation	Cases
All Farms				
	1968	.3302	.2949	1,352
	1969	.3127	.2892	1,374
	1970	.3182	.2799	1,243
	1971	.3298	.2769	1,147
	1972	.3370	.2826	1,146
	1973	.3588	.2972	1,206
	1974	.3750	.2995	1,262
	1975	.4049	.3075	1,264
Crop Farms				
	1968	.2944	.2736	105
	1969	.3328	.3075	139
	1970	.3718	.2890	124
	1971	.3947	.2888	107
	1972	.3553	.3009	98
	1973	.3847	.3020	123
	1974	.3917	.3163	150
	1975	.4493	.3400	161

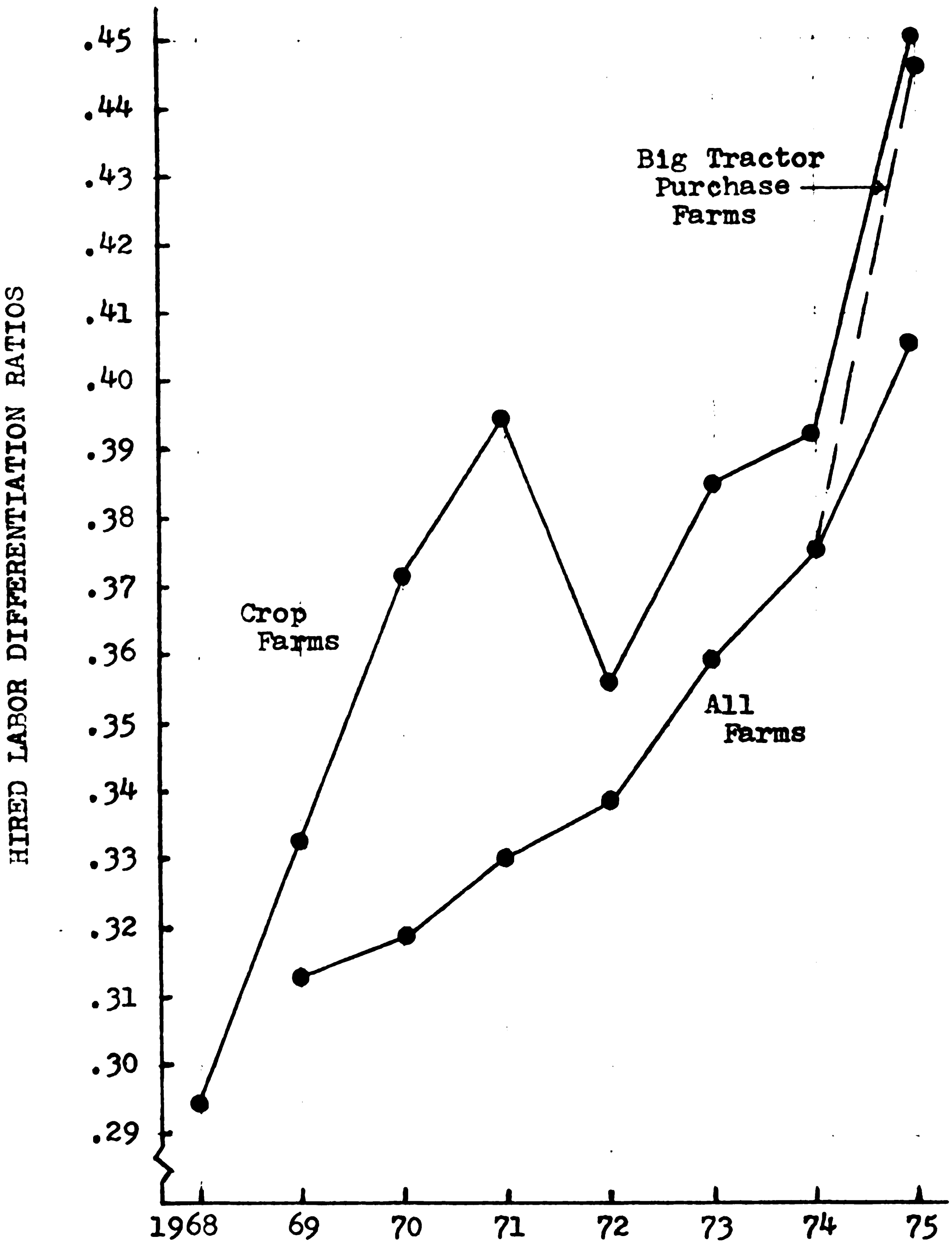

FIGURE 2

HIRED LABOR DIFFERENTIATION, 1968-1975, ON ALL FARMS, CROP FARMS, AND BIG TRACTOR PURCHASE FARMS. (Big Tractor Purchase Farms represented by ----)

increase was twice that of the mean of the subset of highest-cost tractor purchase farms. The two-fold increase in differentiation between the groups was coincident with a two-fold greater mean tractor cost in the ten-case study farm subset over the mean of the subset of highest-cost tractor purchase farms.

The large decrease in hired-labor differentiation on crop farms from 1971 to 1972 (illustrated in Figure 2) was undoubtedly affected by the decrease in farm labor income in 1971. In that year the farm labor income dropped to $2,700 for the mean TelFarm farm according to 1971 TelFarm record statistics.

Capital Differentiation--Capital differentiation was calculated as the ratio of cash interest paid divided by the sum of cash interest plus non-cash interest for each farm enterprise. The increase in capital differentiation on all farms was 17 percent over the seven-year time period. From 1974 to 1975 the increase was 9.3 percent. On crop farms, capital differentiation decreased 18 percent from 1968 to 1971, and then increased 61 percent from 1971 to 1975. The mean increase for 1974 to 1975 was 18 percent.

The highest-cost tractor purchase farms increased capital differentiation .0127 (SD .2407) (c 116) from 1974 to 1975. The significance level was .02. Highest-cost combine purchase farms increased differentiation .0029 (SD .1725) (c 97) during the same period.

TABLE III

CAPITAL DIFFERENTIATION RATIOS

	Year	Mean	Standard Deviation	Cases
All Farms				
	1968	.3099	.2018	1,781
	1969	.3011	.4666	1,324
	1970	.3068	.5055	1,163
	1971	.3077	.3164	1,094
	1972	.3509	.4892	1,091
	1973	.3122	.3446	1,155
	1974	.3320	.3874	1,206
	1975	.3630	.4725	1,214
Crop Farms				
	1968	.3194	.3040	119
	1969	.2945	.2501	146
	1970	.2788	.2101	119
	1971	.2625	.2670	113
	1972	.3562	.4840	91
	1973	.3438	.3763	117
	1974	.3578	.4922	148
	1975	.4216	.5150	164

CAPITAL DIFFERENTIATION RATIOS

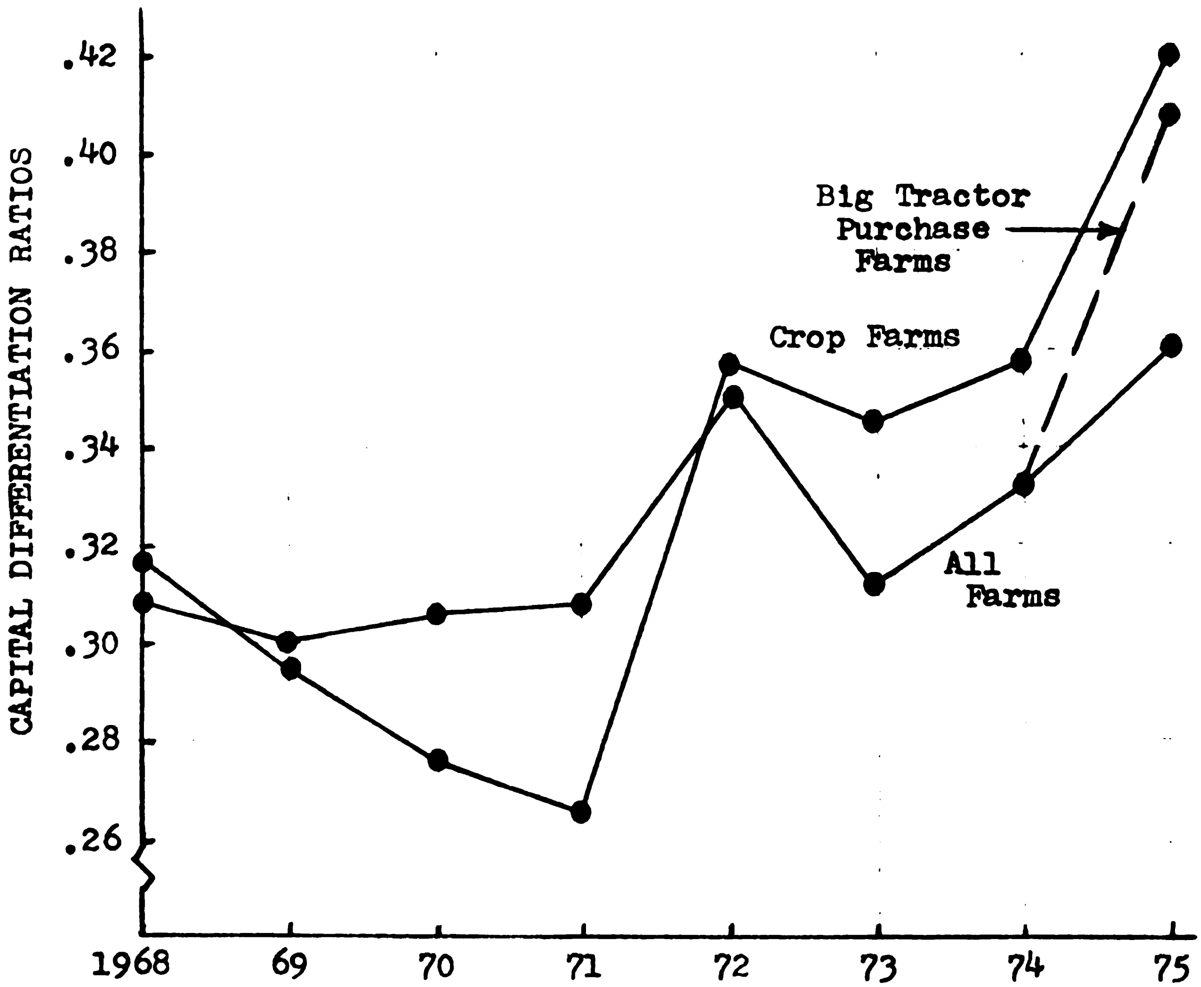

FIGURE 3

CAPITAL DIFFERENTIATION, 1968-1975, ON
ALL FARMS, CROP FARMS AND BIG TRACTOR PURCHASE FARMS.
(Big Tractor Purchase Farms represented by ----)

From 1968 to 1969 on the ten-case study farms, the capital differentiation remained the same; however, from 1974 to 1975 capital differentiation increased .093. The high increase in capital differentiation for 1972 (as seen in Figure 3) was likely an indication of increased borrowing of capital due to the low farm labor income for 1971 which was reported by TelFarm statistics.

Land Differentiation--Land differentiation, as determined by the ratio of land rented divided by total land operated, was reported in Table IV. Land differentiation increased 10 percent over the seven years, or a 0.87 percent increase for 1974 to 1975 for all farms. The crop farm land differentiation had an apparent decrease of 12 percent over the 1968-to-1970 time period, and an increase of 18 percent from 1970 to 1975. In absolute terms, land differentiation changed from a mean of .38 in 1968 to a mean of .42 for all TelFarm farms (S .01).

Land differentiation increased .0347 (SD .2591)(c 80) (S .03) on highest-cost combine purchase farms between 1974 and 1975. This was in contrast to a similar size decrease for highest-cost tractor purchase farms.

The mean values of the ratio of land differentiation indicators were affected very little by widely varying data in contrast to absolute values such as hired labor hours. The reason for this was that the ratios only varied from plus one to minus one; whereas one absolute value such as hired labor varied from a minimum of 1 to

TABLE IV

LAND DIFFERENTIATION RATIOS

	Year	Mean	Standard Deviation	Cases
All Farms				
	1968	.3829	.2454	844
	1969	.3845	.2532	827
	1970	.3818	.2353	719
	1971	.3992	.2347	755
	1972	.4011	.2366	741
	1973	.4080	.2441	798
	1974	.4159	.2457	845
	1975	.4195	.2459	838
Crop Farms				
	1968	.5319	.2556	105
	1969	.4835	.2546	102
	1970	.4663	.2590	85
	1971	.4883	.2383	82
	1972	.4978	.2399	68
	1973	.4812	.2381	81
	1974	.5211	.2534	92
	1975	.5483	.2552	96

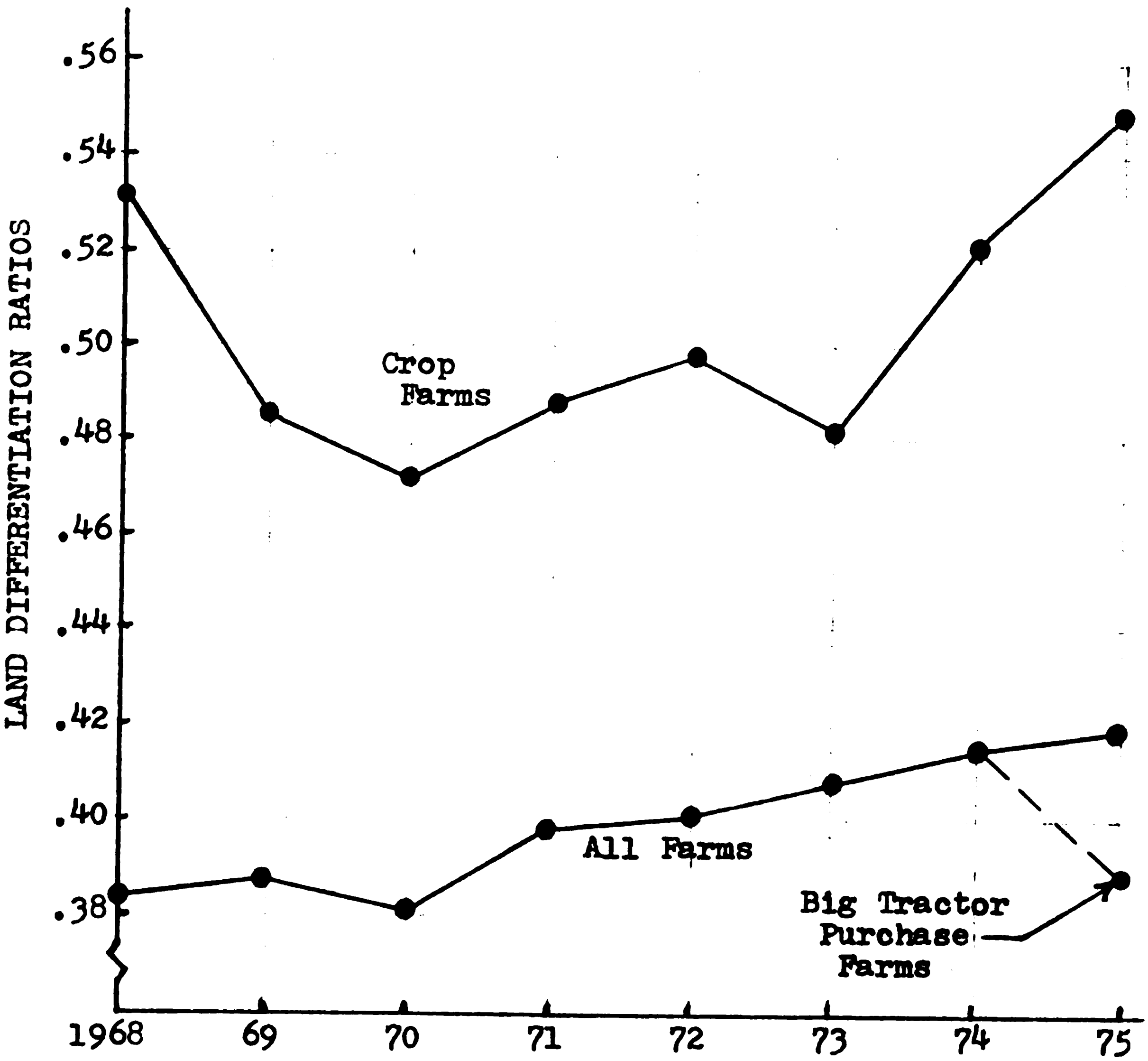

FIGURE 4

LAND DIFFERENTIATION, 1968-1975, ON ALL FARMS AND CROP FARMS, AND BIG TRACTOR PURCHASE FARMS.

a high of over 100,000. When the mean was calculated for labor, the resulting mean was not representative of the labor on the individual average farm because of the extremely high value on one farm.

In terms of management-land differentiation change, the 1968-1969 ten-case study of highest-cost tractor purchases indicated a .10 mean change for the ten farms which would tend to indicate that the largest ten farms at that time were increasing their land rentals much faster than the average farm which had a mean change of .04 over the 1969-to-1975 time period. The 1974-1975 ten-case study indicated a mean decrease of .03 in the management land differentiation ratio.

The figures for all farms and the ten-case study farms, indicated an increase in management-land differentiation from 1968 to 1975; however, there was a possibility of a downward trend in the 1974 to 1975 time period on the highest-cost tractor purchase farms. Such a downward trend would indicate a decrease in rentals and a concentration in land ownership as the means of expansion of farm enterprise.

Machinery Differentiation--Machinery differentiation was calculated by dividing the expenditures for custom-hired services plus expenditures for the leasing of equipment, for the year, by the farm's reported machine depreciation for the year. Machinery differentiation fluctuated widely on all farms and crop farms. From 1972 to

1975 machinery differentiation on all farms increased 17 percent; however, in the four years preceding 1972, there was a similar size differentiation decrease. From 1974 to 1975 machinery-differentiation increased 4.8 percent. Crop farms had a machinery differentiation increase of 14 percent from 1968 to 1975 and an increase of 1.8 percent from 1974 to 1975.

The highest-cost tractor purchase farms decreased machine differentiation by a mean of .0231 (SD .0932) (c 120) (S .01) and highest-cost combine purchase farms decreased by .0285 (SD 1140) (c 100) (S .01) from 1974 to 1975. Since this differentiation was a measure of rental of equipment and/or machine hire services, it would seem logical to assume that a large combine or tractor purchase would reduce the need for the rental of equipment or the hire of outside services.

The mean machinery differentiation on the ten-case study farms increased .03 from 1968 to 1969 and .013 from 1974 to 1975. However, seven of the values had a decrease in differentiation in 1975. Such variation illustrated the need for a larger sample size.

Part of the wide fluctuations in machinery differentiation may be explained by low labor income in 1972 which likely caused an increase in rentals the following year. Changes in the tax law for investment credit also could have caused irregular machine rental periods.

TABLE V

MACHINERY DIFFERENTIATION RATIOS

	Year	Mean	Standard Deviation	Cases
All Farms				
	1968	.1473	.1540	1,317
	1969	.1373	.1584	1,323
	1970	.1327	.2353	1,199
	1971	.1294	.1397	1,133
	1972	.1253	.1409	1,101
	1973	.1451	.1432	1,228
	1974	.1393	.1521	1,250
	1975	.1460	.1546	1,267
Crop Farms				
	1968	.1461	.1660	109
	1969	.1508	.1607	132
	1970	.1646	.1631	125
	1971	.1615	.1721	113
	1972	.1609	.1755	97
	1973	.1771	.1757	130
	1974	.1637	.1999	159
	1975	.1667	.1790	180

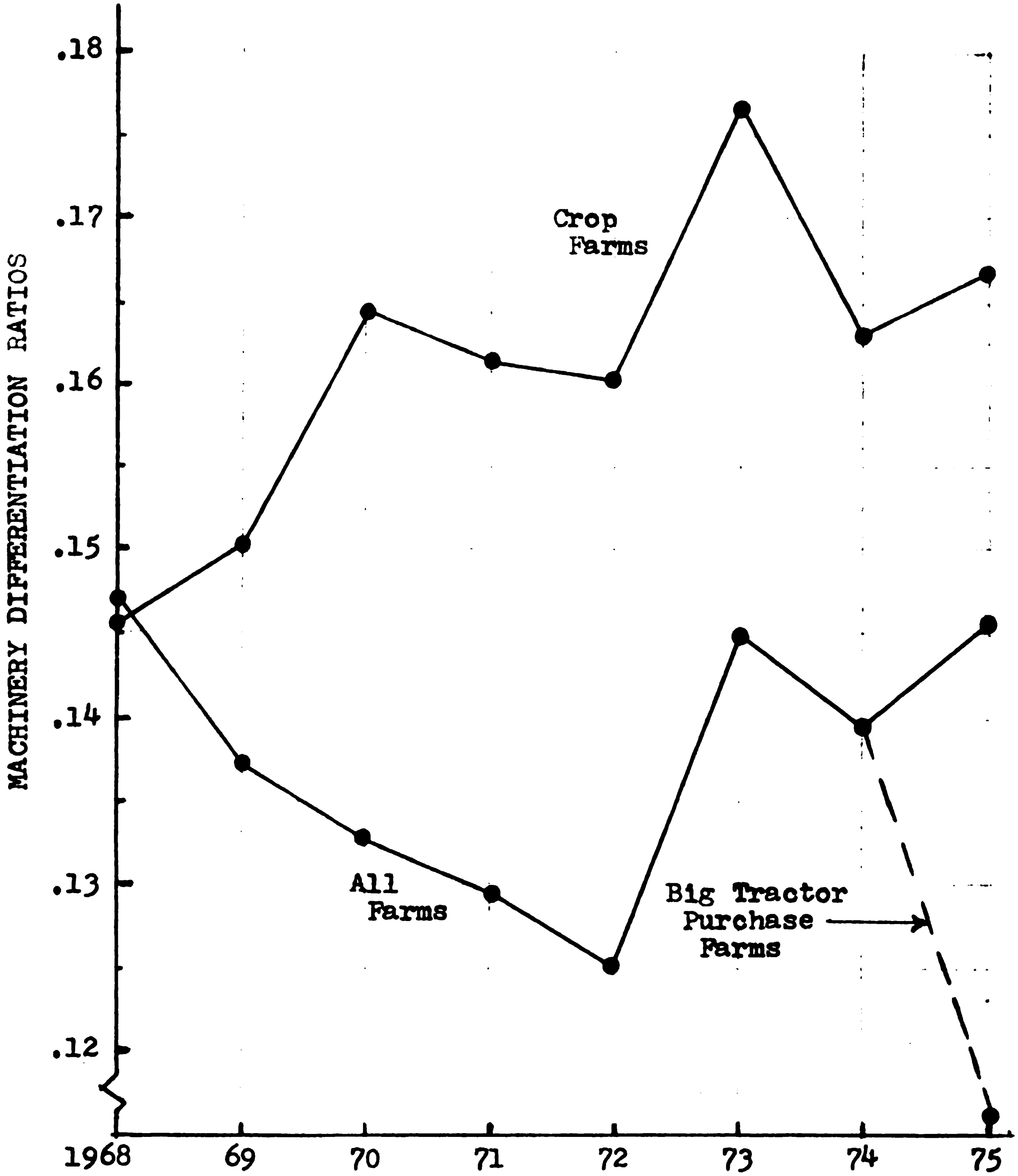

FIGURE 5

MACHINERY DIFFERENTIATION, 1968-1975, ON
ALL FARMS AND CROP FARMS,
AND BIG TRACTOR PURCHASE FARMS.

Total tillable acres farmed--Table VI listed total tillable acres farmed. The all-farms group of farms increased acreage a mean of 29 percent from 1968 to 1975. The crop farms increased mean acreage 33 percent from 1968 to 1973 followed by a decrease of 3 percent from 1973 to 1975.

Highest-cost tractor purchases--Mean highest-cost tractor purchases from Table VII increased 108 percent for all farms from 1968 to 1975. The crop-farm mean for highest-cost tractor purchases increased 131 percent from 1968 to 1975.

Structural correlation--The correlation results refer to the all-farms group of farms unless indicated otherwise. Only those farms which reported adequate data were included in the correlations. Tractor purchase cost correlated .16 (S .02) in 1968 and .05 (S .16) in 1975 with the level of land differentiation. The change in correlation suggested a possible change in structure.

A .06 (S .17) and -.10 (S .01) correlation indicated that a possible change had taken place between machine differentiation and tractor purchase cost from the year 1968 to 1975.

Tillable acres farmed correlated .22 (S .001) in 1968 and .37 (S .001) in 1975 with tractor purchase cost. The data indicated a stronger relationship between tractor size (as determined by cost) and acres farmed in 1975 than in 1968. The correlation values for the interim years

TABLE VI

TOTAL TILLABLE ACRES FARMED

	Year	Mean	Standard Deviation	Cases
All Farms				
	1968	296	237	1,353
	1969	301	218	1,326
	1970	311	206	1,175
	1971	345	244	1,108
	1972	351	255	1,070
	1973	354	253	1,151
	1974	367	262	1,188
	1975	383	279	1,175
Crop Farms				
	1968	361	228	133
	1969	379	257	139
	1970	429	328	120
	1971	460	382	114
	1972	469	418	93
	1973	481	424	114
	1974	472	405	140
	1975	467	413	151

TABLE VII

HIGHEST-COST TRACTOR PURCHASES

	Year	Mean	Standard Deviation	Cases
All Farms				
	1968	$4,649	.2864	284
	1969	$4,643	.2856	308
	1970	$4,939	.2833	303
	1971	$5,213	.3318	356
	1972	$6,275	.4037	449
	1973	$6,950	.4418	540
	1974	$8,143	.5711	561
	1975	$9,688	.7397	499
Crop Farms				
	1968	$6,193	.2475	16
	1969	$4,942	.2796	19
	1970	$6,386	.3147	23
	1971	$6,007	.4118	33
	1972	$7,612	.5000	38
	1973	$9,375	.6234	43
	1974	$12,144	.6415	62
	1975	$14,302	.9882	73

were .26 (S .001); .15 (S .006); .17 (S .001); .22 (S .001); .31 (S .001); and .31 (S .001) respectively.

The respective values for cash crop farms for 1968 through 1975 were .37 (S .10), .22 (S .20), .68 (S .001), .08 (S .22), .20 (S .13), .21 (S .13), .33 (S .01) and .54 (S .001). The wide variations and low significances were due to the small sample size which ranged from 16 cases to 61 cases.

Labor correlations--The tractor purchase cost correlation with family labor of .02 (S .32) and .09 (S .07) shows no significant relationship for the years of 1968 and 1975. Total labor per tillable acre correlated .006 (S .46) in 1968 and -.21 (S .001) in 1975 with tractor purchase cost. The 1975 correlation indicated the higher the tractor purchase cost, the less total labor required per tillable acre. Such a relationship would have been expected.

The structural variables of family-labor participation and hired-labor differentiation were designed to illustrate change in farm structure based conceptually on a farm-by-farm equivalency basis. The size or magnitude of the variables was diminished or eliminated by eliminating the size component from the calculation and placing the indicator value into a ratio form. Such a ratio-comparison technique proved to describe structural change fully only when the magnitudes remained relatively stable. In order to fully understand the structural change relationships between the interrelated variables of family labor and hired labor, it was necessary to understand the trend changes. The decline in family-labor participation and the increase in hired-labor participation would, at first consideration, appear to have been a direct-substitution relationship. Such a substitution relationship would have been valid only if the total amount of labor remained nearly the same. In actuality, there was a significant decrease in total labor per farm when all farms were considered. The -.50 and -.56 correlations, each with significance of .001, between family-labor participation and hired-labor differentiation indicated the extent to which a high or low level of labor participation by either variable was associated with the opposite level of labor involvement in the other category for 1968 and 1975, respectively. Nearly a perfect correlation existed between total-labor hours and hired-labor hours in 1968. In 1975 the same variables correlated .908.

From the standpoint of structural differentiation, family labor decreased and hired labor assumed a higher level of the fractional share of labor input into the farm enterprise in both the case studies and all farms studied for the years 1968 to 1969 and 1974 to 1975.

Land correlations--The correlation between tractor cost, having a mean of $17,014, and the additional acres added to the farm operations since the previous year was .45. The mean acres added for the subset of highest-cost tractor purchase farms was 31 contrasted to a mean of

19 acres added for farms not purchasing their largest tractor in 1975. The mean acreage added for farms which made their highest-cost tractor purchase in 1975 was 12 acres greater than farms which did not make highest-cost tractor purchases in 1975.

In the case study of ten highest-cost tractor purchases in 1975, there was a mean acreage added of 132 acres. If the mean acreage of 19 acres added for the overall increase in farm size was subtracted from the mean of 132 acres added for the ten-case study farms, then the mean difference would be 113 acres added for the ten-case study farms. If the mean increase of 12 acres for the subset was then subtracted from the mean of 113 acres for the case-study farms, the difference would have been 101 acres greater increase for the highest-cost tractor purchase farms in the ten-case study.

When looking at this information from the point of view of the case study, one farm added 8.2 percent of the mean acres added for the 122 farms. Also 8.2 percent of the farms added 35 percent of all mean acres added; this represented all farms in the case study and represented individual tractor investments of from $42,000 to $30,000.

The same relative procedure was completed for a case study of ten farms for 1968 to 1969. The mean acreage gained for highest-cost tractor purchase farms was 50 acres. The largest or highest-cost tractors purchased were John Deere 5020's with a price range of $15,000 to

$10,000 and a 126 DBH, or 140 PTO horsepower.

Harrington's (1975) values for horsepower per crop acre--which were approximately .7 horsepower per crop acre for 1970, and half of that value for 1950--illustrated the increased use of more horsepower for the same acreage of crop production in recent years. The concept of cropland-handling ability on a per-tractor basis was introduced at this point to illustrate the difference in technology modification between 1968-1969 and 1975. The largest available tractors being purchased by TelFarm farmers in 1969 produced 140 PTO horsepower. This was 67 PTO horsepower over the mean tractor horsepower sold in 1969. If a value such as .7 horsepower would provide power for one acre of crop production, then the new large tractor had a land handling capability of 96 acres greater than the average tractor size sold in that year. From the ten-case study of 1968-1969, the farms which purchased a similar tractor added a mean of 50 acres to each farm operation the year of tractor purchase. From the 1975 ten-case study, one commonly-purchased large tractor was the John Deere 8636 with 225 PTO horsepower. The difference between 225 and 98 PTO horsepower (the mean for tractors sold in 1975) was 127 PTO horsepower. If the same value of .7 horsepower per acre was used, then the 1975 large tractor had a land-handling capability of 181 acres greater than the mean size of tractor sold in 1975. The ten-case study for 1975 found a mean of 132 acres added per farm for farms which purchased a high-cost tractor similar to the one illustrated. In the calculations the retirement of tractor horsepower was not considered. The reserve tractor capacity found in the preceding analysis was consistent with Bowers' (1975) findings of additional horsepower added per given land area.

Labor per tillable acre--Crop farms which made highest-cost tractor purchases in 1975 decreased total mean labor per tillable acre from the previous year. An additional structural relationship was derived from the change in the total labor hours reported for 1975 minus reported total labor hours for 1974. The resultant value was a mean of 484 hours (Standard Error, SE 205) (SD 2255) (c 12). When this value was divided by 30.7 mean acres added, (SE 8.734) (SD 80.52) (c 85), the result was 15.77 hours labor added per tillable acre added. Hired labor added on the farms was 648 (SE 197.558) (SD 2024.367) (c 105) hours divided by 30.7 mean acres added which equaled 21.11 hours hired labor added per tillable acre added.

On all other farms not making highest-cost tractor purchases in 1975, the mean labor hours added were 146 (SE 87.45) (SD 2956.518) (c 1143). The number of acres added was 19.0 (SE 2.775) (SD 79.275) (c 816). When calculated as previously indicated, the results were 7.68 hours labor added per acre of land added to the farm operation. Hired labor added per tillable acre added was

316 (SE 84.451) (SD 2690.53) (c 1015) divided by 19.0 which gave 16.63 hired labor hours added per tillable acre. From these figures it may be seen that farms which purchased highest-cost tractors in 1975 did not decrease hired labor on a per acre basis.

Family-labor participation decreased on highest-cost tractor purchase farms from 1974 to 1975 by a ratio difference of .028 (SE .009) (SD .094) (c 122). Since the mean ratio value was .1979 (SD .2113) (c 1415), the family labor participation decreased 14.15 percent. This, multiplied by the mean of 24.04 (SD 25.09) (c 1180) hours, gave a decrease of family labor of 3.4 hours per tillable acre.

The remaining farms decreased the ratio .013 (SE .003) (SD .118) (c 1175) from the mean ratio of .1979. The change resulted in a 6.57 percent decrease. This result multiplied by the 24.04 hours labor per acre gave 1.58 hours of labor less per acre which was contributed from family labor.

Farm types--Farm types, as related to highest-cost tractor and combine purchase costs, were investigated for 1975. The following information was extracted from the total data set for all farms by selecting only those farms which made the highest-cost purchase ever made by the farm for a tractor or combine in 1975. This selection of farms, from the total of 1,424 farms, gave a subset of 122 highest-cost tractor purchase farms and 104 highest-cost

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combine purchase farms. The farms selected had the restriction that adequate records were reported sufficient for computation for structural data for both 1974 and 1975. From the selection criteria of highest-cost machine ever purchased for a farm, one must not get the idea that all highest-cost machines on TelFarm farms were large, high-cost machines. The cost range of highest-cost machine further illustrates the point. The cost range for highest-cost tractor purchases on TelFarm farms for 1975 varied from a low of $1,495.00 to a high of $47,788.21. The combine-cost range was from $500.00 to $41,346.45.

The 122 tractors were distributed on Michigan TelFarm farm types as follows: 33 percent on Southern Dairy, 16 percent on Cash Grain, 10 percent on Hog, 10 percent on Northern Dairy, 6 percent on Saginaw Valley Cash Crop, 5 percent on Southern Mixed, 3 percent on Southern Dairy, 3 percent on Beef Cow, 3 percent on Cattle Feeding and the remainder on the other specialized farm types. The distribution consisted of 22 percent crop farms and 70 percent livestock farms. The combines were distributed 13 percent on crop farms, 85 percent on livestock farms, and 2 percent on specialized farms. Crop farms represented 14 percent of all farms in 1975.

The highest-cost tractor purchases for 1975 were identified as to farm-type location through the use of a scattergram. A $47,000 and $35,000 tractor were purchased by Southern Dairy farms. Six Cash Grain Farms purchased tractors within the cost range of $42,000 to $30,000. One Southern Mixed farm purchased a tractor for $30,000 and one Cattle Feeding farm purchased a $34,000 tractor. Many farm types purchased tractors below $25,000 in cost. Within this subset of farms no Saginaw Valley Cash Crop farm purchased a tractor at a cost of over $26,000 in 1975.

New tractor market coverage--The extent to which the research covered the new-tractor market was estimated as 499 largest or highest-cost tractors purchased, minus 216 used-largest tractors purchased equaled 283 plus 121 second-largest tractors purchased, minus 67 used tractors, equaled 337 new-tractor purchases out of 4,076 reported by Implement & Tractor (1976). This represented a minimum of 8.3 percent of the total new-tractor sales in Michigan for 1975. As to the representation of the largest tractors, a minimum of 25 four-wheel-drive new tractors were identified among the TelFarm tractor purchasers. With 249 new four-wheel-drive tractors reported sold in Michigan, by Implement and Tractor in 1975, and a minimum of 25 purchased by TelFarm farmers, the study covered at least ten percent of the new four-wheel-drive tractor market.

The ten-percent new-tractor market coverage takes on additional meaning when added to the concept that only two percent of Michigan farms participate in the TelFarm record system. The TelFarm farms therefore have a high proportion of the large tractors in Michigan.

Limitations of the Technology-Driven Assessment--In structural calculation, when one value was zero, the calculation was eliminated from the analysis except for family-labor participation. If structural values were actually zero, (which was entirely possible, but not probable), the structural analysis of the data could have been miscalculated by a small amount. Difference changes in structural data would have also been miscalculated by a very small amount. The limitation was necessary because some farmers did not complete all entries on the TelFarm records. The decision was made to minimize error by eliminating values, rather than calculating erroneous values due to no entry or zero entry.

An example of incomplete structural data which illustrated the point follows: Farm number 10070 reported farming 405 tillable acres in 1969, 0 in 1970, and then reported 530 in 1971. It was highly unlikely that the farmer did not farm in 1970. If in the calculation of structural change, the value of zero minus 405 acres were used, the farm would have decreased acreage by 405, a highly unlikely event in view of the fact that the farm reported 530 acres in 1971 and remained in the TelFarm program through 1975.

Small differences occurred in the use of separate data bases. In such instances, different mathematical operations were conducted on the data using case-selection criteria based on various methods for the elimination of missing values. In the research study, only consistently derived data were discussed as results.

The machinery differentiation index may have been overly sensitive to change due to the limited number of components considered in the calculation equation.

Possible advantages could be gained in future research by the use of additional machinery differentiation components or by inserting a correction factor of 3 or 4 in the denominator in order to more nearly reflect actual cost considerations of machine use.

Total differentiation for each case was calculated on an individual case basis by the computer and then cumulated on an individual variable basis. Small differences were noted between such cumulations and composite total differentiation values when cumulated after composites had been made. Rounding errors may also contribute to small differences. Relative comparisons of values were made only on data derived by consistent methodologies.

If a small, newer piece of equipment would have been equivalent in cost to an older, larger piece of equipment, an error in estimate of level of technology or technology modification could have occurred. Some factors in the consideration were counterbalancing. A newer, smaller piece of equipment would likely have a seasonal effective work capacity similar to an older large machine because the older machine would likely have more down time.

Differences due to inflation were minimized whenever possible by holding the time covered in the analysis to one year. Inflation correction factors were not used in the study.

Structural data for 1968 were obtained by a conversion of data from a different computer system. There was an error in a labor conversion value which could not be corrected because there was no hard copy of data for 1968. Whenever the error did occur in 1968 data, longitudinal data were started from 1969.

As indicated earlier, the lack of complete records submitted by TelFarm participants and the lack of continuous participation decreased the significance which could have been placed on data generated from data sets containing low numbers of cases.

Preliminary Problem-Driven Assessment

Research procedure

Problem-driven assessment outlines were developed as educational and communication aids for various clientele groups identified earlier. The problems which were associated with agricultural technology were selected as examples of how the process of technology assessment could be used to illuminate and clarify issues which surround the application and use of technology in society.

The initial part of the problem-driven assessment was an accumulation of problems, clientele groups, and references which the author felt were representative for the problem under study. The list of references included for each problem illustrated either the connections between the problem areas and the technologies, or provided essential background information necessary for completion of a technology assessment.

Because of the repetitive nature of the assessment technique for each problem, a standardized matrix pattern was developed. The assessment matrix for all problems was determined to be the same. The matrix horizontal array was Provision, Environment, Freedom, and Justice. The vertical technology alternative array consisted of the following:

Draft animals only

Mixed power (Draft animals + small tractor + small combine).

2-3 plow tractor + pull-type combine.

4-6 plow tractor + small self-propelled combine.

7-12 plow tractor + medium self-propelled combine.

Over-130-horsepower tractor + large self-propelled combine.

An example of a similar assessment matrix may be found in this study under "Technology assessment as an educational aid."

Preliminary results of investigation, societal problems

Societal problem--Unemployment. Clientele groups: taxpayers and unemployed.

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Discussion of preliminary results

The problem outline development and references were developed as a starting point for continued study. The analysis outline system was not intended to be complete but only a starting point for evaluation of the alternative technologies or technology modifications impacted against the components of provision, environment, freedom, and justice which were developed by the Michigan State University Group for the Analysis and Assessment of Technology. An assessment would be required for each clientele group identified unless an overall societal assessment was to be made.

It was the opinion of the author that individuals associated with technology-assessment exercises would gain significant understanding of conflicting viewpoints and issues along with an understanding of values from contrasting lifestyles. For the successful completion of a technology assessment, it would be imperative that all participants have significant correct knowledge of the technologies, and that no participant would assume quality-of-life components regarding components of lifestyles, such as definitions of work or work types, with which the individual was not familiar. Components of freedom and justice must be determined by those individuals within a clientele group and must not be evaluated by others not having an understanding of the clientele group.

With reference to the urban versus agricultural lifestyle settings and food production potentials, it was the author's opinion that the alternative technologies suggested for assessment could decrease the element of finality associated with technological irreversibility and entry into agricultural occupations while at the same time add new measures of freedom for intellectual and physical pursuits for those individuals with limited financial resources.

Technology assessment as an educational aid

In order to introduce and acquaint the graduate agricultural engineering class entitled Agricultural Mechanization in Developing Countries with concepts of problem-oriented technology assessment, a technology assessment worksheet, similar to the following, was distributed to members of the classes of the Spring terms of 1974 and 1975.

Technology Assessment of Agricultural Lifestyles

	Subsistence	Cooperative Subsistence	Traditional Family Farm	Commercial Farm - Hired Labor
Provision	______	______	______	______
Environment	______	______	______	______
Freedom	______	______	______	______
Justice	______	______	______	______
TOTALS	______	______	______	______

The clientele for which the assessment was to be completed was described to the class to be the total population of the home country for each individual class member. The class was instructed to use the numerical values on a scale from -2 to +2 including 0 to evaluate the alternative technologies of agricultural production lifestyles as to the ability of the technology to fulfill the needs of the clientele group when considering the quality of life problem areas. The +2 was to be used for the most adequate or desirable alternative. Such numerical values were often called impact values.

The farm type or agricultural lifestyles which made up the alternative technology array of the matrix consisted of subsistence, cooperative subsistence, traditional family farm, and commercial farm-hired labor. The problem array consisted of the quality of life variables, developed by Montgomery (1975) and the Group for Analysis and Assessment of Technology of Michigan State University, which were: provision of goods and services, environment, freedom, and justice. Approximately twenty minutes was required, each year, to explain the concepts associated with each of the variables so that the individuals could proceed to complete the assessment procedure. In both years, after the individuals had begun to fill out the questionnaires, there were questions raised as to the clientele groups which were to be covered by the questionnaire. Even though the clientele group had been previously defined as the whole of society, the concept of clientele group was not clearly understood when the variable of commercial farm-hired labor was encountered. The author believed the indecisiveness over clientele and the agricultural lifestyle to be the beginning of a learning experience which forced clarification of conflict of interest between groups as to role designation, loyalty, and concerns of the groups or individuals at interest. Such points of clarification to interest groups should provide insight into dealing with technological impacts in developing countries.

Even though the number of participants was limited to eleven in 1975 and ten in 1976, there were several interesting points in the cumulative results. Impact values were selected between -2 and +2 for each matrix intersection. In the results of the farm-type or alternative variable, out of a possible range of -8 to +8, the range for 1975 was -4 to +8, and in 1976 the range was -6 to +8, thus vindicating the variable range selected. The cumulative average value for each farm type for 1975 was: subsistence, 3.1; cooperative subsistence, 4.2; traditional family farm, 4.4; and commercial farm-hired labor, 1.3. The respective values for 1976 were 0.8, 3.1, 3.4, and 1.3. One value was consistent between years, namely, that for the commercial-farm hired-labor farm type. The cooperative-subsistence and traditional-family farms were close in evaluation, and averaged out three times higher than the commercial farm type on the value scale. Due to the limited number of cases, no conclusions should be derived from the assessment other than the authors belief that technology assessment could be used to advantage as an educational aid. This was consistent with the findings of Krauss (1974).

Technology assessment as an inquiry into professionalism

Components related to the generation and use of the technology under study along with associated professionalism were structured into a questionnaire. The questionnaire was designed to evaluate components of awareness in areas of: societal needs, professional insularity, professional responsibility, externality costs, societal restrictions used to control technology, and level of personal commitment to societal goals as opposed to personal or corporate goals. The context of the questionnaire designed for one-page administration convenience follows.

QUESTIONNAIRE

Your response is invited in a Technology Assessment of large-scale farm tractors as related to the proposed ASAE long-range goal number 1:

> "To develop public understanding of the consequences, both positive and negative, of existing and proposed engineering-technology-for-agriculture on human health, social structure, the environment, economy, and natural resources."

Agree	Disagree	
____	____	Do you agree with certain members of the USDA who suggest the economic problems of the small family farm should be considered as a welfare problem instead of an agricultural problem?
____	____	Due to the inaccessibility to large amounts of capital and various economies of scale, the institution of the small family farm should be discarded as an obsolete agricultural alternative.
____	____	In light of recent trends in unemployment, production of large-scale tractors should be discouraged in contrast to the encouragement of the production of two or more smaller tractors of total equivalent horsepower.
____	____	Design engineers should be directly responsible for the preparation of a social-impact statement before a technology change or technology modification is released for societal use.
____	____	Like the technologies of nuclear energy and hard drugs and the technology modification of the SST, the technology modification of the large-scale farm tractor should be placed under regulated control.

If there are external social and economic costs (such as unemployment and welfare) which are imposed on secondary groups in the production and use of a technology (such as very large tractors), which of the following control measures do you feel would maximize justice to all segments within society:

_____ 1. Direct taxation on the initial purchase.

_____ 2. Yearly taxation on the user (similar to a pollution-use tax).

_____ 3. Graduated tax which increases geometrically with increasing farm size.

_____ 4? ____

____

Agree	Disagree	
_____	_____	As an individual agricultural engineer, I feel that I can accomplish the necessary changes required to implement the proposed long-range goals of ASAE without the overriding assistance of a social OSHA or EPA.

Your age: _____ Student: _____Yes _____No

Member of ASAE _____ years

Division: P&M___ S&W___ EP&P___ St&Env___ Food Eng___

Employment: Industry___ University___ USDA___ Consultant___

Percent of time involved with:

Management_____ Design_____ Sales______

Extension _____ Teaching___ Research___

SUMMARY

The technology-driven assessment methodology was used in the research study to determine farm structural differentiation characteristics and farm structural differentiation change on all TelFarm farms and on various subsets of the farms. Table VIII was presented both as a definitional summary of farm types and as a structural analysis summary of structural differentiation characteristics on all farms and crop farms for 1969, 1974, and 1975. Table IX summarized the total cumulative structural change, for both farm structural differentiation characteristics and family-labor participation on all farms and crop farms for the years indicated.

Family-labor participation--The mean family-labor participation decreased significantly on all farms with crop farms decreasing the greatest amount. In 1975 highest-cost tractor purchase farms decreased family-labor participation twice as much as other farms (S .06).

Hired-labor differentiation--Hired-labor differentiation, in contrast to family-labor participation, increased significantly over the period of the study. Highest-cost tractor purchase farms increased hired-labor differentiation over twice that of all farms.

TABLE VIII

FARM STRUCTURAL DIFFERENTIATION RATIOS

Structure	Traditional Family Farm	TelFarm Structure 1969	1974	1975	Totally Differentiated Factory Farm
All Farms					
Hired-labor Diff.	0	.31	.37	.40	1.00
Capital Diff.	0	.30	.33	.36	1.00
Land Diff.	0	.38	.41	.42	1.00
Machinery Diff.	0	.14	.14	.15	1.00+
*TOTALS	0	1.13	1.25	1.33	4.00+
Crop Farms					
Hired-labor Diff.	0	.33	.39	.45	1.00
Capital Diff.	0	.29	.36	.42	1.00
Land Diff.	0	.48	.52	.55	1.00
Machinery Diff.	0	.15	.16	.17	1.00+
*TOTALS	0	1.25	1.43	1.59	4.00+

*TOTALS obtained by adding the separate various structural differentiations.

TABLE IX

FARM STRUCTURAL CHANGE

Structure	Year	Percent of Change
All Farms		
Family Labor Participation	1974 to 1975	- 4.4
	1969 to 1975	- 4.5
Hired Labor Differentiation	1974 to 1975	8.0
	1969 to 1975	29.
Capital Differentiation	1974 to 1975	9.3
	1968 to 1975	17.
Land Differentiation	1974 to 1975	.87
	1968 to 1975	10.
Machinery Differentiation	1974 to 1975	4.8
	1972 to 1975	17.
CUMULATIVE STRUCTURAL CHANGE	1974 to 1975	27.37
	1968 to 1975	77.5
Crop Farms		
Family Labor Participation	1974 to 1975	-12.
	1969 to 1975	-35.
Hired Labor Differentiation	1974 to 1975	15.
	1968 to 1975	53.
Capital Differentiation	1974 to 1975	18.
	1971 to 1975	61.
Land Differentiation	1974 to 1975	5.2
	1970 to 1975	18.
Machinery Differentiation	1974 to 1975	1.8
	1968 to 1975	14.
CUMULATIVE STRUCTURAL CHANGE	1974 to 1975	52.0
	1968 to 1975	181.

<u>Capital differentiation</u>--A general over-all capital differentiation increase was found from 1968 to 1975 on all farms. Highest-cost tractor purchase farms increased capital differentiation over twice that of all farms from 1974 to 1975.

<u>Land differentiation</u>--Mean land differentiation was found to increase on all farms from 1968 to 1975 except for the 1969 to 1970 time period. Highest-cost tractor farms decreased differentiation from 1974 to 1975 indicating a possible concentration of land ownership.

<u>Machinery differentiation</u>--Machinery differentiation fluctuated widely due to the design of the variable; however, a mean increase was found for crop farms.

<u>Structural correlations</u>--Correlations between structural variables and the cost of tractor and combine purchases were generally low. Often a structural variable would change from a low correlation with high significance to no correlation with low significance over the time period from 1968 to 1975. Such an example was tractor purchase cost with land differentiation; the correlations were .16 (S .02) in 1968 and .05 (S .16) in 1975. Such correlation differences indicated that change had occurred in the relationship of the variables, but analytically the change was not necessarily predictive of the change which had occurred. In such instances the only informative finding was that a previously weak relationship no longer existed or the opposite.

Tillable acres farmed correlated .22 (S .001) in 1968 and .37 (S .001) in 1975 with tractor purchase cost. This finding indicated a strengthening of the relationship between tractor cost and acres farmed from the 1968 to 1975 time period. The interim year's correlations strengthened the validity of the relationship.

Farm types--Of the 122 highest-cost tractor purchase farms in 1975, 22 percent were crop farms and 70 percent livestock farms. Highest-cost combine purchase farms were 13 percent crop farms, and 85 percent livestock farms. Crop farms represented 14 percent of all farms in 1975.

Southern dairy farms purchased two of the ten highest-cost tractors at $47,000 and $35,000. Cash grain farms purchased 6 of the 10 highest-cost tractors within the cost range of $42,000 to $30,000.

Land--In the study of acreage added to farms and tractor acreage-handling capacity, farms which purchased a highest-cost tractor added relatively more tractor power than acreage to farming operations. The finding indicated that more acreage could be added to the farm operation without a shortage of tractor land-handling capacity.

Concentration of ownership of land on the highest-cost tractor purchase farms was indicated by the ten-case study and by the 122-case study of highest-cost tractor purchase farms in 1975.

Technology Availability--A problem of technology availability was encountered by the author while working on the technology-driven assessment. The author was unable to find any manufacturer offering a small-size multipurpose power-take-off combine capable of meeting the small farmer's needs and economic restrictions.

The problem-driven assessment technique--The problem-driven assessment technique provided a method for conceptualizing second-and higher-order causal-factor relationships between the alternative technologies and problems encountered by society or specific clientele groups within society. The provision, environment, freedom, and justice components provided a convenient method of conceptualizing qualify-of-life components. Such as assessment technique could easily become operational as illustrated by the technology assessment of agricultural lifestyles described in Technology Assessment as an Educational Aid. A questionnaire related to issues of agricultural professionalism was developed using ideas derived from the assessment methodology.

CONCLUSIONS

Farm structural characteristics may be conceptualized to vary from no differentiation on the traditional family farm to total differentiation on the corporate type farm. Sociologists and economists such as Rodefeld (1974), Goldschmidt (1972) and Heady (1975) have established the social and economic undesirability of highly differentiated farm structural characteristics.

This research study found the existence of relationships between the technology modification of the purchase of large tractors or combines and the level of differentiation of the various farm structural characteristics investigated. The exact nature of the relationships or the causal forces involved in the relationships were not investigated. Undoubtedly there were many causal forces acting to increase or decrease the level of differentiation of the structures studied. Evidence of multiple causal forces was obvious in the case of hired-labor differentiation and the acquisition of large tractors. It would normally be thought that the addition of a large tractor would decrease hired-labor differentiation because the farm operator would then provide a higher share of the labor inputs to the farm enterprise. Such was not found to be the case on the TelFarm farms. Other causal forces diminished or overpowered the increased labor efficiency, provided by the new large tractors, to the extent that highest-cost tractor purchase farms increased hired-labor differentiation over twice that of all farms from 1974 to 1975. While hired-labor differentiation increased, family labor participation by members other than the operator decreased twice as much on highest-cost tractor purchase farms than on other farms.

Capital differentiation, like labor differentiation, increased approximately twice as fast on highest-cost tractor purchase farms than on all farms from 1974 to 1975. Such an increase could be explained by the increase in borrowed capital necessary to buy the highest-cost tractors.

Land and machinery differentiation increased from 1974 to 1975 for all farms and crop farms. However, highest-cost tractor purchase farms decreased land and machinery differentiation during the same time period, thus indicating a possible concentration in land ownership and a reduction in the need for hired machine work and leased machines.

Farm operations which purchased highest-cost combines added very small additional acreages to their operations in contrast to large acreage additions for those farms which purchased highest-cost tractors. Large combine purchasers could have used the machines for custom harvesting in addition to harvesting for their own operations.

Techniques of inquiry of problem-driven technology assessment led to controversial issues. Educational aids and inquiry into professionalism were additional areas where problem-oriented technology-assessment techniques were thought by the author to prove useful.

SUGGESTIONS FOR FUTURE RESEARCH

Research studies should be conducted using direct cause-effect methodology to determine the social, economic and environmental effects inflicted upon communities by large-scale agricultural technologies. Such studies should utilize direct relationships rather than the two-step procedure of first using farm structural differentiation as a measure of the effect of technology modification upon farm structure, and second, using sociological and economic research findings concerning structural differentiation to prove associated growth or decline of rural communities and institutions.

Sociological and economic objectives should be determined for rural areas by those societal members residing within the areas. An agricultural technology system could then be selected which would be compatible with the objectives of the community. Control measures could then be initiated through conventional economic channels, such as taxation, to allow all costs of the technology to be paid by those receiving benefits from the technology and to compensate those who received damages from the use of the technology.

The sample population of the technology-driven part of the research study should be extended to cover a random sample of all farms in the state rather than only TelFarm farms. Other states should be researched to determine if the results which were found in this research study would be consistent from state to state.

The second part of this research study, Preliminary Problem-Driven Assessment, was developed as the nucleus for a comprehensive technology assessment relating alternative agricultural technologies to major societal problems. Anyone completing such research which utilizes problem-oriented technology assessment methodology must be aware of the controversial nature of the inquiry procedure when working in professional areas where open controversy is not encouraged.

Research is needed to determine the extent to which technology assessment techniques would prove useful in educating all persons dealing with the transfer of highly developed technology into less-developed countries.

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