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IMPACT OF LARGER EQUIPMENT ON

MICHIGAN CASH CROP FARMS

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Stephen B. Harsh
Major professor

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IMPACT OF LARGER EQUIPMENT ON MICHIGAN CASH CROP FARMS

By

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ABSTRACT

IMPACT OF LARGER EQUIPMENT ON
MICHIGAN CASH CROP FARMS

By

Philip Larry Greenburg

During the twentieth century, one of the biggest changes in agriculture has been increased mechanization. Agriculture has changed from the use of horses as the major source of power to almost complete use of tractors.

In recent years, this size of farm tractors has followed an upward trend. From 1973 to 1976 the retail sales of tractors with a P.T.O. horsepower of 140 or greater increased by 58.5%. At the same time, tractors less than 140 horsepower had decreased retail sales by 36.5%. Along with the shift to larger tractors there has been an associated shift to larger tillage, planting and harvesting equipment.

The purpose of this study was to investigate the reasons for the movement to large machinery systems and calculate if large machinery systems are causing Michigan farmers to be overmechanized. By studying the factors which encourage the trend to large machinery systems, a better historical understanding of changes in agriculture can be developed. If those factors continue to be important in the decision making process, future equipment needs can be predicted. If the observed trend is in effect beneficial or detrimental to the farm operation, this will be a valuable insight into the financial management changes in agriculture.

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TABLE OF CONTENTS

LIST OF TABLES

Table | Page

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

"Since 1900, one of the biggest changes in American agriculture has been the mechanizing of farm operations."[1] Mechanization has allowed the 1977 average farm size to grow to about 393 acres from 348 acres in 1966.[2] Through the use of equipment, farmers have been able to increase the size of their operations and improve labor efficiency.

By 1976, there were approximately 154.5 thousand men and women employed in Michigan agriculture.[3] In 1967, the agricultural sector employed 305.5 thousand people in Michigan. Over the same ten year period, the amount of land in agriculture only declined by 4%.[4] The reduction of 151 thousand workers in ten years represents a 49% decrease. As employee numbers were declining, the pattern of employment has shifted from seasonal workers to more full time workers (Table 1).

Table 1-1. Number of Employees on Michigan Farms with Sales over $2,500 per Year in 1969 and 1974

Length of Employment	Year 1969	Year 1974
More than 150 days	9,879	12,273
Less than 150 days	176,547	127,602

Source: 1974 Census of Agriculture, U.S. Department of Commerce, Bureau of the Census, Vol. 1, part 22, pp. 1-16.

With a declining labor force and an increasing average farm size, a substitution effect between labor and equipment has allowed a farmer to decrease his labor requirements and increase the number of acres farmed. The change from seasonal to full time workers has also decreased the number of workers needed.[5]

In this shift to higher mechanization of farms, (Table 2) it is desirable that a proper mix between machinery, labor and other resources be maintained. Otherwise, farmers having too much or not enough machinery resources in relationship to other resources will be at a competitive disadvantage. In recent years, there has been an accelerated trend to larger sized machinery systems. The core of these large machinery systems is the high horsepower tractor, many of which are four wheel drive (Table 3).

Table 1-2. Estimated Market Value of all Machinery and Equipment on Michigan Farms 1969 and 1974

	Year	
	1969	1974
Number of farms	76,060	61,877
Estimated market value (million $)	$716	$1,313

Source: 1974 Census of Agriculture, U.S. Department of Commerce, Bureau of the Census, Vol. 1, part 22, pp. 1-4.

Table 1-3. Michigan Retail Sales of Farm Wheel Tractors, 1973-1976[a]

P.T.O. Horsepower	Year of Sale 1973	1974	1975	1976
	number			
<60	1649	1513	1166	1113
60-99	1567	1377	1258	1227
100-139	1214	1210	1090	1105
140-169	228	314	371	257
170≥	88	121	191	244

Source: Adapted from "Retail Sales of Farm Wheel Tractors by Horsepower (in units)," Implement and Tractor, Intertec Publishing Corp., Vol. 92, no. 10, pp. 28, 29; vol. 91, no. 10, pp. 28, 29; vol. 90, no. 10, p. 10; vol. 89, no. 23, p. 30.

[a]Two assumptions were made in compiling the data. The first was that all two wheel tractors had a P.T.O. horsepower rating less than 170. The second assumption was that all four wheel tractors were rated above 140 horsepower. These assumptions were necessary because the original data were divided between two wheel and four wheel tractors.

From 1973 to 1976, yearly tractor sales have decreased by about 17%. When the data presented in Table 3 are stated in percentages, the retail sale decrease was not uniform for all classes (Table 4). While the retail sales of tractors with a P.T.O. horsepower less than 140 decreased by 36.5%, the sales of tractors rated 140 h.p. and greater increased by 58.5%. Therefore the trend to larger tractors is also evident in Michigan.

Along with the shift to larger tractors, related equipment must be changed to take advantage of the increased tractor size. Planter, plow and other field equipment must be matched with the work capacity of the tractors. It would not be economical to use a 200 horsepower tractor to pull a 4 bottom plow. The rate of work would be much less than expected for a 200 horsepower tractor. Therefore, the shift to larger tractors has caused an associated shift to larger tillage, planting and harvesting equipment.

Table 1-4. Percent Michigan Retail Sales of Farm Wheel Tractors, 1973-1976

P.T.O. horsepower	Year of Sale 1973	1974	1975	1976
<60	100%	91.8%	70.7%	67.5%
60-99	100	87.9	80.3	78.3
100-139	100	99.7	89.8	91.0
140-169	100	137.7	162.7	112.7
170≥	100	137.5	217.0	277.3

Source: Implement and Tractor, op. cit.

The question that needs to be addressed is whether Michigan farmers, in their movement to large machinery systems, are becoming overmechanized, therefore, at a comparative disadvantage. Or conversely, whether they have been undermechanized and are now at a more competitive advantage.

The objectives of this study are:

1. To study the economic advantage or disadvantage of equipment size for different sized Michigan farming operations. In particular, has the trend to large tractors and related equipment improved the profitability of Michigan farms.
2. To determine the economic and non-economic factors which influence farmers' decisions in selecting the size of tractor purchased.

ENDNOTES

[1] Earl O. Heady and Harold R. Jensen, Farm Management Economics, Prentice-Hall, New York, 1954, p. 374.

[2] USDA, "U.S. Farms: Still Disappearing," Agriculture Situation, March 1977, p. 11.

[3] Michigan Department of Labor, "Michigan Agricultural Labor in Perspective," The Michigan Farm Worker, Vol. 1, no. 1, p. 2.

[4] USDA, op. cit., p. 11.

[5] Michigan Department of Labor, op. cit., p. 11.

CHAPTER II

THEORY OF EQUIPMENT SIZE AND RESEARCH METHODOLOGY

There are two basic problems to be addressed in this study. The first problem is gaining a better understanding of factors which caused farm managers to purchase larger equipment. The second problem is evaluating the economic advantages or disadvantages of different size groups of equipment.

By studying the factors which encouraged the trend to large machinery systems, a better historical understanding of changes in agriculture can be developed. If those factors continue to be important in the decision making process, future equipment needs can be predicted.

In addressing the second problem, it is important to determine if the observed trend is in effect beneficial or detrimental to the farm operation. The answer to this problem will give insight into the financial management changes in agriculture.

There are probably many reasons for buying larger tractors. These reasons should reflect the size, work capacity and financial situation of the operation. When a farmer purchases a large tractor, it should be because a smaller tractor is unable to complete the tasks involved within the expected time constraints. There are also financial tax advantages for making the purchase. Tax advantages include increased depreciation and more investment tax credit.

Economics of Machinery Size

Many of the perceived needs for large equipment cannot be economically justified. On the other hand, farmers who are trying to use a minimal amount of equipment might be at an economic disadvantage in the planting or harvesting seasons.

The timeliness of farm operations is very important to production. Not planting or harvesting at the optimum time can reduce yield. Planting date affects expected yield. Corn that is planted in the middle of May will only yield 80% of its potential (Table 5). A later planting date will reduce the yield potential by limiting the growing season and the number of heat degree days.

Table 2-1. Five Year Average Corn Yield Related to Different Planting Dates in Central Michigan 1970 through 1974.

Average planting date	% moisture at harvest	Average Bushels per acre at 15.5% moisture
April 21	26	102
May 3	28	96
May 13	31	83
May 23	34	78
June 2	39	64
June 11	43	72

Source: Michigan Corn Production Series, Department of Crops and Soil Science, Michigan State University, East Lansing, Michigan, 1976.

Table 6 shows the results of corn planted at the same time but harvested during different periods. There is a yield reduction of 12% between the different harvest times. A late harvest will have a lower yield because of stalk lodging.

Table 2-2. Relative Corn Yield and Percent Moisture with Different Harvest Dates in Michigan.

Harvest Period	% moisture at harvest	Relative yields per acre at 15.5% moisture
Sept. 27-Oct. 3	28	90
Oct. 4-Oct. 10	28	100
Oct. 11-Oct. 17	26	99
Oct. 18-Nov. 7	23	98
Nov. 8-Nov. 28	21	88

Source: User's Guide For Corn, Soybean Farm Planning Guide, Department of Agricultural Economics, Corn-Soybeans Planning Guide, Program No. 18, Form 1, January, 1973.

Table 7, which is a combination of Tables 5 and 6, shows that a low work capacity causes a 49.3% reduction in yield. If land potential were 120 bushels per acre, a delayed planting and harvesting schedule would result in an estimated yield of 61 bushels. With a market value of $2.00 per bushel, the crop loss of 59 bushels would reduce gross income by $118.00 an acre.

A farm operation that does not have adequate machinery and labor is at a serious disadvantage. As shown by tables 5, 6, and 7, there is a reduction in yield because of untimely operations.

Table 2-2. Relative Corn Yield and Percent Moisture with Different Harvest Dates in Michigan.

Harvest Period	% moisture at harvest	Relative yields per acre at 15.5% moisture
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A farm operation that does not have adequate machinery and labor is at a serious disadvantage. As shown by tables 5, 6, and 7, there is a reduction in yield because of untimely operations.

Table 2-3. Relative Corn Yield Loss in Michigan with Different Planting and Harvesting Dates.

Planting date	Harvest date Sept. 27 – Oct. 3	Oct. 4 – Oct. 10	Oct. 11 – Oct. 17	Oct. 18 – Nov. 7	Nov. 8 – Nov. 28
April 21	10.0%	0.0%	1.0%	2.0%	12.0%
May 3	15.9	5.9	6.9	7.9	17.9
May 13	28.6	18.6	19.6	20.6	30.6
May 23	33.5	23.5	24.5	25.5	35.5
June 2	47.2	37.3	38.3	39.3	49.3
June 11	39.4	29.4	30.4	31.4	41.4

How much equipment a farm should have is as difficult to know as predicting the weather. Given ideal conditions, it is possible to maximize profits with small equipment. During a wet or poor growing year, larger equipment would be necessary for maximum profit.

There are costs to having and operating farm machinery which should be considered in determining the proper equipment size. Large equipment can help achieve maximum yield, but ownership and operating costs might more than offset the increased yield.

Ownership costs are fixed costs which do not vary with production. These costs include depreciation, interest, or opportunity cost on capital invested and insurance. Total fixed costs do not change with production, but the cost per unit decreases as more units are produced.

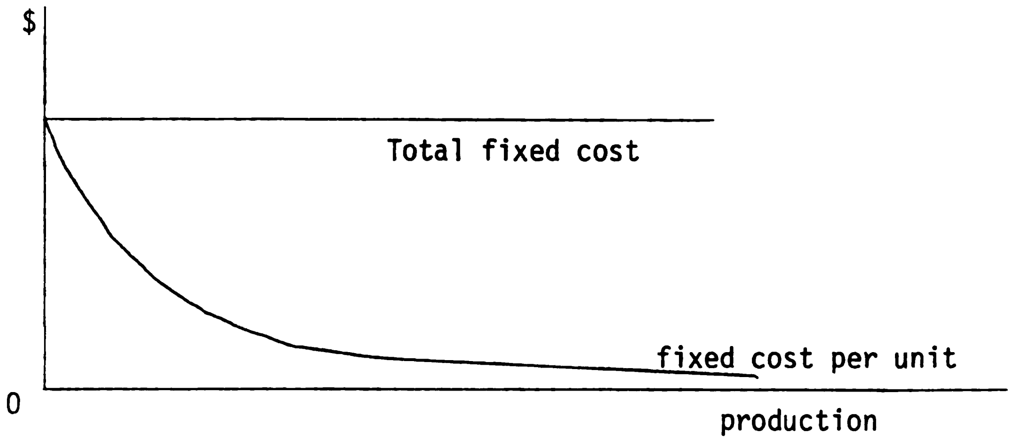

Figure 2-1. Fixed Costs with Increasing Production.

Operating costs are variable costs of production. Variable costs consist of repairs, fuel, oil, grease and other inputs that change with production. Total variable cost increases as production increases. Some of the costs, such as repairs, increase at an increasing rate as production increases.

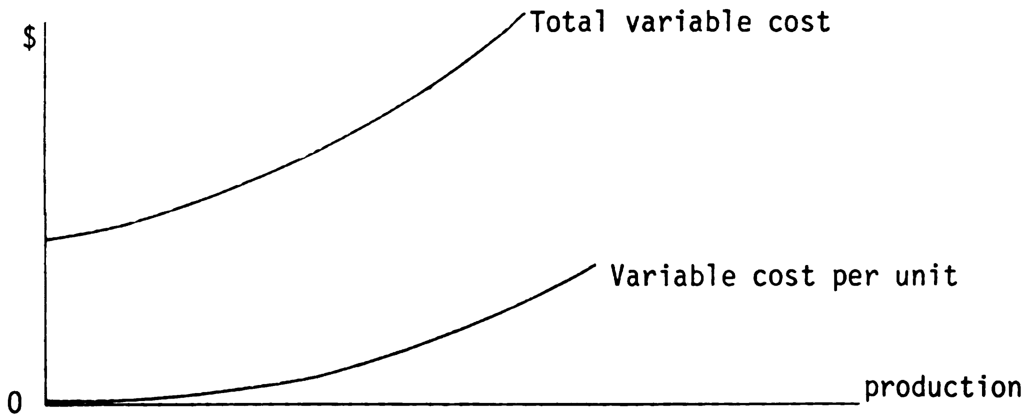

Figure 2-2. Variable Costs with Increasing Production.

Graphically, fixed costs and variable costs can be combined to show total costs and average cost.

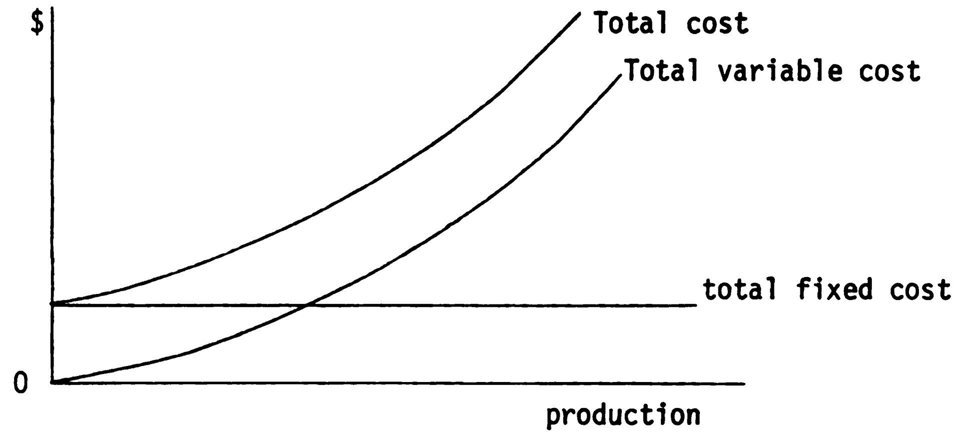

Figure 2-3. Total Cost with Increasing Production.

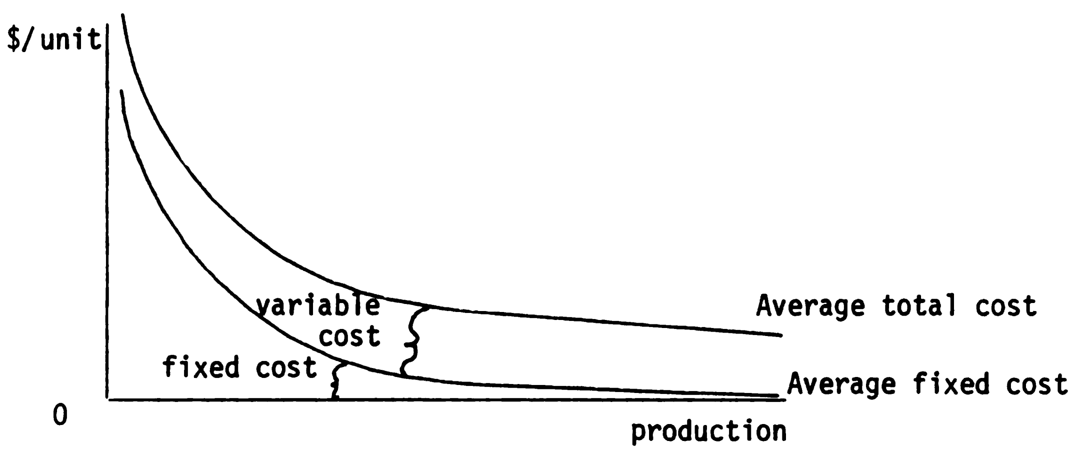

Figure 2-4. Average Costs Per Unit with Increasing Production.

The ideal size of equipment used on a farming operation is the one that maximizes returns. The exact size of equipment might be different for each farm based on:

(1) The availability of labor.

(2) The amount of work to be done in the critical crop operations.

(3) The number of working days that have satisfactory weather for field work during the critical periods.

If the available labor force is small, larger equipment might be required to complete field work in the time constraints. More workers extend the number of hours worked per day and thus reduce equipment needs. Limited labor supply, large amounts of work to be done, or weather conditions that restrict field work are factors which reduce the ability to finish the planting or harvesting during the ideal time period.

Table 7 shows the potential yield reduction associated with untimely cropping operations. Because of the severe penalties, it is desirable to have equipment which reduces yield loss.

Point A in Figure 2-5 is the location where economic losses due to untimely field operations begin. Any production to the right of point A has increasingly high economic loss. Speeding up the work rate or having more favorable weather conditions will shift point A to the right.

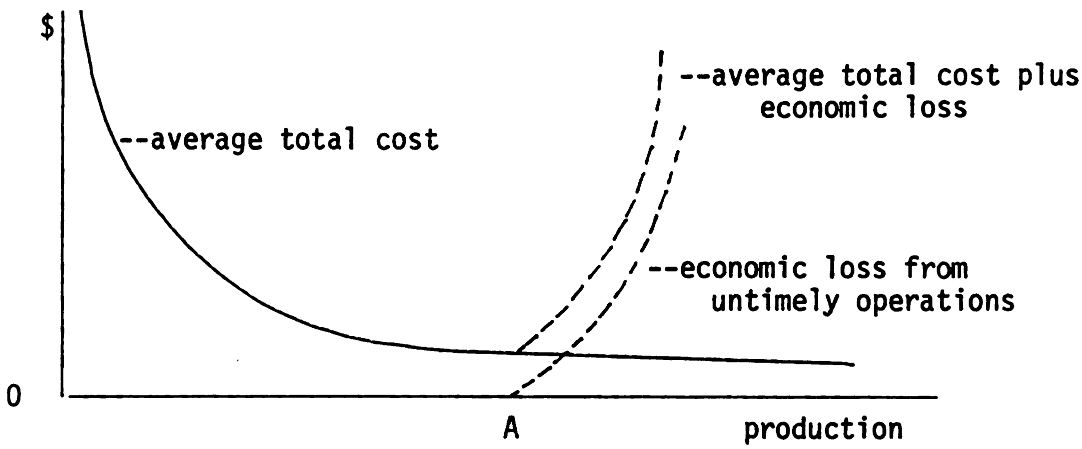

Figure 2-5. Average Total Cost and Economic Loss with Increasing Production.

Source: Managing the Farm Firm, S.B. Harsh, L.J. Connor, G.D. Schwab, In publication process, Prentice-Hall, New York, 1981.

Assuming that labor and equipment are being used at their capacity and normal weather conditions are expected, the way to expand production and minimize economic loss from untimely field work is to increase the size of equipment. Larger equipment can increase the productivity of labor. This allows more acres to be covered per hour with the same labor force.

Total ownership costs and operating costs will increase with larger equipment. Higher equipment cost will increase annual depreciation, interest, or opportunity cost, insurance and repairs. Therefore, the curves shown in figures 2-4 and 2-5 will shift to the right as large equipment is acquired.

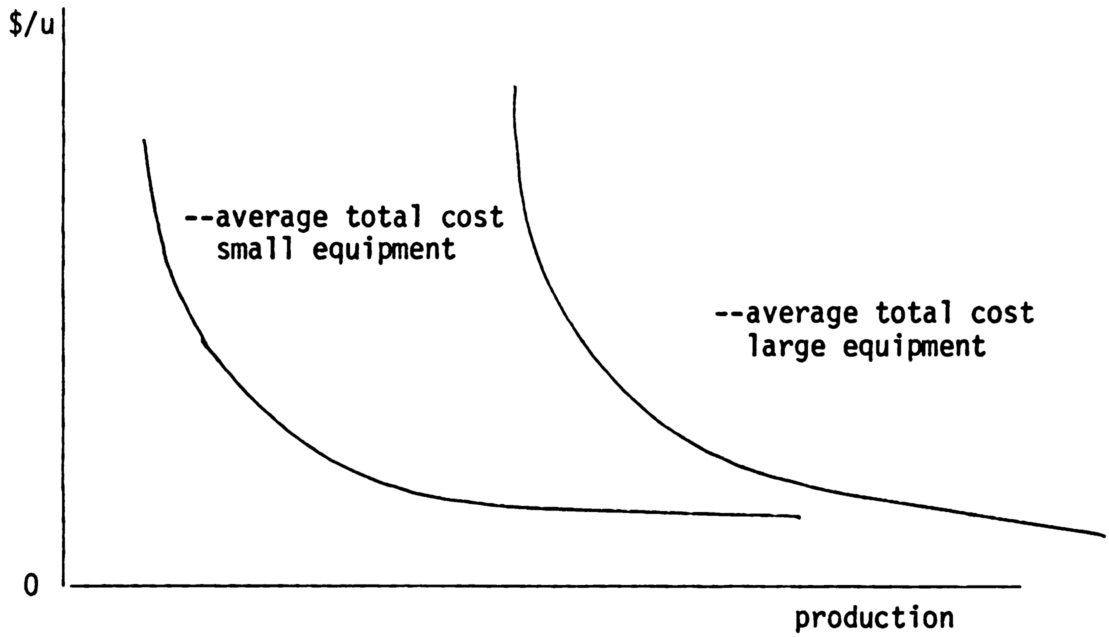

Figure 2-6. Average Total Cost for Small and Large Equipment.

Figure 2-6 shows the shift of the average total cost curve to the right when larger equipment is used. Figure 2-7 illustrates the average total cost curves with the economic loss curves added for 2 sizes of equipment. Point B is the threshold level where it is more profitable to change equipment size.

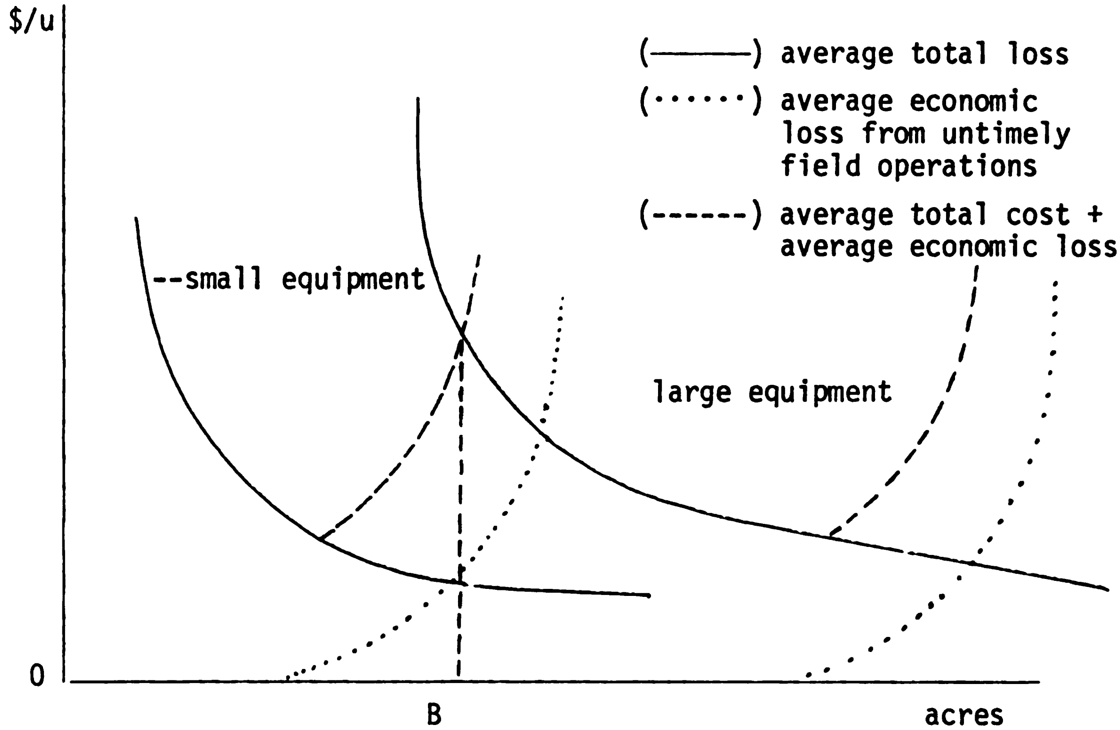

Figure 2-7. Average Total Cost and Economic Loss for Small and Large Equipment.

Source: Managing the Farm Firm, S.B. Harsh, L.J. Connor, G.D. Schwab, In publication process, Prentice-Hall, New York, 1981.

Any farm size smaller than point B could maximize net income by using small equipment. Farms larger than B would benefit from using large equipment. In the short run, there could be farms that are using the wrong sized equipment because of good economic reasons. A farm with fewer acres than point B might have large equipment to expand to operations larger than B.

One input can often be substituted for another and the same level of production maintained. Between labor and equipment there are several different combinations which can produce the same amount. This is referred to as the substitution effect and is a physical relationship between inputs. Figure 2-8 illustrates the various possible combinations of two inputs (labor and equipment) to achieve a certain level of production.

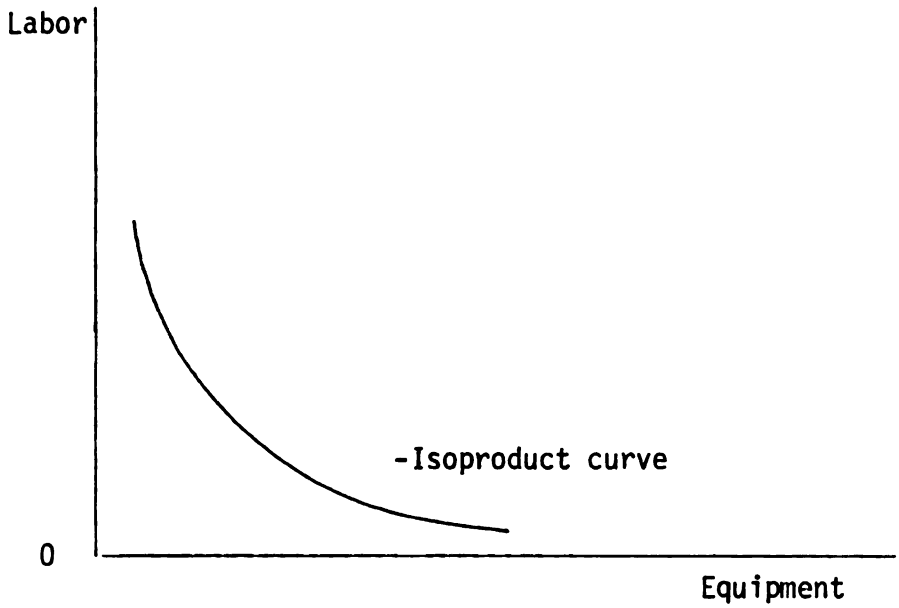

Figure 2-8. Isoproduct Curve of Labor and Equipment.

The different possible combinations of inputs which achieve a constant level of production defines an isoproduct curve.

The least cost combination of inputs at any production level is determined by the price relationships of the inputs. An isocost line then, is a series of combinations of the two inputs which have constant total cost. Any point on line L_3, E_3 has the same total cost.

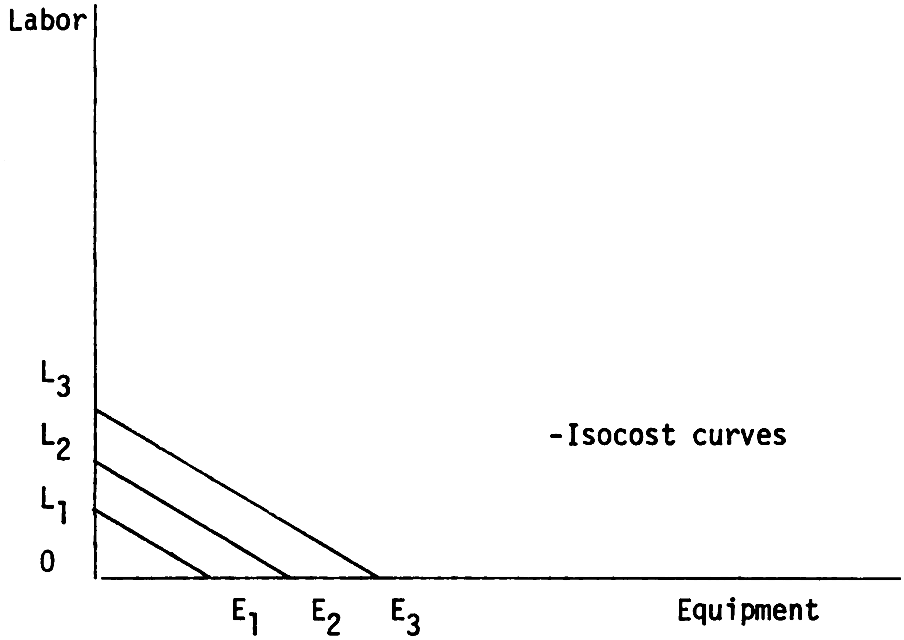

Figure 2-9. Isocost Curves of Labor and Equipment.

Figures 2-8 and 2-9 can be combined to find the least cost combination of inputs at a production level. The point where the isoproduct curve and isocost curve are tangent is the least cost combination. In figure 2-10, point A is the point of tangency to achieve output level Q. This means that L_1 of labor and E_1 of equipment would be the least cost combination to product at quantity Q_1. If more production is required, a higher isoproduct curve (eq. Q_2) needs to be used. Increased production requires more inputs so a higher isocost curve is needed to find the least cost combination at Q_2 production.

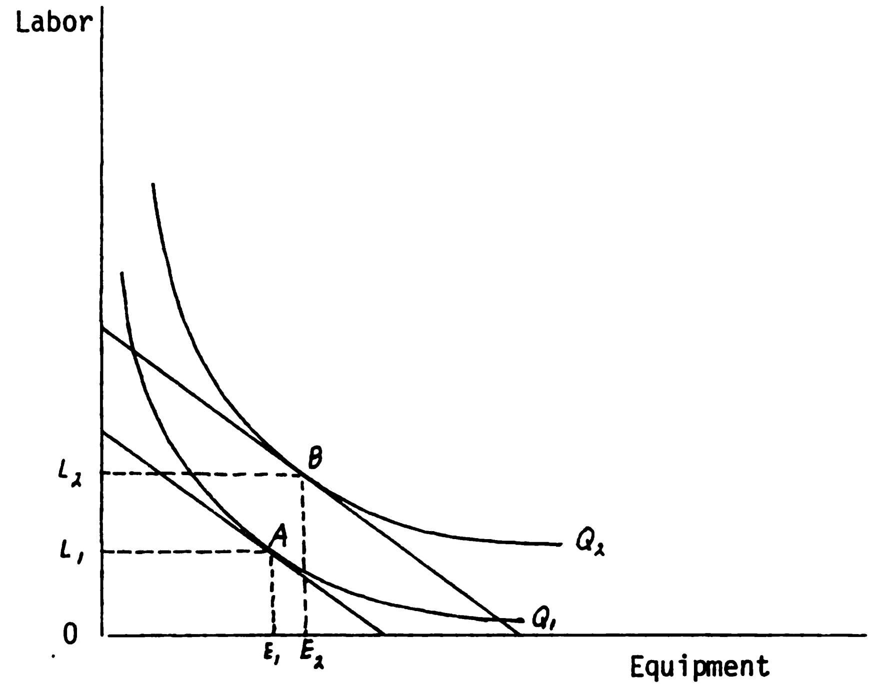

Figure 2-10. Isoproduct Curves and Isocost Curves for Two Different Levels of Production.

Points A and B in figure 2-10 are the least cost combinations at production levels Q_1 and Q_2. For any level of production the least cost combination can be found at the point of tangency of the iso-cost and isoproduct curves. Figure 2-11 shows least cost points for several different levels of production.

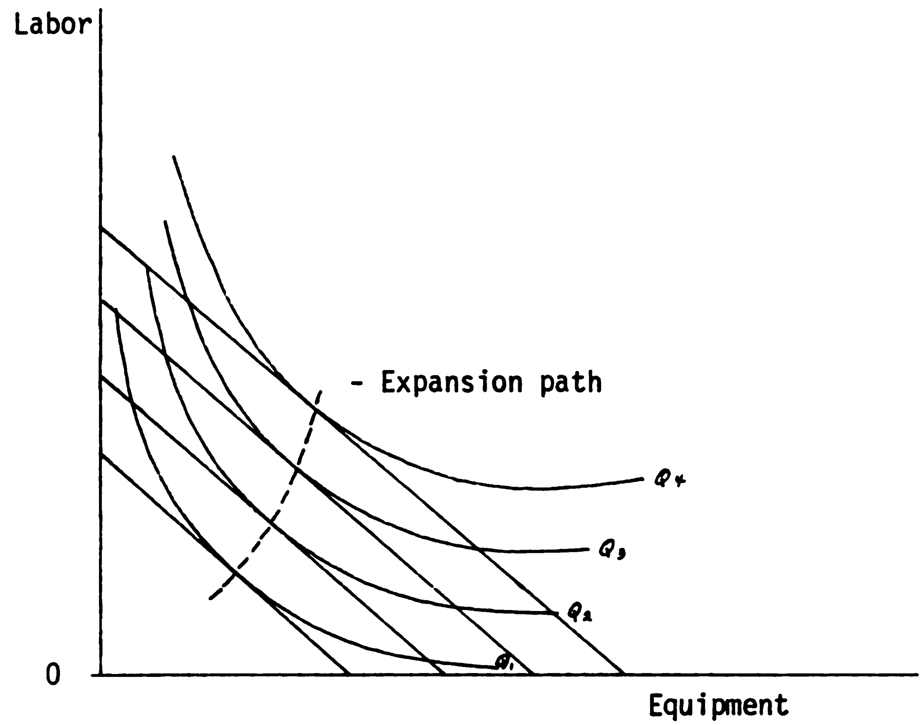

Figure 2-11. Expansion Path on the Least Cost Combination of Inputs at Different Production Levels.

The expansion path in figure 2-11 is a curve which connects each of the least cost points. This path is the combination of inputs which will minimize labor and equipment costs at any level of production. If a farm is not on the expansion path, then it is not using the most profitable combination of inputs to maximize profit. In the short run, it is possible that a farm would not be on the expansion path because of the way resources are purchased. In the long run, to be efficient, a farm should be on the expansion path to minimize total cost.

Theory of Equipment Decision Making

The decision making process of buying farm tractors and related machinery is an involved process. There are many factors which are used to determine the size of tractor to purchase. The purchased tractor must help satisfy the power needs of the farm operation and be compatible with existing equipment. Existing equipment requiring a certain type of hitch or hydraulic system can limit the number of tractor options.

Jones[1] and Lambert[2] conducted studies which compared farmers' intentions to buy tractors with actual purchases. They interviewed farmers regarding their intentions to purchase and subsequently determined if their intentions were realized. In both cases the best predictors of a purchase were the farmer's initial intentions. Some of the other factors considered in their studies included tillable acreage farmed, current disposable income and the change in disposable income.

<u>Methodology</u>

Two different models are needed to meet the objectives of this study. A linear regression model can be used to test the importance of several variables on the decision making process. A linear programming model can be used to evaluate the economics of different sizes of equipment on different sizes of farms.

TELPLAN program number 18 is a computerized program which calculates the yield and subsequent return above variable cost. The objective of using this linear programming model is to see if there is a difference in returns over variable cost of one size of equipment over another. An input sheet for TELPLAN 18 is in Appendix F.

The TELPLAN system is a series of computer programs developed for educational purposes in either the classroom or for extension work.[3] These computer programs were developed by many people who were interested in the educational uses of computers. Programs are available in the following areas: capital investment and planning, crops and soils, dairy, family living, financial management, horticulture and forestry, and livestock. There are over eighty different programs on the TELPLAN system.

TELPLAN program number 18 is a crop planning guide. The program considers the trade-offs between the amount of corn and soybeans to plant given prices, machinery system and labor force. A projected budget is printed for the best combinations of corn and soybeans. The budget includes yield, income and expenses and constraints on limiting resources.

From data collected by interviewing farmers, the number of tillable acres can be used to divide the farms into size groups. Within each group the total tractor horsepower of each farm can be calculated and ranked from smallest to largest. Then, three different sizes of equipment and labor can be estimated as being characteristic of the smallest 25%, medium 50%, and the largest 25% of each class. TELPLAN program number 18 can be run three times for each of the different size classes to generate returns to each of the three equipment and labor classifications.

TELPLAN program number 18 is designed to determine the most profitable combination of corn, soybeans and other crops given expected yields, production costs, prices, equipment, work capacity and labor. The major change in the original program was to convert the soybeans option to a navy beans option. The necessary changes involved limiting the planting and harvesting seasons to reflect normal operations of navy bean production. Navy beans should not be planted before the last week of May and must be harvested by the first week of November.

The percentage of time available for field work for different time periods was taken from another study done for Lenawee, Monroe and

Livingston counties of eastern Michigan.[4]

The linear programming model will compute returns above variable cost for the small, medium and large types of equipment in each group of farms. Returns above variable costs will be reduced by fixed costs so that the results can be comparable between equipment groups.

A linear regression model can be used to test the importance of several variables on the decision making process. The regression model should consider measures of the size of operation and working capacity. The only exception is a dummy variable to reflect the 1975 change in investment tax credit from 7% to 10%. These types of variables should be considered because they are important in determining which size of equipment to purchase. The following linear regression model was hypothesized to determine the predictability of tractor size purchases:

Size of tractor purchased = f(size of tractor traded in, tillable acres farmed, horsepower of existing tractors, returns above variable costs, farm labor, percentage of favorable work days during the spring, investment tax credit).

The hypothesis used in building this model was that the purchase of the tractor is influenced by the amount of work to be done, the farm's resources in labor and machinery, disposable income and the investment tax credit allowed.

The model used the number of tillable acres after the purchase to reflect the amount of work to be done. Because a tractor is a capital investment which will be used for several years, the number of tillable acres after the purchase was used instead of the number of tillable acres before the purchase. The calculated regression coefficient should be positive because larger farms should have a need for large tractors to provide the necessary working capacity.

Another variable is the estimated favorable field work days in the spring. This variable showed how much time the farmer felt was available for his planting operations. The regression coefficient should be negative because a farmer who thought that he had more days to plant in the spring might be less likely to buy a large tractor than a farmer who felt that he had limited time to do his spring work.

Variables which indicate the farm's work capacity are drawbar horsepower of trade-in, horsepower of tractors available for field work and adult equivalents of farm labor. Drawbar horsepower of the trade-in was used because most purchases are to replace a worn-out or an out-dated model. Since most farmers who purchase tractors are expanding instead of decreasing their size of operation, the regression coefficient should be positive. The horsepower of tractors available for field work and labor in adult equivalents are both measures of work capacity of the farm. The regression coefficient should be negative for both of these variables because small tractor horsepower and few adult labor equivalents would suggest the need for a large tractor, and a large amount of existing horsepower and several workers would indicate that a large tractor might not be needed.

Estimated returns above variable costs were used to indicate the amount of money available for a tractor purchase. This variable should have a positive sign on the regression coefficient because a farmer would be willing to invest more in a larger tractor if his income from the previous crop year had been good than if it had been a low income year. It was decided that this variable needed to be estimated because of the difficulty of obtaining this information from farmers. Income estimation is to be accomplished by using yearly variable cost of production budgets,[10] average yearly price and average yield for Saginaw

Valley cash crop farms.[6] For each year and commodity, the return above variable cost per acre was calculated and multiplied by each farmer's reported acreage of each commodity to compute an estimated return above variable cost.

The variable which represented the change in investment tax credit was coded so the years before 1975 were set equal to zero and purchases in 1975 and 1976 were given the value one. When the investment tax credit changed from 7% to 10% after 1974, this was an incentive for more investment. The regression coefficient should be positive because of increased advantage of purchasing large tractors when the investment tax credit rate increased.

The linear regression model can be used to estimate the relationships between each of the independent variables and the size of tractor purchased. From the results of this analysis, the impact of each of the independent variables on the size of tractor purchased can be determined.

Data Collection Techniques

The approach used in this study was first to collect data which could be used to determine factors important in the decision making process, and second to analyze the comparative advantage or disadvantage of different sizes of equipment.

To make the study manageable and the sample data comparable, Huron and Tuscola counties in Michigan were selected as the study area. This area has had a large increase in use of large tractors. It is an important agricultural area. Most of the farms in this area are comparable because production is mainly cash crops of corn, edible beans, sugar beets and small grains.

Data collection began by first contacting several Cooperative Extension agents in the study area for their insights regarding the trend towards purchasing larger tractors. From the agents a list of tractor dealers was compiled. Later several of the dealers were contacted for their opinions on the present trend and possible changes in the near future. The next step was to collect a list of farmers who had purchased a tractor within the last six years from the dealers. Farmers on the list were then contacted to complete a questionnaire. The questionnaire contained questions about the size and type of operation, tractor purchased, other tractors used for field work, labor force and questions about the reasons for a tractor purchase (Appendix A).

The method of selecting farmers to interview was not a random selection. The list of farmers was from dealers and did not include a complete list of all farmers who had purchased a tractor. Also attempts were made to get an equal mix of large and small tractors. A questionnaire was administered to the farmers as they appeared on the list. Some of the questionnaires were not used because of incomplete data or because the operation was not a cash crop farm. When a questionnaire was rejected, another farmer was selected from the list. Fifty-six questionnaires were used in the data analysis.

ENDNOTES

[1]A.R. Jones, Factors Affecting Tractor Purchases and Expenditures, MS Thesis, Department of Agricultural Economics, MSU, 1966.

[2]L.D. Lambert, The Relationship of Intentions to Buy and Subsequent Purchase of Farm Machinery, MS Thesis, Department of Agricultural Economics, MSU, 1964.

[3]S.B. Harsh, A Progress Report on TELPLAN Activities, Department of Agricultural Economics, Michigan State University, 1979.

[4]R.A. Hinton, User's Guide For Corn, Soybean Farm Planning Guide, form 1, 1973.

[5]W. Knoblauch, S. Nott, G. Schwab, S. Harsh, J. Black, Michigan Farm Enterprise Budgets, Agricultural Economics Report, Department of Agricultural Economics, MSU, No. 295, 1972, 73, 74, 75, 76.

[6]__________ "TELFARM", yearly summary for the Saginaw Valley, (unpublished), 1971, 72, 73, 74, 75, 76.

CHAPTER III

ANALYSIS OF DATA

The procedure employed to analyze the data was first to compile the data into tables which could help identify similarities and differences. Later the regression model was tested, and finally the linear programming model was used to compare the economic advantage or disadvantage of different equipment sizes.

Characteristics of Farms in Survey

The range of farms in the sample was from a low of 300 tillable acres to a high of 2,850 tillable acres. The data were grouped by tillable acreage from 300 to 599 acres, 600 to 999 acres, 1,000 to 1,299 acres and 1,300 or more acres. The size groupings had a fairly even distribution of observations. Both the first and second classes had 16 observations, the third class had 13 observations and the last class had 11 observations. Table 3-1 shows the average values and standard deviations of several variables within each of the tillable acreage class groupings.

From Table 3-1, several observations can be made about the similarities and contrasts between groups. The drawbar horsepower of the tractor bought, total drawbar horsepower of other tractors, farm labor and the change in total average horsepower all increase with tillable acreage. This trend is consistent with the regression hypothesis that larger farms need more equipment and labor.

The average horsepower of the tractor purchased by the largest farmers was 60.14 horsepower larger than that purchased by the smallest

Table 3-1. Selected Factors Related to Size of Acreage Farmed on 56 Farms, Thumb-Area of Michigan, 1977.

Size Class (Tillable Acreage)	HP. of Tractor Purchased	HP. of Tractor Traded	No. of Tractors[4]	Total HP. Of Other Tractors[5]	Tillable Acreage	Labor Work Equ.	Change In Total HP.	Age of Operator[6]	Year of Exp. as an Operator[7]	Tillable Acreage Owned	Tillable Acreage Rented	Percent Acreage Owned
					---Average of Farms in Group---							
300- 599 (16)[1]	114.72[2] (29.15)[3]	50.87 (40.40)	3.69 (1.16)	160.04 (55.48)	398.44 (66.70)	1.86 (0.59)	63.87 (38.26)	45.75 (8.16)	23.75 (7.84)	315.93 (93.43)	83.25 (84.41)	79.46% (20.27)
600- 999 (16)	123.00 (37.50)	48.00 (47.27)	4.06 (0.97)	250.22 (88.99)	792.50 (112.89)	2.94 (0.98)	74.99 (41.15)	40.16 (7.72)	19.63 (7.08)	456.25 (173.34)	336.25 (115.10)	56.18% (18.03)
1000-1299 (13)	157.07 (40.29)	104.97 (47.99)	3.69 (0.82)	281.86 (79.18)	1067.69 (95.61)	2.69 (0.69)	52.10 (36.51)	39.69 (6.87)	18.38 (5.12)	613.46 (184.24)	454.23 (184.79)	57.20% (15.58)
≥ 1300 (11)	174.88 (40.14)	85.63 (68.90)	4.82 (1.40)	393.49 (92.20)	1952.73 (554.55)	3.68 (1.77)	89.25 (63.52)	41.88 (7.92)	21.74 (7.46)	772.27 (476.26)	1180.45 (601.73)	40.97% (19.81)
Total (56)	138.74 (43.68)	69.44 (56.09)	4.02 (1.17)	259.94 (112.90)	971.70 (601.41)	2.72 (1.23)	69.30 (46.57)	41.99 (8.09)	20.43 (7.48)	514.52 (301.93)	457.18 (479.65)	60.08% (23.00)

[1]Number of observations in each class.

[2]Average value for each class.

[3]Standard deviation in each class.

[4]Includes the purchased tractor.

[5]Tractors available for field work excluding the purchased tractor.

[6]Average age of all operators on a farm.

[7]Average number of years of experience as a farm manager of all operators on a farm.

farmers and is 36.14 horsepower larger than the average for all farms in the sample. Total horsepower of other tractors available for field work for the largest farmers was 233 above that for the smallest farms. Because there is not much difference between the number of tractors in each of the groups, there must be a difference in the average tractor horsepower. By adding the average horsepower of the tractor bought to the average total horsepower of other tractors in each class, the average total horsepower can be calculated. By dividing the average total horsepower by the average number of tractors, the average tractor size can be observed for each class (Table 3-2).

Table 3-2. Average Values of Tractor Size and Number by Acreage on 56 Farms, Thumb Region of Michigan, 1977.

Tillable Acreage	HP of Newly Purchased Tractor	HP of Other Tractors	Total HP	Number of Tractors	HP Per Tractor
300-599	114.74	160.04	274.78	3.61	74.47
600-999	123.00	250.22	373.22	4.06	91.93
1000-1299	157.07	281.86	438.93	3.69	118.95
≥ 1300	174.88	393.49	568.37	4.82	117.92
Average	138.74	259.94	398.69	4.02	99.17

The average horsepower per tractor does show a trend for large farms to have larger tractors. The difference is not as great as might be expected, but this is probably because large firms have a need for small tractors to complement the large tractors.

There is not much difference between the average age of the farmer or the number of years of farming experience among the different sizes of farms. The amount of tillable acres owned and rented and the percentage of tillable acres owned does change with the total tillable acreage of the farm. Larger farms tend to have more rented land than smaller operations. Large farms tend to have larger equipment which reduces the risk of not getting their cropping done on time, and gives them the flexibility to rent more land. A land owner might prefer to rent his land to larger farmers because large farmers have larger and probably newer equipment and are more likely to be timely in their operations.

Table 3-3 compares the size of the tractor purchased in relationship to other characteristics of the farm. Several variables are included in each of the horsepower groups to compare and contrast characteristics of purchasers of a large or medium size tractor. From the questionnaire data there were 7 observations of a purchase of less than 100 horsepower, 21 observations between 100 and 129 horsepower, 16 between 130 and 189 horsepower and 12 observations of 190 or more.

The amount of tillable land is a strong indicator of the size of tractor purchased. Farms with more tillable acres tended to purchase larger tractors. Likewise, the larger the tractor purchased, the greater the tendency to expand the acres farmed. Bigger farms are able to make better use of the land working capacity of large tractors than the smaller acreage farms are. Farmers who purchased tractors with over 190 horsepower had over twice as many acres as those farmers who purchased a tractor with less than 100 horsepower. It is interesting to note that farmers who purchased the biggest tractors also owned less of the land that they farm. On the average, all farmers who bought tractors also increased the number of tillable acres farmed. Those farmers who purchased the largest tractors increased their acreage by 110 tillable acres. When compared to the other groups, there is a positive correlation between the increase in acreage and size of tractor bought.

Table 3-3. Selected Factors Related to Size of Tractor Purchased on 56 Farms, Thumb-Area of Michigan, 1977.

Size Class (Drawbar HP. of Tractor Purchased)	HP. of Tractor Purchased	HP. of Tractor Traded	No. of Tractors[4]	Total HP. Of Other Tractors[5]	Tillable Acreage	Labor Work Equ.[6]	Change In Tillable Acreage[8]	Tillable Acreage Owned	Tillable Acreage Rented	Percent Acreage Owned	Percent Days in Spring[7]	Change In Total HP.
					Average of Farms in Group							
>100 (7)[1]	79.11[2] (19.45)[3]	57.52 (26.75)	2.57 (1.05)	247.25 (114.21)	655.71 (242.36)	2.43 (1.18)	25.71 (34.99)	347.14 (162.89)	308.57 (215.96)	56.74% (23.60)	58.00% (8.93)	21.60 (21.88)
100-129 (21)	109.29 (4.82)	30.90 (34.56)	2.90 (1.19)	238.21 (116.89)	845.95 (661.77)	2.80 (1.65)	32.86 (59.43)	475.62 (406.23)	370.33 (448.75)	62.07% (23.01)	58.29% (11.66)	78.39 (36.51)
130-189 (16)	152.49 (13.52)	82.74 (51.33)	3.06 (1.09)	251.25 (94.48)	950.00 (400.48)	2.81 (0.81)	74.38 (108.11)	548.13 (205.73)	401.88 (337.17)	63.61% (21.31)	53.69% (10.54)	69.75 (47.67)
190> (12)	206.74 (9.34)	126.11 (50.30)	3.42 (1.19)	316.96 (105.88)	1405.00 (631.75)	2.63 (0.74)	110.00 (138.50)	635.42 (172.04)	769.58 (643.98)	53.85% (23.29)	53.33% (4.71)	80.63 (53.65)
Total (56)	138.74 (43.68)	69.44 (56.09)	3.02 (1.17)	259.94 (112.96)	971.70 (601.41)	2.72 (1.23)	60.36 (102.12)	514.52 (301.93)	457.18 (479.65)	60.08% (23.00)	55.88% (10.15)	69.30 (46.57)

[1]Number of observations in each class.

[2]Average value for each class.

[3]Standard deviation in each class.

[4]Number of tractors available for field work excluding purchased tractor.

[5]Horsepower of tractors available for field work excluding purchased tractor.

[6]Part time labor was counted as one half of full time labor, or as indicated more or less than one half by operators.

[7]Estimation by farm operators of the average number of days that they could do field work in a normal year during the spring and fall.

[8]Change in tillable acreage from the crop year before the purchase to the crop year of the purchase.

Almost all purchases increased the total amount of horsepower. Purchase of a tractor smaller than 100 horsepower on the average increased the total tractor power by 21.5 horsepower. By comparison, those purchasing a tractor over 190 horsepower increased the overall farm horsepower by 80.63. The second class has a very large increase in total horsepower which is caused by the fact that less than half of this group had a trade-in.

The difference in farm labor between groups is very small. With approximately the same amount of labor the purchaser of a tractor with 190 or more horsepower is farming over twice as much land as a farmer who buys a tractor with less than 100 horsepower. Besides having more land per worker, the buyers of the largest group of tractors also have the largest ratio of tractor to workers. This indicates again that even with large tractors, some small or medium tractors are still needed on the farm for light jobs. The farmer uses the large tractors for land preparation, planting and harvesting, but continues to have a small tractor for jobs like pulling wagons, running an elevator or other light jobs where a big tractor is not necessary.

One of the advantages of a large tractor is to be able to cover more land in less time. This is very important if poor weather delays a field operation. An indication of why some farmers buy large tractors is their estimation of favorable work days in the spring. Farmers that bought large tractors thought they had fewer days to do their spring work than those that purchased smaller tractors.

One of the factors which could influence the size of tractor to buy is the amount of horsepower that a farmer believes he needs to get his work done on time. The farmer's perception of favorable work days in the fall, in comparison to the spring, tends to have less influence on the size of tractor purchased. Several farmers mentioned that if they did not complete harvest before the first snow or freeze they would have some losses, but eventually they would be able to get the the crop out.

Analysis of Factors Affecting the Decision

A linear regression model was used to test the hypothesized factors which influence the decision making process. The model included several independent variables which should influence the size of tractor purchased. This linear regression model considers the farm's size, labor and machinery resources, disposable income and tax considerations.

The model is:

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6 + B_7X_7 + E \quad (1)$$

where

Y = drawbar horsepower of purchased tractor

X_1 = drawbar horsepower of traded tractor

X_2 = tillable acres after purchase crop year

X_3 = horsepower of tractors available for field work excluding the purchased tractor

X_4 = estimated returns above variable costs in dollars

X_5 = farm labor in yearly adult equivalents (1 adult equivalent = 3,000 hours of labor)

X_6 = farmer's estimation of favorable field work days in the spring

X_7 = investment tax credit dummy variable

0 = purchases in 1971, '72, '73 and '74
1 = purchases in 1975 or 1976

$B_0, B_1 \ldots B_7$ = regression coefficients of constant term and independent variables

E = error term

The estimated coefficients were:

$$(2)\quad \hat{Y} = 108.7 + .3497(X_1) + .0122(X_2) + .0673(X_3) + .0001(X_4)$$

$$(3.767)^{*} \quad (3.784)^{*} \quad (.691) \quad (1.028) \quad (1.006)$$

$$-8.9622(X_5) - .5380(X_6) + 20.0298(X_7)$$

$$(-1.608)^{*} \quad (-.687) \quad (1.263)$$

R^2 = .506 F statsitic (7, 48) = 7.014

*Regression coefficients which were significantly different from zero at the 90% confidence interval.

The F statistic is a test on the null hypothesis. The null hypothesis is that none of the regression coefficients are significantly different from zero. From a table of F distributions, the acceptance level at the 90% confidence level would be a calculated F value less than or equal to 1.86 (F(.90,7,48) = 1.86). The calculated F value from the results of the model was 7.014 so the null hypothesis was rejected. The F test shows that at least one of the variables has a coefficient significantly different than zero.

The student T test was used to evaluate the significance of each of the variables. With 55 degrees of freedom the student T value is 1.297 at the 90% confidence interval. Each coefficient that has a calculated t value greater than 1.297 has a coefficient which is significantly different from zero at the 90% confidence level.

The R^2 value from the results of the model shows the amount of variation in the dependent variable that is explained by the independent variables. The model has a R^2 value of 0.506 or 50.6 percent of the difference in size of tractor purchased is explained by the independent variables.

Because only two independent variables were significantly different from zero at the 90% confidence level and three correlation coefficients were greater than 0.6, the original model was reformulated. The following independent variables had higher than 0.6 correlation coefficients:

. returns above variable costs and tillable acres

. farm labor equivalents and tillable acres

. farm labor equivalents and returns above variable costs

The only regression coefficient which did not have the hypothesized sign was the horsepower of tractors available for field work excluding the purchased tractor. A negative sign was predicted because farms with a high work capacity (horsepower) would have less need for a large tractor than other farms with less work capacity. Even though the estimated coefficient was not significantly different from zero, the regression model was reformulated.

The reformulated model is:

(3) $Y = B_0 + B_1X_1 + B_4X_4 + B_5X_5 + B_7X_7 + B_8X_8 + B_9X_9 + E$

where:

Y = drawbar horsepower of purchased tractor

X_1 = drawbar horsepower of traded tractor

X_4 = estimated returns above variable costs in dollars

X_5 = farm labor in yearly adult equivalents (1 adult equivalent = 3,000 hours of labor)

X_7 = investment tax credit dummy variable

0 = purchases in 1971, '72, '73 and '74
1 = purchases in 1975 and '76

X_8 = tillable acres divided by the horsepower of tractors available for field work excluding the purchased tractor

X_9 = farmer's estimation of favorable field days in the spring divided by the number of tillable acres

$B_0, B_1 \ldots B_9$ = regression coefficients of constant term and independent variables

E = error term

The new variable, tillable acres per horsepower of tractors available for field work excluding the purchased tractor, should have a positive regression coefficient. A farmer who has more acres per horsepower would need to increase his tractor power by purchasing a large tractor. The opposite should be true of a farmer who has a small ratio of acres to tractor horsepower.

The regression coefficient on the number of favorable field days per tillable acre should have a negative sign. A farmer who estimates he has more time per acre would be less likely to purchase a large tractor than a farmer with less time per acre.

The estimated regression coefficients were:

$$(4)\quad \underset{(3.488)^*}{Y = 109.3} + \underset{(4.205)^*}{.360(X_1)} + \underset{(2.235)^*}{.0001(X_4)} - \underset{(-.949)}{4.375(X_5)} + \underset{(2.670)^*}{33.664(X_7)}$$

$$+ \underset{(.441)}{2.510(X_8)} - \underset{(-.879)}{.684(X_9)}$$

$R^2 = .485$ F statistic (6,49) = 7.694

*These coefficients were significantly different from zero at the 90% confidence level.

In the revised model, each of the estimated coefficients had the correct sign to agree with the regression hypothesis. According to the results, when a farmer buys a tractor it will have more horsepower than the trade-in. The amount of disposable income and government incentives also have a positive effect on the size of tractor purchased. When farm income is up, farmers tend to purchase larger tractors. The other variables had a hypothesized coefficient sign, but they were not significantly different from zero at the 90% confidence level.

The decision to accept or reject the results of the model was based on the calculated F statistic and the table value for rejecting or accepting the F test. The table value for F(.90,6,49) = 1.91. The calculated F value was 7.69 so one or more of the coefficients is significantly different than zero.

The R^2 value was 48.5 percent. This means that 48.5% of the variation in the dependent variable is explained by the independent variables.

Equation 4 was preferred to equation 3 even though the R^2 value is slightly less. The reasons for preferring the results of the reformulated model were that more independent variables were significant and all of the coefficient signs were the same as hypothesized.

Comparative Economics of Different Size Machinery Systems

Before the linear programming model could be run, several field work rates were calculated for each type of equipment. In each farm size group, the farms were grouped by total tractor horsepower. These three different groups of equipment were based on 25% of the farms with the largest total tractor horsepower, and the middle 50% of the farms with average total horsepower.

The four farms that were in the small equipment group of the 300 to 599 tillable acres group had an average of 165.8 total tractor horsepower, 2.25 tractors and 1.55 adult equivalents. The average size of tractor purchased was 92.4 horsepower. A representative farm which represents each size group was developed by the researcher and is tabulated in Table 3-4.

Table 3-4. Machinery and Labor Systems on Representative Farms for the Small Group of Farms.

	Machinery and Labor System		
	Small	Medium	Large
Tractor	94 HP 71 HP	108 HP 74 HP 55 HP 32 HP	135 HP 86 HP 74 HP 42 HP 27 HP
Tillage	5-16" plow 18' f. cult	5-16" plow 18' f. cult	7-16" plow 4-16" plow 20' f. cult
Plant	8 r. planter 14' drill	8 r. planter 14' drill	8 r. planter 14' drill
Harvest	3 r. beet combine	3 r. beet combine	4 r. beet combine
Labor	1.55 adult eq.	1.75 adult eq.	2.38 adult eq.

Because the interest is in the effect of different sizes of tractors, all equipment combinations have the same combine. The size of a combine is not determined by tractor size.

After selecting the above equipment, their work capacity was calculated based on a study by White.[1]

Table 3-5. Work capacity on Representative Farm for the Small Group of Farms by Equipment Size.

	Equipment System		
Operation	Small	Medium	Large
Plowing	2.72 acres/hr.	2.90 acres/hr.	2.99 acres/hr.
Plant corn	3.10 " "	3.10 " "	3.29 " "
Plant navy beans	3.20 " "	3.20 " "	3.43 " "
Plant sugar beets	2.90 " "	2.90 " "	3.14 " "
Drill wheat	2.96 " "	2.96 " "	3.14 " "
Drill oats or barley	2.78 " "	2.78 " "	2.94 " "
Harvest sugar beets	4.50 " "	4.50 " "	6.00 " "
Harvest corn	3.70 " "	3.70 " "	3.70 " "
Harvest navy beans	5.00 " "	5.00 " "	5 00 " "

Using TELPLAN program 18, the above equipment was used on an identical representative farm which is the average of all farms in the smallest class of tillable acres. This hypothetical farm, for all sizes of machinery systems, produced:

Corn	133 acres
Navy beans	144 "
Sugar beets	42 "
Wheat	53 "
Barley	8 "
Oats	6 "

The above method of selecting low, medium and high sets of equipment and labor was used for each of the land size classes in Table 8 (appendix B). The work coefficients were also calculated the same way. A list of the labor, equipment and rate of work of each set of equipment is in appendixes C and D.

From the linear programming model, the following data were calculated on three different sizes of equipment in each of four different sizes of the representative farms. A more complete listing of the results is in the appendix E.

Table 3-6. Returns Over Variable Costs on Four Representative Farms with Different Sizes of Equipment.*

Representative Farm Size (Tillable Acreage)	Equipment Size		
	Small	Medium	Large
386 acres	$37,736	$37,873	$38,981
699 acres	59,115	60,122	60,467
982 acres	78,712	88,321	91,364
1860 acres	84,229	88,691	90,974

*Variable costs include a land charge for property tax and land rent. Property tax was estimated to be $24.80 per acre. (31 mil at $800 per acre). The median cash rental rate of $50.00 per acre was used.

Before an analysis could be performed on the comparative advantage or disadvantage of the different equipment sizes, the data was adjusted for fixed costs and labor costs. Fixed cost on equipment consisted of depreciation, interest and insurance. Depreciation was estimated by using the straight line method with a varying years of life depending on the type of equipment and a 10% salvage value. The average retail price for each piece of equipment was taken from the Official Guide Tractors and Farm Equipment.[2] Where data were not available, local dealers gave an estimated average retail price. Both interest and insurance were based on the average value. They were calculated as a percentage of the average value. Interest was 7% and insurance was 1%. An interest rate of 7% was used because at the time of the survey, Spring, 1977, this was the approximate rate of opportunity cost.

Table 3-7. Total Annual Fixed Costs for Different Equipment Sizes on the Representative Farms.

Representative Farm Size (Tillable Acreage)	Equipment Size Small	Medium	Large
386 acres	$10,469	$11,771	$15,996
699 acres	14,122	14,432	10,758
982 acres	18,326	23,628	25,672
1860 acres	25,005	29,525	31,662

The labor costs were estimated by taking the field time for each operation times the number of men needed times the wage rate of $3.50. The median wage rate from the results of the applied questionnaire was $3.50.

Table 3-8. Total Annual Labor Costs for Different Equipment Sizes on the Representative Farms.

Representative Farm Size (Tillable Acreage)	Equipment Size Small	Medium	Large
386 acres	$ 1,989	$ 1,933	$ 1,872
699 acres	3,399	3,316	3,161
982 acres	3,950	3,721	3,476
1860 acres	7,249	7,084	6,895

After adjusting for fixed costs and labor costs, the total farm net returns were divided by the number of acres. The net return per acre was used to compare the economic advantage or disadvantage of different equipment sizes. Within each size group, the difference observed in net return per acre reflects the timeliness in the cropping system. Timeliness was determined based on the available work force and equipment work capacity.

Some caution should be used when net return per acre is compared between size groups. The crop mix is slightly different for each size of farm and could account for differences. The mix of rented and owned land would result in different variable costs per acre.

Table 3-9. Net Return Per Acre Over Fixed and Variable Costs for the different Equipment Sizes on the Representative Farms.

Representative Farm Size (Tillable Acreage)	Equipment Size		
	Small	Medium	Large
386 acres	$65.49	$62.61	$55.73
699 acres	59.51	60.62	53.42
982 acres	57.47	62.09	63.39
1860 acres	27.94	26.93	28.18

Table 3-6 shows that as equipment size increases, the returns above variable costs also increases. This was true for every farm size. Additional equipment made the farm operation more likely to complete its work on time.

Net return per acre in Table 3-9 varies for the different farm sizes. In the first size farm, the smallest equipment was the most profitable. The medium equipment was the most profitable in the second farm size and the large equipment showed more profit on the last two farms.

From Table 3-9, the results indicate that many farms are under equipped or over equipped. Where the operation is in a state of change, this could be a short run problem. However, if this is not corrected in the long run, the operation will be at a financial disadvantage.

The net return per acre between different sizes of the representative farms shows the different economies of size. As the number of tillable acres increases, the net return per acre decreases. At the same time, total farm returns above variable costs increase.

ENDNOTES

[1] Robert G. White, Effect of Speed on Power Requirements for Selected Farming Operations, Agricultural Engineering Facts, Michigan State University, No. 41, file 18.4, 1975.

[2] National Farm and Power Equipment Dealers Association, Official Guide Tractors and Farm Equipment, Lansing, Michigan, 1971, '72, '73, '74, '75, '76.

CHAPTER IV

CONCLUSIONS

The trend in tractor purchases has been to larger tractors. Between 1973 and 1976, tractors of 170 drawbar horsepower or more had increased sales of 277.3% in Michigan. During the same period, the sales of tractors with less than 100 horsepower decreased to 72.8% of their 1973 sales.

In the analysis of factors affecting tractor purchases, a linear regression model showed that tractor purchases were affected by net farm income, government tax incentives and the size of the tractor traded. The other variables in the model (tillable acres per tractor horsepower, farm labor and farmers' estimation of favorable field work days in the spring divided by the number of tillable acres) had correct coefficient signs but were not significantly different from zero at the 90% confidence level. The model indicates that the observed trend to larger tractors was because there were favorable returns to investments in agriculture and government incentives for machinery investment.

The farmers' decisions were influenced by the size of tractor to be traded in. The regression model coefficient was positive, showing a trend to trade for larger tractors. The average tractor purchased is twice the size of the trade-in. Reasons for trading to larger tractors are timeliness factors during the planting or harvesting season or adoption of a cropping system which requires more horsepower.

In 1975, the investment tax credit was changed from 7% to 10%. Investment tax credit is a government incentive for investment. The

The credit is a percentage of the investment cost which can be used to offset federal income tax due. The regression coefficient showed that there is a positive correlation between larger tractor purchases and the investment tax credit change. When the investment tax credit rate changed from 7% to 10%, there was an increase in the size of tractor purchased.

Another important variable in the decision process is net farm income. When net farm income increased, there was also an increase in the size of tractor purchased. A high net income facilitates financing and also induces a purchase to decrease tax liabilities.

The size of the tractor that a farmer purchases was determined by the tractor to be traded in, government tax incentives and net farm income. As long as tax incentives continue, and net farm income is high, the trend to large tractors should continue as long as they can be used on sufficient acreage to make them economical. Depending on the severity of the change, a reduction in net farm income or government incentives would slow down or reverse the trend.

In the trend to larger tractors it is desirable to maintain a proper mix between machinery, labor and other resources. Farms that have too much or not enough machinery resources in relation to other resources will be at a competitive disadvantage.

The estimated net returns per acre were calculated from the results of the linear programming model for the different equipment sizes. Within each size of farm there is a difference between returns per acre with the type of equipment used. The smallest farm size had net return per acre which varied as much as $10 depending on the size of the equipment system. Each of the four farm sizes had a difference in net returns per acre with different sizes of machinery.

While net return per acre decreased with farm size, total farm returns increased. The largest representative farm had an estimated average return above variable costs of $87,298. The smallest representative farm had an estimated average return of $26,863.

Even though net return per acre varied within each farm size, there was not a trend to suggest that one equipment size was at an advantage or disadvantage among all farm sizes. The smallest farm had the highest return with the smallest equipment. The two largest farms had the highest net returns with the largest machinery system. Only the second farm size had a higher net return with the medium type of equipment.

The trend to larger equipment has not put farmers at an economic disadvantage. If large equipment put farms at an economic disadvantage, net profit per acre would have shown large equipment to be the least profitable in all farm sizes.

From the results of the questionnarie data, it can be concluded that there are several farms which are not on the expansion path. The data used in this study shows the smaller farms usually have too much equipment and large farms are underequipped. To maintain the proper mix of machinery, labor and other inputs, farmers should be on the expansion path. If the situation persists where farmers do not have the proper resource mix, they will have a financial handicap.

APPENDICES

APPENDIX A

Field Questionnaire

Name:____________________________ Phone:________________

Address:____

Tractor Purchases and On Hand:

	Date of Purchase	Model	Tractor hrs./yr.	Principal Use	Model Traded
(Purchased) (Owned)					
(Purchased) (Owned)					

What options were on the tractor purchased and what extra equipment was needed?

1.

2.

Is your equipment used on a partnership basis?

Why did you select the model purchased? (Rank by importance)

[ ] Replace worn out model
[ ] Needed more power, why
[ ] Only model available then
[ ] Goes with other equipment
[ ] Special features
[ ] Other reasons (see comments)

What influenced the timing of your purchase? (Rank by importance)

[ ] Reduce taxes
[ ] When dealer received it
[ ] Problem with other tractors
[ ] Easier to get financing at this time
[ ] Cash flow
[ ] Other reasons (see comments)

Are rented, leased or custom hire tractors available?
Cost? Terms?

Have you ever rented, leased or used custom hire tractors? When?

Do you have a brand preference in your tractor purchases? Why?

[ ] Dealer service
[ ] Have always been satisfied with brand
[ ] Convenient location
[ ] Other reasons (see comments)

Acreage in Tillable Crops:

Crop	Year Before Purchase	Owned	Rented	Year of Purchase	Owned	Rented
1.						
2.						
3.						
4.						
5.						
1.						
2.						
3.						
4.						
5.						

If you are using rented land, what are the terms?

When are your most critical time requirements?

Last year, when did you start and finish planting corn? Harvesting corn?

Given favorable weather, how many working days are needed to:

	Prepare land	Plant	Harvest
1.			
2.			
3.			
4.			
5.			
1.			
2.			
3.			
4.			

In an average year, how many favorable work days do you have to:

	Prepare and Plant	Harvest
1.		
2.		
3.		
4.		
5.		

Farm Labor:

Time available for field work; family and hired; (including owned) before and after purchase:

1.

2.

During your critical time commitments, is it possible for you to hire extra help? How many hours per day? Cost?

Age of operators

Number of years in farming

APPENDIX B

Cropping Program of Representative Farms

APPENDIX B

Table B-1. Cropping Program of Representative Farms

	Farm Size			
	Small	Medium	Large	Extra Large
Corn	133 acr.	252 acr.	401 acr.	951 acr.
Navy beans	144 acr.	206 acr.	269 acr.	495 acr.
Sugar beets	42 acr.	109 acr.	168 acr.	101 acr.
Wheat	53 acr.	96 acr.	117 acr.	193 acr.
Barley	8 acr.	14 acr.	8 acr.	105 acr.
Oats	6 acr.	22 acr.	19 acr.	15 acr.

APPENDIX C

Machinery and Labor Systems for Representative Farms

Table C-1. Machinery and Labor Systems on 386 Tillable Acre Representative Farm Size

	Machinery System		
	Small	Medium	Large
Tractor	94 HP	108 HP	135 HP
	71 HP	74 HP	86 HP
		55 HP	74 HP
		32 HP	42 HP
			27 HP
Tillage	5-16" plow	5-16" plow	7-16" plow
	18' f. cult.	18' f. cult.	4-16" plow
			20' f. cult.
Plant	8 r. planter	8 r. planter	8 r. planter
	14' drill	14' drill	14' drill
Harvest	3 r. beet combine	3 r. beet combine	4 r. beet combine
Labor	1.55 adult eq.	1.75 adult eq.	2.38 adult eq.

Table C-2. Machinery and Labor Systems on 699 Tillable Acre Representative Farm Size

	Machinery System		
	Small	Medium	Large
Tractor	126 HP	126 HP	135 HP
	108 HP	104 HP	113 HP
	32 HP	84 HP	108 HP
		55 HP	85 HP
			45 HP
Tillage	6-16" plow	6-16" plow	7-16" plow
	5-16" plow	5-16" plow	6-16" plow
	20' f. cult.	20' f. cult.	5-16" plow
			24' f. cult.
Plant	12 r. planter	12 r. planter	12 r. planter
	14' drill	14' drill	14' drill
Harvest	4 r. beet	4 r. beet	4 r. beet
	combine	combine	combine
Labor	3.0 adult eq.	2.5 adult eq.	3.75 adult eq.

Table C-3. Machinery and Labor Systems on 982 Tillable Acre Representative Farm Size

	Machinery System		
	Small	Medium	Large
Tractor	155 HP	181 HP	194 HP
	113 HP	132 HP	135 HP
	86 HP	68 HP	108 HP
		33 HP	74 HP
			55 HP
Tillage	8-16" plow	9-16" plow	10-16"plow
	6-16" plow	7-16" plow	7-16" plow
	36' f. cult.	38' f. cult.	38' f. cult.
Plant	12 r. planter	12 r. planter	12 r. planter
	14' drill	14' drill	14' drill
Harvest	4 r. beet combine	6 r. beet combine	6 r. beet combine
Labor	2.33 adult eq.	2.86 adult eq.	2.66 adult eq.

Table C-4. Machinery and Labor Systems on 1860 Tillable Acre Representative Farm Size

	Machinery System		
	Small	Medium	Large
Tractor	181 HP	202 HP	227 HP
	135 HP	160 HP	194 HP
	108 HP	108 HP	135 HP
	42 HP	94 HP	64 HP
		33 HP	47 HP
Tillage	9-16" plow	10-16" plow	12-16" plow
	7-16" plow	8-16" plow	10-16" plow
	38' f. cult.	38' f. cult.	7-16" plow
			40' f. cult.
Plant	12 r. planter	12 r. planter	12 r. planter
	14' drill	14' drill	14' drill
Harvest	6 r. beet combine	6 r. beet combine	6 r. beet combine
Labor	3.17 adult eq.	3.3 adult eq.	3.17 adult eq.

APPENDIX D

Field Work Speed on Representative Farms by Different Equipment Systems

Table D-1. Field Work Speed on 386 Tillable Acre Representative Farm with Different Equipment Systems

Operation	Equipment System: Small	Medium	Large
Plowing	2.72 acr./hr.	2.90 acr./hr.	2.99 acr./hr.
Plant corn	3.10 acr./hr.	3.10 acr./hr.	3.29 acr./hr.
Plant navy beans	3.20 acr./hr.	3.20 acr./hr.	3.43 acr./hr.
Plant sugar beets	2.90 acr./hr.	2.90 acr./hr.	3.14 acr./hr.
Drill wheat	2.96 acr./hr.	2.96 acr./hr.	3.14 acr./hr.
Drill oats or barley	2.78 acr./hr.	2.78 acr./hr.	2.94 acr./hr.
Harvest sugar beets	4.50 acr./hr.	4.50 acr./hr.	6.00 acr./hr.
Harvest corn	3.70 acr./hr.	3.70 acr./hr.	3.70 acr./hr.
Harvest navy beans	5.00 acr./hr.	5.00 acr./hr.	5.00 acr./hr.

Table D-2. Field Work Speed on 699 Tillable Acre Representative Farm with Different Equipment Systems

Operation	Equipment System: Small	Medium	Large
Plowing	2.99 acr./hr.	2.99 acr./hr.	3.29 acr./hr.
Plant corn	3.29 acr./hr.	3.29 acr./hr.	3.69 acr./hr.
Plant navy beans	3.43 acr./hr.	3.43 acr./hr.	3.86 acr./hr.
Plant sugar beets	3.13 acr./hr.	3.13 acr./hr.	3.50 acr./hr.
Drill wheat	3.14 acr./hr.	3.14 acr./hr.	3.46 acr./hr.
Drill oats or barley	2.94 acr./hr.	2.94 acr./hr.	3.26 acr./hr.
Harvest sugar beets	6.00 acr./hr.	6.00 acr./hr.	6.00 acr./hr.
Harvest corn	3.70 acr./hr.	3.70 acr./hr.	3.70 acr./hr.
Harvest navy beans	5.00 acr./hr.	5.00 acr./hr.	5.00 acr./hr.

Table D-3. Field Work Speed on 982 Tillable Acre Representative Farm with Different Equipment Systems

Operation	Equipment System		
	Small	Medium	Large
Plowing	3.81 acr./hr.	4.35 acr./hr.	4.62 acr./hr.
Plant corn	4.60 acr./hr.	4.75 acr./hr.	4.75 acr./hr.
Plant navy beans	4.90 acr./hr.	5.03 acr./hr.	5.03 acr./hr.
Plant sugar beets	4.30 acr./hr.	4.43 acr./hr.	4.43 acr./hr.
Drill wheat	4.17 acr./hr.	4.25 acr./hr.	4.25 acr./hr.
Drill oats or barley	3.96 acr./hr.	4.10 acr./hr.	4.10 acr./hr.
Harvest sugar beets	6.00 acr./hr.	9.00 acr./hr.	9.00 acr./hr.
Harvest corn	3.70 acr./hr.	3.70 acr./hr.	3.70 acr./hr.
Harvest navy beans	5.00 acr./hr.	5.00 acr./hr.	5.00 acr./hr.

Table D-4. Field Work Speed on 1860 Tillable Acre Representative Farm with Different Equipment Systems

Operation	Equipment System		
	Small	Medium	Large
Plowing	4.35 acr./hr.	4.90 acr./hr.	5.25 acr./hr.
Plant corn	4.75 acr./hr.	4.75 acr./hr.	4.87 acr./hr.
Plant navy beans	5.03 acr./hr.	5.03 acr./hr.	5.17 acr./hr.
Plant sugar beets	4.43 acr./hr.	4.43 acr./hr.	4.54 acr./hr.
Drill wheat	4.25 acr./hr.	4.25 acr./hr.	4.34 acr./hr.
Drill oats or barley	4.10 acr./hr.	4.10 acr./hr.	4.15 acr./hr.
Harvest sugar beets	9.00 acr./hr.	9.00 acr./hr.	9.00 acr./hr.
Harvest corn	3.70 acr./hr.	3.70 acr./hr.	3.70 acr./hr.
Harvest navy beans	5.00 acr./hr.	5.00 acr./hr.	5.00 acr./hr.

APPENDIX E

Results of Linear Programming Analysis of Representative Farms

Table E-1. Results of the Linear Programming Analysis on 386 Tillable Acre Representative Farm with Different Equipment Sizes

	Equipment Size		
Item	Small	Medium	Large
Return above variable cost	$37,736	$37,873	$38,981
Corn yield	98 bu/acre	98 bu/acre	98 bu/acre
Navy bean yield	17.3 cwt/acre	17.3 cwt/acre	17.5 cwt/acre
Scarce resources:			
Planting time June 4-June 11	$104.54/hr.	$107.81/hr.	$111.08/hr.

Table E-2. Results of the Linear Programming Analysis on 699 Tillable Acre Representative Farm with Different Equipment Sizes

	Equipment Size		
Item	Small	Medium	Large
Return above variable cost	$59,115	$60,122	$60,468
Corn yield	91.8 bu/acre	92.4 bu/acre	96.8 bu/acre
Navy bean yield	17.2 cwt/acre	17.3 cwt/acre	17.4 cwt/acre
Scarce resources:			

Table E-3. Results of the Linear Programming Analysis on 982 Tillable Acre Representative Farm with Different Equipment Sizes

Item	Equipment Size: Small	Medium	Large
Return above variable cost	$78,712	$88,321	$91,384
Corn yield	92.8 bu/acre	97 bu/acre	98.3 bu/acre
Navy bean yield	17 cwt/acre	17.8 cwt/acre	18.3 cwt/acre
Scarce resources:			
Planting time			
April 25-May 10	$67.90/hr.	$69.98/hr.	
June 4-June 11	$160.08/hr.	$179.85/hr.	$230.21/hr.

Table E-4. Results of the Linear Programming Analysis on 1860 Tillable Acre Representative Farm with Different Equipment Sizes

Item	Equipment Size: Small	Medium	Large
Return above variable cost	$84,229	$86,691	$90,974
Corn yield	87.8 bu/acre	88.3 bu/acre	90.2 bu/acre
Navy bean yield	17.1 cwt/acre	17.1 cwt/acre	17.2 cwt/acre
Scarce resources:			
Land preparation			
Sept. 27-Oct. 17	$44.00/hr.		
Oct. 18-Nov. 7	$44.00/hr.		
Nov. 8-Nov. 28	$44.00/hr.		
Apr. 1-Apr. 24	$44.00/hr.		
Apr. 25-May 10	$255.06/hr.	$211.06/hr.	
May 11-May 18	$184.21/hr.	$140.21/hr.	
May 19-May 26	$114.51/hr.	70.51/hr.	
May 27-June 3	$44.00/hr.		
June 4-June 11	$44.00/hr.		
Planting time			
Apr. 25-May 10	$255.06/hr.	$211.06/hr.	$143.47/hr.
May 11-May 18	$184.21/hr.	$140.21/hr.	$71.15/hr.
May 19-May 26	$114.51/hr.	$70.51/hr.	
May 27-June 3	$44.00/hr.		
June 4-June 11	$181.50/hr.	$181.50/hr.	$187.04/hr.

APPENDIX F

Input Form for TELPLAN Program Number 18 (Crop Farm Planning Guide a TELPLAN Program)

Program:	18
Form:	3
System:	TOUCH-TONE PHONE
Data File No:	

CROP FARM PLANNING GUIDE
A TELPLAN PROGRAM*

NAME ______________________ **ADDRESS** ______________________

PHONE ______________________ **DATE RUN** ______________________

BUDGET ANALYSIS ____

Problem: To determine the most profitable mix, corn, soybean, and other crop acreages given expected prices, yields, production costs, machinery performance, field time, and land available. Too, the program can be used to explore the machinery requirements for alternative land and labor bases.

INPUT:

	LINE NO.	FIRST ANALYSIS	ADJUSTED ANALYSIS
SECTION I. CROP BUDGETS AND TILLABLE ACREAGE AVAILABLE:			
1 Tillable Acres a. Owned b. Rented	01.	|__a__|__b__|	|__a__|__b__|
2 Corn Budget (Owned Land) a. Expected corn yield (bu. @ 15.5% moisture) when planted during the period April 26-May 10 and harvested during the period October 4-10. b. Expected variable cost ($/acre) excluding drying costs. c. Expected drying costs (¢/bu.) for drying corn down one point.	02.	|_a_|__b_._|_c_|	|_a_|__b_._|_c_|
3 Corn Budget (Rented Land) a. Expected yield. If share-rented, enter your share. b. Expected variable costs. If share-rented, enter your share.	03.	|_a_|__b_._|	|_a_|__b_._|
4 Soybean Budget (Owned Land) a. Expected yield when planted during the period May 19-26 and harvested during the period September 27-October 3. b. Expected variable cost.	04.	|_a_._|__b_._|	|_a_._|__b_._|
5 Soybean Budget (Rented Land) a. Expected yield. If share-rented, enter your share. b. Expected variable costs. If share-rented, enter your share.	05.	|_a_._|__b_._|	|_a_._|__b_._|
SECTION II. LAND PREPARATION, PLANTING, AND POST PLANTING OPERATIONS:			
6 Land Preparation a. Fall land (acres prepared/hour) b. Spring land (acres prepared/hour) c. If yield on spring prepared ground is different than the yield on fall prepared ground, enter the estimated percentage of fall yield.	06.	|_a_._|_b_._|_c_|	|_a_._|_b_._|_c_|

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*Basic program developed as a cooperative effort by J. Roy Black and Stephen B. Harsh, Michigan State University; Duane Erickson and Royce Hinton, University of Illinois; and Allan Lines and Paul Wright, Ohio State University.

	LINE NO.	FIRST ANALYSIS	ADJUSTED ANALYSIS
7 Corn a. Acres planted/hour b. Acres harvested/hour	07.	|—a.—|—b.—|	|—a.—|—b.—|
8 Soybean a. Acres planted/hour b. Acres harvested/hour c. Estimate what percentage a typical harvesting day for corn can be used in harvesting soybeans	08.	|—a.—|—b.—|—c—|	|—a.—|—b.—|—c—

SECTION III. TIME AVAILABLE FOR FIELD OPERATIONS:
(If you want to enter individualized time availability, enter "0" in line 09 and complete lines 10 through 16. Otherwise, complete line 09 and proceed to line 17.)

	LINE NO.	FIRST ANALYSIS	ADJUSTED ANALYSIS
9 Machine-Man Equivalent Availability a. Fall land preparation b. Spring land preparation c. Planting d. Harvesting	09.	|—.a—|—.b—|—.c—|—.d—|	|—.a—|—.b—|—.c—|—.d
10 Fall Land Preparation (Hours/Period) a. Sept. 27-Oct. 17 (21 days) Days_____ x hrs/day_____ %_____ b. Oct. 18-Nov. 7 (21 days) Days_____ x hrs/day_____ %_____ c. Nov. 8-Dec. 12 (35 days) Days_____ x hrs/day_____ %_____	10.	|—a—|—b—|—c—|	|—a—|—b—|—c—|
11 Spring Land Preparation (Hours/Period) a. April 1-April 24 (24 days) Days_____ x hrs/day_____ %_____ b. April 25-May 10 (16 days) Days_____ x hrs/day_____ %_____ c. May 11-May 18 (8 days) Days_____ x hrs/day_____ %_____	11.	|—a—|—b—|—c—|	|—a—|—b—|—c—|
12 (Spring Land Preparation Continued) a. May 19-May 26 (8 days) Days_____ x hrs/day_____ %_____ b. May 27-June 3 (8 days) Days_____ x hrs/day_____ %_____ c. June 4-June 11 (8 days) Days_____ x hrs/day_____ %_____	12.	|—a—|—b—|—c—|	|—a—|—b—|—c—|
13 Planting (Hours/Period) a. April 25-May 10 (16 days) Days_____ x hrs/day_____ %_____ b. May 11-May 18 (8 days) Days_____ x hrs/day_____ %_____ c. May 19-May 26 (8 days) Days_____ x hrs/day_____ %_____	13.	|—a—|—b—|—c—|	|—a—|—b—|—c—|
14 (Planting Continued) a. May 27-June 3 (8 days) Days_____ x hrs/day_____ %_____ b. June 4-June 11 (8 days) Days_____ x hrs/day_____ %_____ c. June 12-June 19 (8 days) Days_____ x hrs/day_____ %_____	14.	|—a—|—b—|—c—|	|—a—|—b—|—c—|
15 Harvest (Hours/Period) a. Sept. 27-Oct. 3 (7 days) Days_____ x hrs/day_____ %_____ b. Oct. 4-Oct. 10 (7 days) Days_____ x hrs/day_____ %_____ c. Oct. 11-Oct. 17 (7 days) Days_____ x hrs/day_____ %_____	15.	|—a—|—b—|—c—|	|—a—|—b—|—c—|

	LINE NO.	FIRST ANALYSIS	ADJUSTED ANALYSIS
16 (Harvest Continued) a. Oct. 18-Nov. 7 (21 days) Days_____x hrs/day_____x %_____ b. Nov. 8-Nov. 28 (21 days) Days_____x hrs/day_____x %_____	16.	|—a—|—b—|	|—a—|—b—|

SECTION IV. TRADE-OFFS BETWEEN FIELD OPERATIONS:

17 Trade-offs between spring land preparation planting and the planting operation would occur in (0 = no; 1 = yes) a. Apr. 25-May 10 b. May 11-May 18 c. May 19-May 26 d. May 27-June 3 e. June 4-June 11	17.	|a|b|c|d|e|	|a|b|c|d|e|
18 Trade-offs between harvest and fall land preparation would occur in (0 = no; 1 = yes): a. Sept. 27-Oct. 3 b. Oct. 4-Oct. 10 c. Oct. 11-Oct. 17 d. Oct. 18-Nov. 7 e. Nov. 8-Nov. 28	18.	|a|b|c|d|e|	|a|b|c|d|e|

SECTION V. CUSTOM HIRE FIELD WORK:

19 Enter "1" if you are interested in custom hiring to replace or supplement self-performed field operations; otherwise, enter "0" a. Fall preparation b. Spring preparation c. Soybean harvest d. Corn harvest	19.	|a|b|c|d|	|a|b|c|d|
20 Fall Preparation a. Maximum number of acres b. Net rate (custom rate $_____/A - variable cost of own fall preparation $_____/A)	20.	|——a——|——b.——|	|——a——|——b.——|
21 Spring Preparation (maximum acres available/period) a. Apr. 1-May 10 b. May 11-May 18	21.	|——a——|——b——|	|——a——|——b——|
22 Spring Preparation a. May 19-May 26 b. Net rate (custom rate $_____/A - variable cost of own fall preparation $_____/A)	22.	|——a——|——b.——|	|——a——|——b.——|
23 Soybean Harvest (maximum acres available/period) a. Sept. 27-Oct. 3 (7 days) b. Oct. 4-Oct. 10 (7 days) c. Oct. 11-Oct. 17 (7 days)	23.	|—a—|—b—|—c—|	|—a—|—b—|—c—|
24 (Soybean Harvest Continued) a. Oct. 18-Nov. 7 (21 days) b. Net rate (custom rate $_____/A - $_____/A + (-) loss (gain) associated with custom harvest)	24.	|—a—|——b.—|	|—a—|——b.—|

	LINE NO.	FIRST ANALYSIS	ADJUSTED ANALYSIS

25 Corn Harvest (maximum acres available/period)
- a. Sept. 27-Oct. 3 (7 days)
- b. Oct. 4-Oct. 10 (7 days)
- c. Oct. 11-Oct. 17 (7 days)

25. |__a__|__b__|__c__| |__a__|__b__|__c__|

26 (Corn Harvest Continued)
- a. Oct. 18-Nov. 7 (21 days)
- b. Nov. 8-Nov. 28 (21 days)
- c. Net rate (custom rate $_____/A - variable cost of own harvest $_____/A + (-) loss (gain) associated with custom harvest)

26. |__a__|__b__|__c__| |__a__|__b__|__c__|

SECTION VI. ALTERNATIVE CROP INFORMATION:

27 ALTERNATIVE CROP 1 (if no more, enter "0" and proceed to line 57)
- a. Net return per acre (_____ yield/A x price______ = ________ - variable cost $_____/A)
- b. Land type (0 = no land used; 1 = owned; 2 = rented; 3 = either)
- c. Acreage restriction**
- d. Number of acres related to restriction

27. |__a__|_b_|_c_|__d__| |__a__|_b_|_c_|__d__|

Competition by time periods (when no more competition, enter "0" and proceed to next crop)

28
- a. Period of competition code***
- b. Hours per period per acre
- c. Period of competition code***
- d. Hours per period per acre

28. |_a_|__b__|__c__|__d__| |_a_|__b__|__c__|__d__|

29
- a. Period of competition code***
- b. Hours per period per acre
- c. Period of competition code***
- d. Hours per period per acre

29. |_a_|__b__|__c__|__d__| |_a_|__b__|__c__|__d__|

30
- a. Period of competition code***
- b. Hours per period per acre
- c. Period of competition code***
- d. Hours per period per acre

30. |_a_|__b__|__c__|__d__| |_a_|__b__|__c__|__d__|

31
- a. Period of competition code***
- b. Hours per period per acre
- c. Period of competition code***
- d. Hours per period per acre

31. |_a_|__b__|__c__|__d__| |_a_|__b__|__c__|__d__|

** 0 = none; 1 = maximum acres; 2 = actual acres; 3 = minimum acres

*** 1 = land preparation (April 1-April 24); 2 = land preparation/planting (April 25-May 10); 3 = land preparation/planting (May 11-May 18); 4 = land preparation/planting (May 19-May 26); 5 = land preparation/planting (May 27-June 3); 6 = land preparation/planting (June 4-June 11); 7 = planting (June 12-June 19); 8 = harvest/land preparation (September 27-October 3); 9 = harvest/land preparation (October 4-October 10); 10 = harvest/land preparation (October 11-October 17); 11 = harvest/land preparation (October 18-November 7); 12 = harvest/land preparation (November 8-November 28).

	LINE NO.	FIRST ANALYSIS	ADJUSTED ANALYSIS
32 ALTERNATIVE CROP 2 (if no more, enter "0" and proceed to line 57) a. Net return per acre (_____ yield/A x price______ = _________ - variable cost $_____/A) b. Land type (0 = no land used; 1 = owned; 2 = rented; 3 = either) c. Acreage restriction** d. Number of acres related to restriction	32.	|___ . _|_|_|___| a b c d	|___ . _|_|_|___ a b c d

Competition by time periods (when no more competition, enter "0" and proceed to next crop)

	LINE NO.	FIRST ANALYSIS	ADJUSTED ANALYSIS
33 a. Period of competition code*** b. Hours per period per acre c. Period of competition code*** d. Hours per period per acre	33.	|_|_ . __|__|_ . __| a b c d	|_|_ . __|__|_ . _ a b c d
34 a. Period of competition code*** b. Hours per period per acre c. Period of competition code*** d. Hours per period per acre	34.	|_|_ . __|__|_ . __| a b c d	|_|_ . __|__|_ . _ a b c d
35 a. Period of competition code*** b. Hours per period per acre c. Period of competition code*** d. Hours per period per acre	35.	|_|_ . __|__|_ . __|	|_|_ . __|__|_ . _
36 a. Period of competition code*** b. Hours per period per acre c. Period of competition code*** d. Hours per period per acre	36.	|_|_ . __|__|_ . __| a b c d	|_|_ . __|__|_ . _ a b c d
37 ALTERNATIVE CROP 3 (if no more, enter "0" and proceed to line 57) a. Net return per acre (_____ yield/A x price______ = _________ - variable cost $_____/A) b. Land type (0 = no land used; 1 = owned; 2 = rented; 3 = either) c. Acreage restriction** d. Number of acres related to restriction	37.	|___ . _|_|_|___| a b c d	|___ . _|_|_|___ a b c d

Competition by time periods (when no more competition, enter "0" and proceed to next crop)

	LINE NO.	FIRST ANALYSIS	ADJUSTED ANALYSIS
38 a. Period of competition code*** b. Hours per period per acre c. Period of competition code*** d. Hours per period per acre	38.	|_|_ . __|__|_ . __| a b c d	|_|_ . __|__|_ . _ a b c d
39 a. Period of competition code*** b. Hours per period per acre c. Period of competition code*** d. Hours per period per acre	39.	|_|_ . __|__|_ . __| a b c d	|_|_ . __|__|_ . _ a b c d
40 a. Period of competition code*** b. Hours per period per acre c. Period of competition code*** d. Hours per period per acre	40.	|_|_ . __|__|_ . __| a b c d	|_|_ . __|__|_ . _ a b c d
41 a. Period of competition code*** b. Hours per period per acre c. Period of competition code*** d. Hours per period per acre	41.	|_|_ . __|__|_ . __| a b c d	|_|_ . __|__|_ . _ a b c d

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** See explanation of footnote on Page 4.

*** See explanation of footnote on Page 4.

		LINE NO.	FIRST ANALYSIS	ADJUSTED ANALYSIS
42	ALTERNATIVE CROP 4 (if no more, enter "0" and proceed to line 57) a. Net return per acre (_____ yield/A x price______ = _________ - variable cost $_____/A) b. Land type (0 = no land used; 1 = owned; 2 = rented; 3 = either) c. Acreage restriction** d. Number of acres related to restriction	42.	|___ . _|_|_|_| a b c d	|___ . _|_|_|_| a b c d

Competition by time periods (when no more competition, enter "0" and proceed to next crop)

		LINE NO.	FIRST ANALYSIS	ADJUSTED ANALYSIS
43	a. Period of competition code*** b. Hours per period per acre c. Period of competition code*** d. Hours per period per acre	43.	|_|_ . _|_|_ . _| a b c d	|_|_ . _|_|_ . _| a b c d
44	a. Period of competition code*** b. Hours per period per acre c. Period of competition code*** d. Hours per period per acre	44.	|_|_ . _|_|_ . _| a b c d	|_|_ . _|_|_ . _| a b c d
45	a. Period of competition code*** b. Hours per period per acre c. Period of competition code*** d. Hours per period per acre	45.	|_|_ . _|_|_ . _| a b c d	|_|_ . _|_|_ . _| a b c d
46	a. Period of competition code*** b. Hours per period per acre c. Period of competition code*** d. Hours per period per acre	46.	|_|_ . _|_|_ . _| a b c d	|_|_ . _|_|_ . _| a b c d
47	ALTERNATIVE CROP 5 (if no more, enter "0" and proceed to line 57) a. Net return per acre (_____yield/A x price______ = _________ - variable cost $_____/A) b. Land type (0 = no land used; 1 = owned; 2 = rented; 3 = either) c. Acreage restriction** d. Number of acres related to restriction	47.	|___ . _|_|_|_| a b c d	|___ . _|_|_|_| a b c d

Competition by time periods (when no more competition, enter "0" and proceed to next crop)

		LINE NO.	FIRST ANALYSIS	ADJUSTED ANALYSIS
48	a. Period of competition code*** b. Hours per period per acre c. Period of competition code*** d. Hours per period per acre	48.	|_|_ . _|_|_ . _| a b c d	|_|_ . _|_|_ . _| a b c d
49	a. Period of competition code*** b. Hours per period per acre c. Period of competition code*** d. Hours per period per acre	49.	|_|_ . _|_|_ . _| a b c d	|_|_ . _|_|_ . _| a b c d
50	a. Period of competition code*** b. Hours per period per acre c. Period of competition code*** d. Hours per period per acre	50.	|_|_ . _|_|_ . _| a b c d	|_|_ . _|_|_ . _| a b c d
51	a. Period of competition code*** b. Hours per period per acre c. Period of competition code*** d. Hours per period per acre	51.	|_|_ . _|_|_ . _| a b c d	|_|_ . _|_|_ . _| a b c d

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** See explanation of footnote on Page 4.

*** See explanation of footnote on Page 4.

	LINE NO.	FIRST ANALYSIS	ADJUSTED ANALYSIS
52 ALTERNATIVE CROP 6 (if no more, enter "0" and proceed to line 57) a. Net return per acre (_____ yield/A x price______ = ________ - variable cost $_____/A) b. Land type (0 = no land used; 1 = owned; 2 = rented; 3 = either) c. Acreage restriction** d. Number of acres related to restriction	52.	|__a._|b|c|_d_|	|__a._|b|c|_d_

Competition by time periods (when no more competition, enter "0" and proceed to next crop)

	LINE NO.	FIRST ANALYSIS	ADJUSTED ANALYSIS
53 a. Period of competition code*** b. Hours per period per acre c. Period of competition code*** d. Hours per period per acre	53.	|a|_.b_|_c_|_.d_|	|a|_.b_|_c_|_.d_
54 a. Period of competition code*** b. Hours per period per acre c. Period of competition code*** d. Hours per period per acre	54.	|a|_.b_|_c_|_.d_|	|a|_.b_|_c_|_.d_
55 a. Period of competition code*** b. Hours per period per acre c. Period of competition code*** d. Hours per period per acre	55.	|a|_.b_|_c_|_.d_|	|a|_.b_|_c_|_.d_
56 a. Period of competition code*** b. Hours per period per acre c. Period of competition code*** d. Hours per period per acre	56.	|a|_.b_|_c_|_.d_|	|a|_.b_|_c_|_.d_

SECTION VII. OPTION TO RESTRICT CERTAIN PRODUCTION ALTERNATIVES:
(Enter "0", after you have entered the last restriction)

RESTRICTION		RES. CODE†	RES. TYPE††	RESTRICTION AMOUNT	RES. CODE†	RES. TYPE††	RESTRICTION AMOUNT
57. ______________________	57.	a	b	c	a	b	c
58. ______________________	58.						
59. ______________________	59.						
60. ______________________	60.						
61. ______________________	61.						
62. ______________________	62.						
63. ______________________	63.						
64. ______________________	64.						
65. ______________________	65.						
66. ______________________	66.						
67. ______________________	67.						
68. ______________________	68.						

** See explanation of footnote on Page 4.

*** See explanation of footnote on Page 4.

† RESTRICTION CODES: 1 is maximum (≤); 2 is equal to (=); 3 is minimum (≥).

†† RESTRICTION TYPES: CORN: 1 = total acres; 2 = owned acres; 3 = rented acres; 4 = owned acres planted between April 25-May 10; 5 = rented acres planted between April 25-May 10; 6 = acres harvested between September 27-October 10; 7 = owned acres harvested between September 27-October 10; 8 = rented acres harvested between September 27-October 10. BEANS: 11 = total acr[illegible] 12 = owned acres, 13 = rented acres, 14 = acres planted between May 19-May [illegible]. ALTERNATIVE CROP ENTERPRISES: 21 = acres of alternative crop 1; 22 = acres of alternative crop 2, [illegible] = etc. for up to 6 crops.

		LINE NO.	FIRST ANALYSIS	ADJUSTED ANALYSIS
69	Storage available for corn and soybeans (1,000 bu.)	69.	|— — a . —|	|— — b . —|
70	Corn, $/Bu. (15.5% moisture) a. @ harvest b. @ spring	70.	|— . a —|— . b —|	|— . a —|— . b —|
71	Soybeans, $/Bu. a. @ harvest b. @ spring	71.	|— — . a —|— — . b —|	|— — . a —|— — . b —|

SECTION IX. OPTION TO ADJUST YIELD ASSUMPTIONS OF ANALYSIS:
(If you accept the assumed reductions, Table 3, enter "100"; otherwise, enter a yield reduction factor where "0" implies no reduction while "200" implies twice the assumed reduction).

		LINE NO.	FIRST ANALYSIS	ADJUSTED ANALYSIS
72	Corn Yield Reductions a. Owned land b. Rented land	72.	|— a —|— b —|	|— a —|— b —|
73	Soybean Yield Reductions a. Owned land b. Rented land	73.	|— a —|— b —|	|— a —|— b —|

SECTION X. OPTION TO ADJUST OTHER ASSUMPTIONS OF ANALYSIS:[†††]

ASSUMPTION		ASSUMPTION VALUE	ASSUMPTION CODE	ASSUMPTION VALUE	ASSUMPTION CODE
74. ______	74.	|— — — a . — —|	|— b —|	|— — — a . — —|	|— b —|
75. ______	75.	|— — — — . — —|	|— — —|	|— — — — . — —|	|— — —|
76. ______	76.	|— — — — . — —|	|— — —|	|— — — — . — —|	|— — —|
77. ______	77.	|— — — — . — —|	|— — —|	|— — — — . — —|	|— — —|
78. ______	78.	|— — — — . — —|	|— — —|	|— — — — . — —|	|— — —|
79. ______	79.	|— — — — . — —|	|— — —|	|— — — — . — —|	|— — —|
80. ______	80.	|— — — — . — —|	|— — —|	|— — — — . — —|	|— — —|
81. ______	81.	|— — — — . — —|	|— — —|	|— — — — . — —|	|— — —|
82. ______	82.	|— — — — . — —|	|— — —|	|— — — — . — —|	|— — —|
83. ______	83.	|— — — — . — —|	|— — —|	|— — — — . — —|	|— — —|
84. ______	84.	|— — — — . — —|	|— — —|	|— — — — . — —|	|— — —|
85. ______	85.	|— — — — . — —|	|— — —|	|— — — — . — —|	|— — —|
86. ______	86.	|— — — — . — —|	|— — —|	|— — — — . — —|	|— — —|
87. ______	87.	|— — — — . — —|	|— — —|	|— — — — . — —|	|— — —|
88. ______	88.	|— — — — . — —|	|— — —|	|— — — — . — —|	|— — —|
89. ______	89.	|— — — — . — —|	|— — —|	|— — — — . — —|	|— — —|
90. ______	90.	|— — — — . — —|	|— — —|	|— — — — . — —|	|— — —|
91. ______	91.	|— — — — . — —|	|— — —|	|— — — — . — —|	|— — —|
92. ______	92.	|— — — — . — —|	|— — —|	|— — — — . — —|	|— — —|
93. ______	93.	|— — — — . — —|	|— — —|	|— — — — . — —|	|— — —|
94. ______	94.	|— — — — . — —|	|— — —|	|— — — — . — —|	|— — —|
95. ______	95.	|— — — — . — —|	|— — —|	|— — — — . — —|	|— — —|

††† See User's Manual for explanation.

SECTION XI. ADDITIONAL INFORMATION:

	LINE NO.	FIRST ANALYSIS	ADJUSTED ANALYSIS
96 State And Regional Codes a. State code b. Region code	96.	|__a__|_b_|	|__a__|_b_|
97 Plan (enter "1" if desired, "0" otherwise) a. Summary b. Details on custom hire c. Details on corn planting and harvest scheduling d. Details on soybean planting and harvest scheduling e. Details on land preparation	97.	|_a_|_b_|_c_|_d_|_e_|	|_a_|_b_|_c_|_d_|_e_|
98 Values Of Scarce Resources And Cost Of Special Restriction a. Land ($/acre) (0 = no; 1 = yes) b. Preparation (0 = no; 1 = $/acre; 2 = $/hour; 3 = both) c. Harvesting (0 = no; 1 = $/acre; 2 = $/hour; 3 = both) d. Planting ($/hour) (0 = no; 1 = yes) e. Alternate crops (0 = no; 1 = cost of acreage restriction; 2 = cost of forcing in nonprofitable crops; 3 = both) f. Cost of special restrictions (0 = no; 1 = yes)	98.	|_a_|_b_|_c_|_d_|_e_|_f_|	|_a_|_b_|_c_|_d_|_e_|_f_|

EXAMPLE OUTPUT

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   *  PROFITABILITY  *
1.  RETURNS ABOVE VAR COST = $   75196.
    VAR COST = $  54769.

   * CORN ACRES AND SALES *
2.  ACRES OWNED LAND =  478.
    AVER BU/ACRE = 96.5
    TOTAL BUSHELS =   46114.
4.  BU CORN SALES AT HARVEST =          0.
    BU CORN SALES AT SPRING =  46114.

   *  SOYBEAN ACRES AND SLAES  *
5.  ACRES OWNED LAND = 122.
    AVER BU/ACRE = 31.8
    TOTAL BUSHELS =   3886.

   * ALTERNATIVE CROP ACRES AND NET INCOMES *

       TOTAL   OWNED   RENTED   TOTAL
CODE   UNITS   UNITS   UNITS   PROFIT
  1     50.     50.      0.   $ 5250.
```

* CORN PLANT AND HARVEST SCHEDULE *

21. OWNED LAND SCHEDULE

ACRES PLANTED	ACRES HARVESTED SEP 27 OCT 03	OCT 04 OCT 10	OCT 11 OCT 17	OCT 18 NOV 07	NOV 08 NOV 28
APR 25-MAY 10	0.	0.	0.	270.	80.
MAY 11-MAY 18	0.	0.	18.	0.	108.
MAY 19-MAY 26	0.	0.	3.	0.	0.

* SOYBEAN PLANT AND HARVEST SCHEDULE *

33. OWNED LAND SCHEDULE

ACRES PLANTED	ACRES HARVESTED SEP 27 OCT 03	OCT 04 OCT 10	OCT 11 OCT 17	OCT 18 NOV 07	NOV 8 NOV 28
MAY 19-MAY 26	0.	60.	62.	0.	0.

41. LAND PREPARATION SCHEDULE

APR 01-APR 24	475.
MAY 19-MAY 26	125.

* VALUE OF SCARCE RESOURCES *

50. OWNED LAND ($/AC) 0.0
    RENTED LAND ($/AC) 0.0

51. PREPARED LAND FOR PLANTING ($/AC)

53. HARVESTING CAPACITY ($/AC)

SEP 27-OCT 03	118.25
OCT 04-OCT 10	109.28
OCT 11-OCT 17	97.47
OCT 18-NOV 07	99.89
NOV 08-NOV 28	69.12

55. PREPARATION TIME ($/HR)

OCT 18-NOV 07	399.56

57. PLANTING TIME ($/HR)

APR 25-MAY 10	203.34
MAY 11-MAY 18	99.70

59. HARVEST TIME ($/HR)

SEP 27-OCT 03	473.02
OCT 04-OCT 10	437.10
OCT 11-OCT 17	389.89
OCT 18-NOV 07	399.56
NOV 08-NOV 28	311.03

64. COST OF ALTERNATE CROPS ACREAGE RESTRICTIONS ($/AC)

CODE	COST
1	-448.25

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BIBLIOGRAPHY

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