AN ECONOMIC ANALYSIS OF ALTERNATIVE MEANS OF ACQUIRING FARM MACHINERY SERVICES FOR SOUTHERN MICHIGAN CASH-GRAIN FARMS

Thesis for the Degree of M. S.
MICHIGAN STATE UNIVERSITY
GARY LEE BENJAMIN
1968

THESIS

ABSTRACT

AN ECONOMIC ANALYSIS OF ALTERNATIVE MEANS OF ACQUIRING FARM MACHINERY SERVICES FOR SOUTHERN MICHIGAN CASH-GRAIN FARMS

By Gary Lee Benjamin

Although current per farm machinery investments only represent 12 percent of total per farm investments, certain unique characteristics make the investment difficult to manage. Some of these characteristics are, (1) rapid technological developments which render machinery to be obsolete long before it is physically depreciated, (2) high initial costs and relatively low disposal values, and (3) the changing farm structure which emphasizes large items of machinery that cannot be passed from "first line" to "second line" equipment.

The major objectives of the study were, (1) to describe alternative methods of acquiring farm machinery services, (2) to determine the relationship between farm size and per acre power, machinery and labor costs for selected farm machinery systems, (3) to determine acreage levels at which total costs and revenues are equal for selected systems of farm machinery, and (4) to determine an optimum farm size which would achieve minimum costs per dollar of revenue for selected farm machinery systems.

A snythetic one-man farming operation was utilized to represent a southern Michigan cash-grain farm. Farm size was varied in 40-acre increments with a constant typical acre consisting of 36 percent corn, 15 percent soybeans, 19 percent navy beans, 15 percent wheat, 12 percent diverted and 3 percent idle. Since primary emphasis was placed on analyzing farm machinery as a system, the following systems were identified: (a) 4-row system with complete ownership, (b) 4-row system with a combination of ownership and custom hiring, (c) 6-row system with complete ownership, (d) 6-row system with a combination of ownership and custom hiring, and (e) complete custom hiring. Because the results of a mailed questionnaire to farm machinery dealers in Michigan showed little evidence of machinery rental and leasing and relatively high rates, rental and leasing were not included in the machinery systems analyzed.

The analysis procedure employed two budgeting models. Budgeting Model I derived average total machinery and labor costs per acre. Budgeting Model II included the concept of timeliness of operations in developing cost: revenue ratios. Revenues were based entirely on cash sales of crops produced, while costs included labor, machinery, seed, fertilizer, herbicide, custom hauling and an opportunity cost on land.

Although the alternative of complete custom hiring gave lowest per acre costs for farms up to 322 tillable acres, the results of Budgeting Model I showed costs per acre decreasing rapidly in this acreage range for the other four machinery systems. Between 323 and 343 tillable acres, the 4-row system with a combination of ownership and custom hiring resulted in the lowest costs per acre, while the 4-row system of complete ownership showed lowest costs per acre for farms of 344 to 597 tillable acres. For farms with more than 597 tillable acres, the 6-row system of complete ownership gave the lowest per acre costs.

In terms of breakeven analysis, the results of Budgeting Model II indicated that the 4-row machinery system with a combination of ownership and custom hiring required a minimum of 89 tillable acres before revenues would equal costs. Other breakeven acreage levels of 107, 123, and 152 tillable acres were noted for the 6-row with a combination of ownership and custom hiring, the 4-row system of complete ownership, and the 6-row system of complete ownership, respectively.

Although all the machinery systems studied showed a range in acreage for relative efficiencies, the greatest economies of size occurred with a farm of 760 tillable acres using a 6-row machinery system of complete ownership. By defining constant costs as those cost: revenue ratios falling with five percent of the most efficient point, the acreage ranges for constant costs were 300, 304, 374, and 470 tillable acres for the 4-row system of complete ownership, the 4-row system with a combination of ownership and custom hiring, the 6-row system of complete ownership, and the 6-row system with a combination of ownership and custom hiring, respectively.

The primary implications of the analysis indicated the following: (1) the importance and benefits of analyzing farm machinery as a system to fulfill the overall needs of a farm; (2) the possibility of an increased demand for the services provided by custom operators; (3) the possibility of an increased supply of custom operators who hold excess machinery capacity and desire to market their labor and capital through custom services; and (4) the potential for a farm machinery dealer to obtain a return on his inventory of used machinery by offering short-term machinery rental to farmers.

The results of this study were limited somewhat by the lack of data in the areas of general farm labor requirements, crop losses due to untimely operations, and the affects of inclement weather on available field work time. The limiting data in these areas indicate relevant needs for future research.

AN ECONOMIC ANALYSIS OF ALTERNATIVE MEANS OF ACQUIRING FARM MACHINERY SERVICES FOR SOUTHERN MICHIGAN CASH-GRAIN FARMS

By

Gary Lee Benjamin

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Agricultural Economics

1968

ACKNOWLEDGMENTS

The author wishes to express his appreciation to the many people who have contributed so much to the completion of this thesis.

Dr. Larry J. Connor deserves much credit and the author sincerely appreciates his contribution. As major professor, he continually provided encouragement, stimulated ideas, and offered helpful suggestions as the study progressed from its beginning to completion.

Thanks are due Dr. L. L. Boger and the Department of Agricultural Economics for the financial assistance and the facilities which have made this segment of my education possible.

Much credit is also due Drs. Ralph E. Hepp, Karl T. Wright, and Alden C. Olson who read earlier drafts and made worthwhile suggestions for improvement. Appreciation is also extended to Dr. Robert G. White and Lauri Ahti who helped considerably in the early planning stages of this project.

Special recognition is extended to Karen who, during the initial phases of this project, became the author's wife. Her cooperation and unselfish attitude made the final phases both possible and bearable.

TABLE OF CONTENTS

		Page
ACKNOWLEDGMENTS		ii
LIST OF TABLES		v
LIST OF FIGURES		vi
LIST OF APPENDIX TABLES		vii

CHAPTER

I	INTRODUCTION AND SETTING	1
	The Changing Agriculture	1
	The Problem Setting	4
	A Problem Statement	11
	Objectives of the Study	11
	The Thesis Format	12
	References	13
II	THEORETICAL FRAMEWORK AND SUBJECT REVIEW	14
	Theoretical Framework	14
	Problems in Applying Theory to Actual Data	19
	Length of Run and Fixed Versus Variable Inputs	19
	Handling Discrete Resources	20
	The Role of Management	22
	Profit and Residual Claimant	24
	A Review of Other Studies	26
	Oklahoma Study	27
	Iowa Study	29
	References	32
III	METHODOLOGY AND INFORMATIONAL SOURCES	34
	Selection of a Farm and Its Characteristics	34
	General Data Sources	36
	Survey on Renting and Leasing	37
	Short-Term Renting and Leasing	38
	Long-Term Renting and Leasing	41
	The Selection and Description of Various Farm Machinery Systems	44

CHAPTER		Page
	General Assumptions	48
	The Analysis Procedure	50
	Budgeting Model I	51
	Budgeting Model II	53
	References	57
IV	THE ANALYSIS	59
	Budgeting Model I	59
	Budgeting Model II	62
	References	69
V	SUMMARY AND CONCLUSIONS	70
	Problem Review and Analysis Results	71
	Implications of Study	74
	Limitations of Study	79
	Indications for Further Study	85
	References	88
APPENDIX TABLES		89
BIBLIOGRAPHY		152

LIST OF TABLES

TABLE		Page
1	Farm numbers, farm size, and crop production index for the United States and Michigan . .	3
2	Value of productive assets per farm used in agriculture for Michigan and the United States	6
3	Michigan commercial farms by type; number and percent of total, 1959-64 and 1980 projections	10
4	Summary of questionnaires returned, number of dealers renting or leasing, and short term contractual responsibilities	40
5	Summary of results for budgeting model I . . .	60
6	Summary of results for budgeting model II . . .	66
7.	Ranges in farm size exhibiting relatively constant costs of production for various definitions of constant costs and various machinery systems	68

LIST OF FIGURES

Figure		Page
1	A diagram of short-run and long-run cost curves	16
2	Costs per acre for various farm sizes and machinery systems	61
3	Cost:revenue ratios for various farm sizes and machinery systems	64

LIST OF APPENDIX TABLES

APPENDIX TABLE		Page
1	Estimated typical acre for a cash-grain farm in southern Michigan	89
2	Crop yields, fertilizer and herbicide requirements, and other productive practices for the synthetic cash-grain farm	90
3	Assumed prices paid and received	92
4	Items, capacity, new cost, ownership costs, and expected life of farm machinery for the 4-row and 6-row machinery systems . .	93
5	Schedule of annual ownership costs by farm size with a 4-row system of complete ownership	96
6	Schedule of annual ownership costs by farm size with a 4-row system using a combination of ownership and custom hiring . . .	97
7	Schedule of annual ownership costs by farm size with a 6-row system of complete ownership	98
8	Schedule of annual ownership costs by farm size with a 6-row system using a combination of ownership and custom hiring . . .	100
9	Operating costs per hour of use for selected farm machinery items	101
10	Factors used to estimate machine, power, and labor requirements for specific field operations in southern Michigan	104
11	Machinery, power, and labor operating costs per acre by enterprise and operation using a 4-row system with complete ownership	106

APPENDIX TABLE		Page
12	Machinery, power, and labor operating costs per acre by enterprise and operation using a 4-row system with a combination of ownership and custom hiring	108
13	Machinery, power, and labor operating costs per acre by enterprise and operation using a 6-row system with complete ownership	110
14	Machinery, power, and labor operating costs per acre by enterprise and operation using a 6-row system with a combination of ownership and custom hiring	112
15	Custom rates per acre and per forty-acre increments by enterprise and operation . .	114
16	Computation of variable cost per acre by enterprise and machinery systems	115
17	Copy of rental and leasing questionnaire . .	116
18	Items, capacity, number of units, time period of contract, rates charged, and delivered sales price as reported by 18 farm machinery dealers holding short-term rental or lease contracts in 1967 . .	120
19	Budget for computing machinery, power, and labor costs per acre using a 4-row system with complete ownership	122
20	Budget for computing machinery, power, and labor costs per acre using a 4-row system with a combination of ownership and custom hiring	123
21	Budget for computing machinery, power, and labor costs per acre using a 6-row system with complete ownership	124
22	Budget for computing machinery, power, and labor costs per acre using a 6-row system with a combination of ownership and custom hiring	126
23	Budget for computing cost per acre for complete custom hiring	128

APPENDIX TABLE		Page
24	Estimated number of days lost in a 6-day work week due to inclement weather	129
25	Relationship between inches of precipitation and field work days lost	131
26	Critical planting and harvesting periods and losses in yield resulting from late planting and harvesting	132
27	Summary of late planting and harvesting operations by farm size and 4-row machinery systems	133
28	Summary of late planting and harvesting operations by farm size and 6-row machinery systems	138
29	Budget for computing cost:revenue ratios for a 4-row system with complete ownership	143
30	Budget for computing cost:revenue ratios for a 4-row system with a combination of ownership and custom hiring	145
31	Budget for computing cost:revenue ratios for a 6-row system with complete ownership	147
32	Budget for computing cost:revenue ratios for a 6-row system with a combination of ownership and custom hiring	149
33	Budget for computing cost:revenue ratios for complete custom hiring	151

CHAPTER I

INTRODUCTION AND SETTING

The Changing Agriculture

Much has been said and written about the changing scene in agriculture. The agricultural industry, once mainly confined within the boundaries of many self-supporting individual farm units, has grown into a truly big industry in every sense of the word. As an industry, it is now one of the biggest employers of human labor and other vital resources such as electricity, steel and oil. As an industry, agriculture also supports and promotes one of the finest research efforts of any industry.

This changing agriculture has also had its effect on the individual farm unit. The magnitude and rapidity of this change is well recorded in countless volumes of statistical data and records. A review of these statistical sources will reveal two distinct trends centered by a crucial turning point in the 1910-20 decade. Prior to that time, history records increasing farm numbers, increasing cropland acres, farm output increasing (but at a decreasing rate), and increasing farm employment. With the beginning of the 1920's, a second trend started to prevail and has lasted to present day. During this second trend farm employment decreased, farm output increased at an increasing rate, and cropland acreage fluctuated with increases and decreases.

Although there are many debates and studies [1]* as to what specifically caused this increased output (in the wake of decreasing farm numbers and employment), the fact still remains that farming has taken on new dimensions. Farming has continued to grow since the 1920's, but this second growth has resulted from new capital formation, adoption of new practices and techniques, and improved farm management abilities. Consequently, from 1920 to 1964, the number of farms in the United States has decreased by 51.1 percent while the average farm size increased in acreage by 136.8 percent. During the same period of time, the crop production index (1957-59=100) for the United States has increased from 76 to 109. Figures for the State of Michigan show a 52.4 percent decrease in farm numbers and a 50.1 percent increase in farm size for the same 1920-64 range. Table 1 gives further details on how rapidly the farm structure has changed.

In spite of the past record of change in farming and agriculture, the future is certain to reveal more of the same, and most likely at an accelerated rate. Cochrane

---

*All references and footnotes appear at the end of each chapter.

TABLE 1.--Farm numbers, farm size, and crop production index for United States and Michigan.

	United States				Michigan		
Year	Farm Numbers	Per-cent Change	Average Farm Size	Crop Prod. Index[2]	Farm Numbers	Per-cent Change	Average Farm Size
			(acres)				(acres)
1850[1]	1,449,073		202.6	NA			
1860[1]	2,044,077	41.1	199.2	NA	62,422		113.0
1870[1]	2,659,985	30.1	153.3	NA	98,786	58.3	101.0
1880[1]	4,008,907	50.7	133.7	NA	154,008	55.9	90.0
1890[1]	4,564,641	13.9	136.5	NA	172,344	11.9	86.0
1900	5,739,657	25.7	146.6	NA	203,261	17.9	86.4
1910	6,366,044	10.9	138.5	63	206,960	1.8	91.5
1920	6,453,991	1.4	148.5	76	196,447	- 5.1	96.9
1925[1]	6,371,640	- 1.2	145.1	72	192,327	- 2.1	93.8
1930	6,295,103	- 1.3	157.3	69	169,372	-11.9	101.1
1935[1]	6,812,350	8.3	154.8	70	196,517	16.0	93.9
1940	6,102,417	-10.5	174.5	78	187,589	- 4.5	96.2
1945[1]	5,859,169	- 3.9	194.8	85	175,268	- 6.6	104.9
1950	5,388,437	- 8.1	215.8	89	155,589	-11.2	111.0
1954[1]	4,782,416	-11.1	242.2	93	138,922	-10.7	118.5
1959	3,710,503	-22.6	302.8	103	111,817	-19.5	132.2
1964	3,157,857	-14.9	351.6	109	93,504	-16.4	145.4

[1]Data for Alaska and Hawaii not included in U.S. figures.

[2]Includes feed grains (corn for grain, oats, barley, sorghum grain), food grains (all wheat, rye, buckwheat and rice), hay and forage (all hay, sorghum forage, corn silage and for 1939 to date, sorghum silage), vegetables (potatoes, sweet potatoes, dry edible beans, dry field peas, truck crops for processing, and truck crops for fresh market having value), fruits and nuts (fruits, berries, and tree nuts having value), sugar crops (sugar beets, sugarcane for sugarcane syrup, and maple syrup), cotton (cotton lint and cotton seed), tobacco, and oil crops (soybeans, peanuts picked and threshed, peanuts hogged, flaxseed and for 1939 to date, tungnuts), farm gardens, hay seeds, pasture seeds and cover-crop seeds and some miscellaneous crop production.

Index 1957-59 = 100

Source: U.S. Department of Commerce, Bureau of the Census, <u>United States Census of Agriculture</u> (by years), Washington.

[2] has done some star gazing into the future for what he labels as "probable and possible" developments up to the year of 2000. Although, some of his ideas appear to be far fetched at present, we can rest assured that they are, indeed, within the realm of possibilities. Farming is now built on a solid foundation of scientific research, rapid technological development, expanding managerial abilities, and superior means of communications. Hence farming, and the hungry farmers starved by the cost-price squeeze, will adopt new developments at a faster rate, in the hopes of lowering per unit costs and increasing net returns. The big question does remain, however, as to whether or not individual farmers will be prepared to meet these rapid changes. The farmer of today who has hopes of still being a farmer in 1980 will be forced to make rapid economic decisions as new developments occur. Unless he has prepared himself knowledgeably and financially, the farmer of today will find it impossible to salvage his economic existence in the future.

The Problem Setting

As indicated above, the future of farming will call for increasing changes. One of the most dynamic aspects of this change will be in the area of farm investments. The emphasis of this study is to analyze one segment of the farm investment structure as it applies to a given type of farm. More specifically, the analysis pertains to farm power and machinery requirements as related to a Southern Michigan cash-grain farm.

As Table 2 shows, farm power and machinery investments make up about 10 to 13 percent of the total farm investment which at first, may appear to be a minor part of the total investment program. However, investment in farm power and machinery carries certain other unique characteristics which do not apply to the other segments making up the total farm investment. Foremost among these unique characteristics is the fact that farm power and machinery are continuously subjected to improvements. Engineers are trying to develop new and better machines to replace old and oftened outdated methods of operation. Witness for example, the surge of new fruit harvesting machines which are gradually replacing the need for hand labor and revolutionizing the fruit industry. Another good example is the trend that is emerging for self-propelled equipment and the "uni-system" which provides one source of power for several field operations.

It should be pointed out, however, that such developments are not limited to the type which revolutionize an industry. In fact, farm equipment manufacturers operate much the same as do automobile manufacturers. Each year brings new models and new improvements to almost every existing item of equipment; new tractors emerge with higher

TABLE 2.--Value of productive assets per farm used in agriculture for Michigan and the United States

Year	United States[1]						Michigan[2]					
	Total	Farm Real Estate	Live-stock	Other	Machinery and Motor Vehicles		Total	Real Estate	Live-stock	Feed and Crops	Power and Machinery	
	$	$	$	$	$	% of Total	$	$	$	$	$	% of Total
1940	6,158	4,608	608	351	591	9.6	13,638	9,145	1,843	1,076	1,574	11.5
1945	11,144	7,783	1,343	861	1,157	10.4	17,538	10,469	2,572	1,907	2,590	14.8
1950	17,378	12,003	2,199	1,193	1,983	11.4	25,141	13,368	3,859	2,649	5,264	20.9
1955	26,165	18,814	2,357	1,592	3,402	13.0	37,594	20,083	5,429	4,145	7,937	21.1
1956	28,456	20,904	2,299	1,596	3,657	12.8	40,474	22,619	3,856	5,730	8,269	20.4
1957	31,805	23,734	2,456	1,685	3,930	12.4						
1958	35,184	26,202	3,206	1,672	4,104	11.7	53,385	32,228	7,759	4,552	8,846	16.6
1959	40,400	29,783	4,221	1,856	4,540	11.2	69,956	46,466	9,021	5,237	9,232	13.2
1960	42,465	31,966	3,843	1,796	4,860	11.4	75,850	49,712	10,486	5,790	9,862	13.0
1961	44,239	33,521	4,087	1,735	4,896	11.1	81,536	52,713	11,822	6,140	10,861	13.3
1962	47,747	36,378	4,446	1,792	5,131	10.7	91,972	58,696	14,165	7,455	11,655	12.7
1963	51,536	39,416	4,834	1,864	5,422	10.5	99,418	62,589	16,104	8,087	12,638	12.7
1964	55,652	43,344	4,561	2,008	5,739	10.3	131,109	88,121	17,053	10,708	15,227	11.6
1965	59,928	47,361	4,288	2,015	6,264	10.5	133,235	91,003	14,927	11,173	16,132	12.1
1966	67,259	52,758	5,385	2,185	6,931	10.3	148,973	100,511	16,220	12,341	18,901	12.7

[1]Average for all farms.

[2]Data for Michigan is based on farm, mailed in records to Michigan State University. Figures are <u>not</u> averages for the state and hence should not be compared directly with U.S. figures.

Source: The Balance Sheet of Agriculture, 1967, Agriculture Information Bulletin No. 329, Economic Research Service, United States Department of Agriculture. Michigan Farm Business Report (by years), Department of Agricultural Economics, Michigan State University.

horsepower ratings, the plow adds an additional bottom, six-row planters gradually replace four-row planters, and tillage tools are developed to handle the once-over operation. As with the automobile industry, it has become almost impossible to keep up with complete line of makes and models representing the various farm equipment companies.

The continuous developments in the farm equipment industry presents another unique characteristic of farm machinery investment. This is the disposal problem. As W. H. M. Morris points out, the increasing capacity of farm machinery has

> ". . . made individual machines more expensive; and it is beginning to create a problem in the disposal of used machinery of large capacity. A depression in the price of these machines (used machinery) is to be expected. These two effects combine to make the ownership cost more expensive.
>
> Increase in size of tractors . . . tends to make the utilization of a machine more uniform throughout its life on a farm. It used to be practiced to demote the first line tractor to the second and even ultimately the third line. It does not seem conceivable that a 125 hp tractor could be used in this way. So when it fails to fulfill the needs as a 'first line' tractor it will have to be traded for a new first line unit. There may be relatively small demand for such a used machine. This also leads to the second line unit being purchased as such"[3].

Aside from the fact that there is little market for a 125 horsepower tractor, the problem of rapid initial depreciation still exists. The continuous developments in farm machinery render a machine to be technically obsolete far sooner than it is physically obsolete. Commercial farmers are perplexed as to whether they should take a loss by trading in their four year old tractor for a new and better model, or continue to struggle along with the older model till it becomes worn out and market values again approximate depreciation.

As can be seen by the above arguments, the costs associated with the farm machinery investment are high. New costs of the larger items of equipment run into several thousand dollars. Financing such an investment requires considerable knowledge of sources of capital and debt repayment abilities. Coupling this to the problem of financing the remaining farm investments, it becomes easy to understand the problem of competition that exists between alternative uses of limited capital and credit. The whole method of establishing investment priorities becomes very important when the entire investment picture is visualized.

Another important characteristic of farm power and machinery is that the services from such equipment can be acquired in several ways. Quite logically, the most common method is through equity ownership of the entire system. However, the range of choice also includes complete custom hiring and combinations of ownership with custom hiring, short-term rental or lease, and long-term rental or lease. Under various situations and circumstances, each alternative would most likely prove feasible, since each offers different costs, different responsibilities of management, varying probabilities of crop completion, and varying probabilities of service acquisition. The problem remains however, as to exactly what situations make these alternatives feasible.

A final important characteristic of the farm power and machinery investment is that it can be analyzed as an entire system. Regardless of what individual machinery units are required to perform the entire sequence of farm operations, the final decision as to how the machinery ought to be acquired, should be based on an analysis of the entire system. Farming is made up of several operations, and usually made up of several enterprises. Because of this, any attempt to reorganize a single portion of the farm structure, should first be evaluated on the basis of what affects the reorganization will have on the entire farm. In the case of farm machinery, this requires that the selection process should be based on an analysis of machinery as a system.

As mentioned above, this study is an analysis of farm machinery selection on a cash-grain farm. The reason for selecting this type of farm is also based on predicted changes in the structure of farming. Based on 1964 data, the number of cash-grain farms made up 25.6 percent of all commercial farms in Michigan. This was second only to the dairy farm which accounted for 33.6 percent of all commercial farms. Projections to the year of 1980 indicate that, even with a reduction in commercial farm numbers of about 57 percent, the number of cash-grain farms in Michigan will comprise some 35.1 percent of all commercial farms and thus become the most prominent farm type in Michigan. Table 3 indicates the projected numbers of all farm types in Michigan by 1980.

TABLE 3.--Michigan Commercial Farms by Type: Number and Percent of Total, 1959-64 and 1980 Projections

	Number of farms			Percent of all farms		
Type of Farm	1959	1964	1980 projection	1959	1964	1980 projection
Dairy	24,663	20,230	8,000	37.9	33.6	21.6
Poultry	2,079	1,734	400	3.2	2.9	1.1
Other livestock	9,849	8,725	8,000	15.1	14.5	21.6
Cash-grain	14,262	15,418	13,000	21.9	25.6	35.1
Other field crops	1,235	1,027	800	1.9	1.7	2.2
Fruit	4,135	4,181	2,000	6.4	7.0	5.4
Vegetable	1,304	1,335	1,000	2.0	2.2	2.7
General	6,197	5,287	2,300	9.5	8.8	6.2
Miscellaneous	1,318	2,250	1,500	2.1	3.7	4.1
Total	65,042	60,187	37,000	100.0	100.0	100.0

Source: Research Report 47 "Project '80 Rural Michigan Now and in 1980," Agricultural Experiment Station and Cooperative Extension Service, Michigan State University, 1964, p. 20.

A Problem Statement

With the understanding of the amount of investment a farmer ties up in farm power and machinery, and with the realization of the swiftness in machinery turnover due to technology, it is not hard to see why farmers have difficulty managing this portion of their total farm investment. A farmer is faced with several alternatives, ranging from ownership, custom hiring, renting, and leasing, when he attempts to acquire farm machinery services. An economically feasible selection process requires knowledge of operating costs, ownership costs, expected years of life, salvage values, efficiency schedules, machine capacities, custom rates, rental rates, and leasing rates. It is the intent of this study to analyze the costs associated with the alternative methods available to the farmer in acquiring the services of the complete farm machinery system.

Objectives of the Study

The main objectives of this study are as follows:

1. To describe various alternatives of acquiring the services of selected farm machinery systems.
2. To determine the relationship between farm size and per acre total farm power and machinery costs for selected farm machinery systems on a Southern Michigan cash-grain farm.
3. To examine the effects of inclement weather on the timeliness of field operations for Southern Michigan cash-grain farms using alternative farm machinery systems.

4. To determine the breakeven points between total costs and revenues for a Southern Michigan cash-grain farm using alternative farm machinery systems.

5. To determine the optimum farm size which would achieve minimum acre production costs for each of the various farm machinery systems selected for a Southern Michigan cash-grain farm.

The Thesis Format

The remainder of this thesis is broken down into four chapters. Chapter II contains a discussion of the theoretical framework for economies of size studies and presents some of the problems in relating the theory to empirical research. Such things as defining length of run, resource divisibility, residual claimant, and risk and uncertainty are described in detail.

Chapter III explains the research methodology used in this study. Discussion centers on the selection of a farm for analysis, the selection and description of various farm machinery systems, and the analysis procedure. A detailed summary of a survey on current farm machinery rental and lease programs in Michigan is also included in Chapter III.

Chapter IV follows with the results of the analysis as applied to a southern Michigan cash-grain farm. Chapter V contains a brief summary on the conclusions and implications of the study, and the needs for future research.

The appendix at the end of the text includes most of the tables of supporting data.

References

1. See Dale E. Hathaway's comments in _Government and Agriculture: Economic Policy in a Democratic Society_, the Macmillan Company, New York, 1963. p. 93.

2. Willard W. Cochrane, _The City Man's Guide to the Farm Problem_, McGraw-Hill Book Company, New York, 1966. pp. 32-42.

3. _Farm Machinery Replacement_, Unpublished manuscript by W. H. M. Morris, Purdue University. Parenthesis mine.

CHAPTER II

THEORETICAL FRAMEWORK AND SUBJECT REVIEW

The groundwork for any type of research rests on the theories of the supporting discipline. In economies of size studies [1], the supporting discipline is economics. The purpose of this chapter is to portray the theory and some of the associated difficulties of applying the theory to real life problems. The latter part of the chapter contains a review of two studies already completed in the area of farm machinery selection.

Theoretical Framework

The theory of production is expressed in terms of short-run and long-run planning horizons. Explanation of the lnegth of run is dependent upon the knowledge of which factors of production are fixed to the firm and which are variable. A fixed resource is defined as one which is worth more in its present use than any other entity will pay for it, but not worth enough in its present use to justify getting more of it. The marginal value of the fixed resource is less than the purchase price of an additional unit of the resource and more than the salvage price obtainable by selling the unit [2].

A variable resource is defined as having a marginal value which exceeds its purchase price or is less than its salvage value. Hence, the amount of a variable resource used by the firm is flexible. More, or less of it can be used at increased profits to the firm.

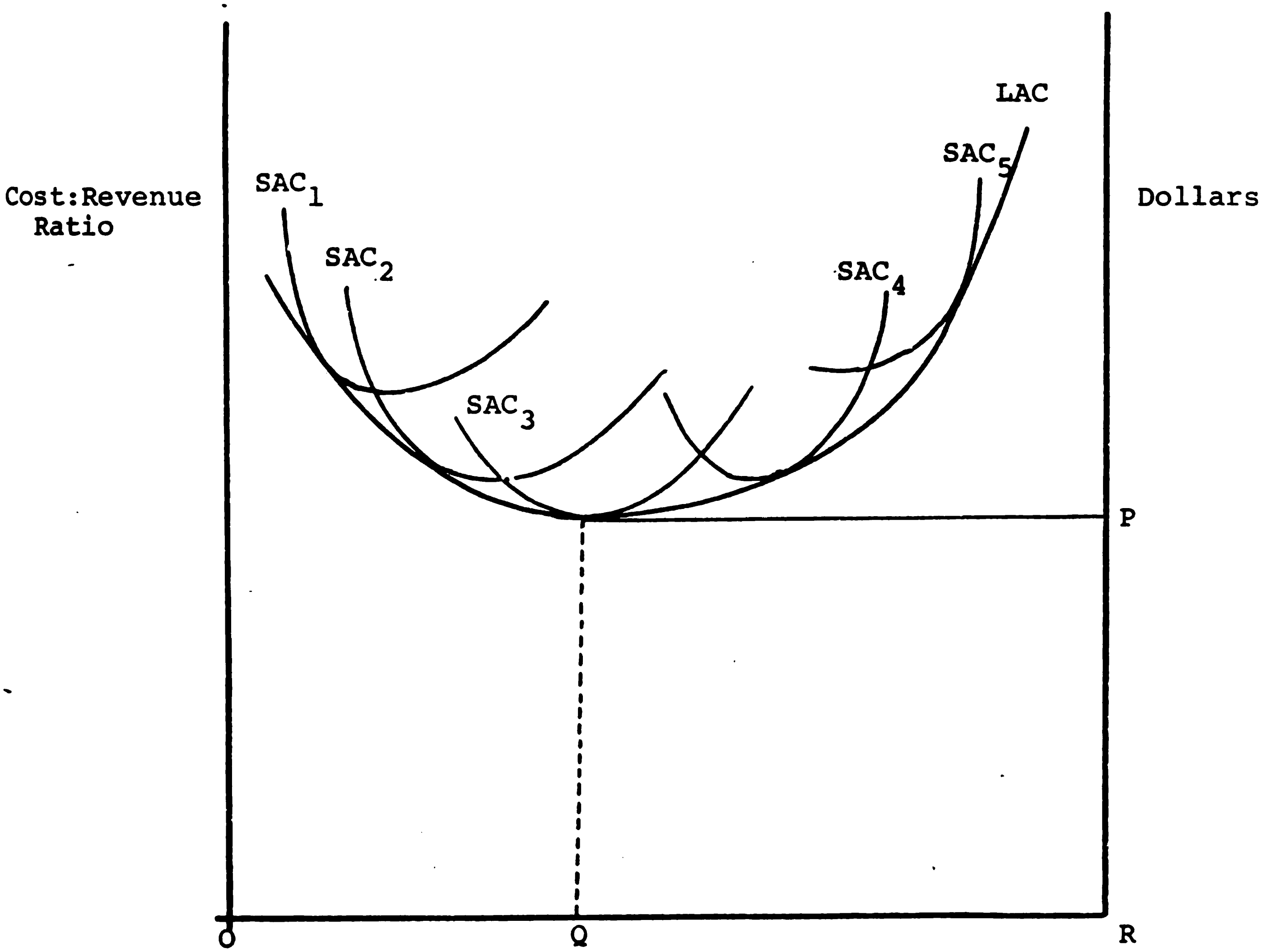
The length of the planning horizon depends on how the factors of production are viewed. In general, economic literature defines four distinct time periods as the very short-run, the short-run, the long-run, and the very long-run.

The very short-run is a time period so short that a firm cannot change its output, while the short-run time period is sufficiently long enough to allow the firm to expand output but not capacity. Hence, the latter time period allows some, but not all, factors of production to vary.

The long-run refers to a time period sufficiently long enough to allow all the firms factors of production to vary. This is distinguished from the very long-run where all factors of the firm, the industry, and the economy, are allowed to change.

To better understand this theory, a diagram is presented on the following page. This diagram shows five different short-run planning horizons which are identified by the five SAC (short-run average cost) curves. Each SAC curve shows the relative position of the firm facing a

FIGURE 1.--A Diagram of the Short-Run and Long-Run Cost Curves



time period so short that part of the resources are fixed. Each SAC represents a different level of fixed resources. The optimum (or most efficient) point of production for each of these planning horizons is at the bottom of the respective SAC curves. This is the point where marginal cost is equal to average cost; hence, per unit of costs of production are lowest. However, the theory says a firm will produce in the short-run at the point where marginal cost is equated with marginal revenue as long as total revenue at least covers the total variable costs and contributes to the fixed cost.

Each SAC curve shows the three general segments of decreasing, constant, and increasing costs. In the downward sloping portion of decreasing costs, more units of the variable resources are added to the existing level of fixed resources, thus resulting in greater output. Total average costs are decreasing because the fixed costs are spread over more units of output. However, a point is eventually reached whereby increasing proportions of the variable resources must be added to the fixed resources in order to increase output. Fixed costs are still being spread over more units of output, but the total variable cost becomes much higher per unit of product. Consequently, total average costs increase.

The long-run planning horizon is shown by the LAC (long-run average cost) curve which is drawn tangent to the SAC curves. This curve reveals the least possible cost per unit of product for various levels of output when all factors of production are variable. Hence, it is an indication of the long-run economies of size available to the firm for assumed levels of technology and price relationships. It presents the least-cost resource combination where the marginal physical products per dollar of resource are equal for all factors of production. In this long-run situation, the firm will continue to produce if revenues are sufficient to cover all costs. The most efficient output level is OQ as indicated by the diagram since, at this point, the per unit costs of production are lowest. If the assumption of perfect competition is added to the model, this will, indeed, be the ultimate output of the firm since price levels tend to adjust to the point where resources gain a return sufficient enough to retain the employment of the inputs being used in production, but not sufficient enough to lure additional units of the inputs into the production function. In other words, there would be no economic profits. This price level is shown as RP on the diagram.

Problems in Applying Theory to Actual Data

The problem in the application of economic theory to real life situations, is the necessary relaxation for some of the assumptions upon which the theory is built. For instance, what happens if the decision maker lacks perfect knowledge? Or, what happens if resources are not perfectly divisible? Or again, what determines the length of run and the fixity of resources? These are some of the questions involved in understanding research on economies of size. Such questions do not negate the true value of economic theory; they just make the application of the theory more challenging. Madden [3] has summarized the research pertaining to farm economies of size and much of what follows is a review of the points which he raises concerning empirical economies of size studies.

Length of Run and Fixed Versus Variable Inputs

Whenever studying problems related to economies of size, some mention must be made of the length of run. Economies which occur from firm adjustment are the result of different motives depending on whether the short-run or long-run is advocated. Madden points out that, "Short-run economies are viewed as resulting from fuller utilization of a fixed plant, long-run economies as resulting from efficiencies obtained by changing plant size, presumably involving a longer time period" [4]. However, the problem still unanswered is: where does the short-run end and where does the long-run begin? Or stated another way: when does a fixed resource become a variable resource?

Farm inputs come in various classes with differing life spans. Durable farm resources have useful life spans ranging from two to forty years, and can reasonably be considered fixed to the firm for this period of time. The issue is complicated more by the fact that there is no predetermined order for which fixed resources become variable. In light of this, length-of-run becomes a fictional time period which cannot be specified by a calendar. Instead, a series of progressively longer lengths-of-run evolve as the planning horizon lengthens and more inputs are considered variable [5]. The length of run and the fixity of resources thus become relative terms, depending solely on the entrepreneur's (or researchers) frame of mind.

Handling Discrete Resources

Economies of size studies must also deal with the problem of discrete and divisible resources. A discrete resource is defined as an input which is available to the firm in the form of specific sizes or in counted quantities. It may be a single item, or it may be increments of set sizes. A divisible resource, on the other hand, is one which is available to a firm in measured quantities.

The discrepancy between these two types of resources occurs in the utilization of the inputs. Divisible resources are usually fully utilized. Such things as gasoline, fertilizer, electricity, herbicides, seeds, etc., can be obtained in the exact amount required for production. If the divisible resource is storable, it may be saved for future use or returned to the seller.

Discrete resources, however, are often underutilized. Farm machinery invariably falls into this trap for the simple reason that the various machinery items within the system have different capacities. As a result, some items of machinery may be underutilized, while others may be overutilized at the same acreage level.

The solutions to the problem of discrete resources hinge on two alternatives. In the first place, the service of a discrete resource may be available to the firm in divisible quantities. Applying this to the farm situation, it is easy to see that such things as the hiring of part-time help, the use of custom hiring, or machinery rental and lease, are all alternatives to the discrete resource hangup. A second alternative is presented by Madden [6], who argues that the firm can come closer to full utilization of discrete resources if it uses smaller increments of the resource relative to the total quantity of the resource used by the firm. Applying this to the situation of discrete machinery inputs, it appears reasonable that, if a farm acquires tractors in discrete units of 100 horsepower for every 200 acres of land, a farm of 300 acres would require two such tractors. However, if tractors were purchased in units of 50 horsepower; and if the assumption that the smaller the tractor--the lower the cost, is valid (and it would be in this case), then a farm of 300 acres would most likely be handled at a lower per unit cost if one, 100 horsepower, and one, 50 horsepower tractor were used.

It perhaps would be wise to point out that the proper emphasis of full utilization of resources should be handled with some caution in economic studies. In general, it is true that the full utilization of resources results in a reduction of average costs; however, full utilization to lower average costs is only one method of increasing profit [7]. Consequently the profit motive may in itself dictate that the underutilization of some discrete resources will lead to increased revenues. Underutilization, or excess capacity, may also be argued as an ace in the hole against risk and uncertainty. Take for example, the accumulation of excess machinery capacity as a guard against unfavorable weather and late field operations.

The Role of Management

The term "farm management" is an often used phrase which covers a considerable area of relatively unknown boundaries. Numerous attempts have been made to define management, but as yet, no one really knows what management is, how it operates, or what capacities it offers. There are even dissenting views as to whether or not management is a factor of production or something in addition which helps explain and describe the production function. About the only concrete aspect of management that is ascertainable, is the apparent results of managerial activities, and in some cases this has to be interpreted with caution.

In general however, farm management is the decision making process for a farm. Not only does this include the day in--day out type of decision required for normal activity, it also pertains to the process of formulating major decisions which often change the structure of a farming operation. The activities of a farm manager are usually described in terms of supervision, coordination, and entrepreneurship. The first two involve decision making to handle daily operations and coordinate daily operations into a smooth and efficient production cycle. Entrepreneurship pertains to the process of making major decisions and accepting the risk and uncertainty associated with the success or failure possibilities after the decision is made [8].

The problem of handling farm management in studies on farm structure and behavior, is that it represents intangible attributes. Farm management per se, cannot be perceived in any form of the senses, and hence cannot be quantified. As a result, the only alternative for defining farm management rests in the ability to qualify the term in some identifiable manner relative to present levels of technology and knowledge. In economies of size studies, once this is done all other resources are added to the production function to develop cost statistics for various levels of output. The real problem occurs when it becomes obvious that to advantageously add resources (other than those with an assumed level), requires excess managerial capacity on the part of the farmer. When farm complexity and size is increased, the chances of financial success or failure become greater; as do the problems of supervision and coordination. Defining the managerial capacity at some level may not be sufficient to cover the entire range studied and, hence, may seriously limit the size or extent of the farm to something below that indicated as most efficient by an assumed managerial level.

Profit and Residual Claimant

Economic studies which include costs and profits are often misinterpreted, especially when comparing one study with another. As Madden points out, the problem is likely to be a lack of specification for the residual claimant; or that set of resources which absorb the profit [9].

The definitions of profit and residual claimant vary, depending on the extent to which the factors of productions have received a fair return from gross income.

For instance, two popular concepts of profit and residual claimant [10] in farm management studies are "net farm income" and "operator management income." Under the first concept, all cash costs and depreciation are subtracted from gross receipts to arrive at the net farm income figure. Such a figure however, fails to recognize the opportunity cost on the equity portion of farm investments, and it fails to recognize an opportunity cost on the farm operator's labor and managerial abilities.

The second concept is a further refinement of residual in that "operator management income" also subtracts a return for interest on investment and a return for operator labor. The amount of receipts which still remain, represent the return to the operator for his managerial services.

The importance of the above two definitions can readily be seen in a hypothetical farming situation. Assume for the moment that a farmer held full equity in his operation and received a positive net farm income but a negative operator management income. Based on this assumption, a farmer in such a position could continue operating indefinitely since, even though he is not receiving a fair market return on his investment, and his ability as a laborer and manager, all depreciation and cash costs would be covered by the receipts. However, for a young individual considering the long-run consequences of starting a similar farm, the revenues would not be sufficient to entice him into the same farm type since alternative investment and employment would offer greater returns.

The above points out that for proper interpretation of farm management and economies of size studies, it is imperative that the individual understand how the residual claimant is defined and how other resources are priced. Unless this is done, a cost statistic, a profit statistic, or a cost:revenue statistic has no real meaning within itself nor in comparison with similar statistics from other studies.

A Review of Other Studies

There recently has been a number of economies of size studies for various types of farms throughout the United States. Some of these studies have emphasized beef-lot economies of size [11, 12], while about an equal number of studies have directed primary emphasis toward economies within a dairy farm [13, 14]. In the area of crop production, size efficiency studies have emphasized such things as optimizing fruit harvesting [15] and least-cost enterprise combinations [16]. The discussion which follows is a review of two prior studies in the area of selecting farm machinery. The first article refers to a study which treated farm machinery in preharvest and harvesting systems, while the latter analyzes cost for entire systems.

Oklahoma Study

In 1964, Walker published a bulletin entitled Machinery Combinations for Oklahoma Panhandle Grain Farms [17]. In his study, Walker attempted to isolate average cost statistics for alternative preharvest farm machinery systems and for alternative harvesting methods. Machinery performance and cost data in his study was obtained from a 1960 survey of 57 farmers and 10 machinery dealers in the Oklahoma Panhandle.

Walker's cost statistics are straightforward average total preharvest machinery costs per acre for the alternative machinery combinations. Thus, the cost curves are continuously downward sloping to a point of limited machinery capacity. These capacities for the alternative systems were calculated on the basis of calendar time periods for all critical jobs, the corresponding probabilities of 10 hour work days available, and machinery performance rates.

The cost curves presented in Walker's study do not include receipts from products sold, and consequently, there are no cost:revenue ratios. His technique is to limit the analysis of cost only to the range of acreage for which a given machinery system is capable of handling field operations within critical time periods. At the acreage level for which the capacity of the preharvest machinery combination limits timely operations, the cost curves abruptly stop.

The preharvest machinery combinations analyzed were; (a) two, 4-plow tractors and equipment, (b) one, 4-plow tractor and equipment, (c) one, 3-plow tractor and equipment, (d) two, 5-plow tractors and equipment, (e) one 5-plow tractor and equipment, and (f) complete custom hiring. The analysis showed that in 50 percent of the years, farmers could cover the critical operations at a minimum cost with the following systems and acreage ranges:

1. custom hiring--0 to 300 acres of cropland

2. one, 3-plow tractor and equipment--300 to 400 acres of cropland

3. one, 4-plow tractor and equipment--400 to 900 acres of cropland

4. one, 5-plow tractor and equipment--900 to 1400 acres of cropland

5. two, 4-plow tractors and equipment--1400 to 2000 acres of cropland

The latter part of Walker's article is devoted to an analysis of harvesting operations using the alternatives of ownership of 12, 14, and 16 foot self-propelled combines versus custom hiring. The author shows that the breakeven acreage levels between ownership and custom hiring at 3 dollars per acre, are 360, 385, and 445 acres for the 12, 14, and 16 foot machines respectively. He goes on to develop five different harvesting "strategies" based on various assumptions as to the availability of custom operators and a fixed number of days available for harvesting operations. For each strategy he develops per acre harvesting and insurance costs for completing harvesting operations on time.

The conclusions that Walker draws from his study are mainly that the number of "tractors and the use of custom rather than owned machinery may have substantial effects on total machinery costs" [18]. The availability of custom operators would reduce costs on farms of up to 300 acres. The decision as to the size of tractor appeared to have little relevance in the 600 to 1000 acre cropland farms, however, the maintenance and purchase of a second tractor added approximately $600 to annual machinery costs on the same size farm.

In regards to harvesting methods, Walker concluded that the larger machines ". . . provide lower cost services when days to combine are fixed. Smaller machines allow lower per acre costs when a restriction is not placed on harvest days" [19].

Iowa Study

In 1964, Ihnen and Heady published a study called Cost Functions in Relation to Farm Size and Machinery Technology in Southern Iowa [20]. The study was directed towards farms in nine southern Iowa counties and used synthetic-firm budgeting models. The farms were divided into three different classes of topography--hilly, upland, and average. The objective was to develop least-cost machinery combinations for various size farms in each of the three classes.

The machinery systems considered in the Ihnen and Heady publication were identified by the size of the moldboard plow and were as follows; (a) 2-plow, (b) 3-plow, (c) 2-plow, 2-plow, (d) 2-plow, 3-plow, and (e) 3-plow, 3-plow. The machinery, excepting for one case of custom operations, was fully owned.

The analysis used by Ihnen and Heady was based on two budgeting models. The first model assumed costs and revenues for crop enterprises while the second model included both crop and a beef-cow enterprise. The results of changing from the first model to the second model showed "relatively little effect upon the basic budgeting results or cost relationships" [21].

The authors included in their analysis a schedule for crop losses due to untimely field operations and treated these losses as a cost rather than reductions in revenue. Other costs included depreciation, interest, taxes, housing and insurance, seed, fertilizer, insecticides, fuel, oil, repairs, land, and labor.

The results of the analysis showed that "substantial reduction in average total cost per dollar of crop product can be obtained by using larger machinery combinations on larger crop acreages when custom operations are not considered" [22]. Minimum unit costs were found to exist at about 320 crop acres on each farm. The range of constant costs [23] ran from 196 to 232 crop acres for a 2-man, 2-tractor machinery combination when custom operations were not considered. For smaller acreages, the smaller machinery systems resulted in the lowest unit costs, but these costs were high relative to the minimum unit costs. Also, the smaller machinery systems resulted in more yield and revenue losses due to untimely field operations when acreage increased.

In the one isolated example of custom operations, Ihnen and Heady found that "custom operations increase the relative efficiency of the 1-man, 1-tractor machinery combination and makes these small machinery combinations as efficient on small acreages as the larger machinery combinations on the larger acreages" [24].

References

1. The expressions "economies of size" and "economies of scale" are often used interchangeably in studies examining the relationship between average costs and levels of production. However, since the word "scale" usually implies constant proportions, much confusion has resulted from the improper specification of these two concepts. In general, since firms do not expand output by increasing resources and products in exactly the same proportions, "economies of size" has evolved as the more proper expression. At any rate, the term economies of size is adopted for this study, and defined as reductions in total cost per unit of production resulting from changes in the quantity of resources employed by the firm or in the firms output.

2. Further refinement of the fixed versus variable classification can be made. For instance, Bradford and Johnson talk of resources which are fixed to the firm, but variable between enterprises. See, Lawrence A. Bradford and Glenn L. Johnson, Farm Management Analysis, John Wiley & Sons, Inc., New York, 1963, p. 168.

3. J. Patrick Madden, Economies of Size in Farming, Agricultural Economic Report No. 107, Economic Research Service, U. S. Department of Agriculture, February 1967.

4. Ibid., p. 3.

5. Ibid., p. 5.

6. Ibid., p. 7.

7. Ibid.

8. Ibid., p. 8.

9. Ibid., p. 13.

10. For a definition and listing of other alternatives see, J. Patrick Madden, Ibid., p. 14.

11. John A. Hopkin, "Economies of Size in the Cattle Feeding Industry of California," Journal of Farm Economics, Vol. 40, No. 2, May 1958, pp. 417-429.

12. Elmer C. Hunter and J. Patrick Madden, Economies of Size for Specialized Beef Feedlots in Colorado, Agricultural Economics Report No. 91, U. S. Department of Agriculture, May 1966.

13. William E. Martin and James S. Hill, Cost-Size Relationships for Central Arizona Dairies, Technical Bulletin No. 149, Arizona Agricultural Experiment Station, September 1962.

14. Boyd M. Buxton, Economies of Size in Dairy Farming, Farm Business Notes 467, University of Minnesota, November 1964.

15. Gerald W. Dean and Harold O. Carter, Economies of Scale in California Cling Peach Production, California Agricultural Experiment Station Bulletin No. 793, February 1963.

16. J. Patrick Madden and Bob Davis, Economies of Size on Irrigated Cotton Farms of the Texas High Plains, Texas Agricultural Experiment Station, Bulletin B-1037, June 1965.

17. Odell L. Walker, Machinery Combinations for Oklahoma Panhandle Grain Farms, Experiment Station Bulletin B-630, Oklahoma State University, November 1964.

18. Ibid., p. 22.

19. Ibid., p. 23.

20. Loren Ihnen and Earl O. Heady, Cost Functions in Relation to Farm Size and Machinery Technology in Southern Iowa. Agricultural and Home Economics Experiment Station, Research Bulletin 527, Iowa State University, May 1964.

21. Ibid., p. 125.

22. Ibid., p. 125.

23. Constant costs were defined as those costs within five percent of the minimum.

24. Ihnen and Heady, loc. cit., p. 125.

CHAPTER III

METHODOLOGY AND INFORMATIONAL SOURCES

There are, depending on the motives and situations, a number of methods for analyzing economies of size studies [1]. However, it is generally recognized that the synthetic firm approach offers the best method for isolating differences in average costs per unit of output which are attributable to differences in size of the firm. Since this represents the main interest of this study, the "synthetic firm" approach was adopted in the analysis procedure.

Selection of a Farm and Its Characteristics

The location of the synthetic farm was placed in the southern half of lower Michigan; exclusive of the Saginaw Valley area. The soils of the hypothetical firm were assumed to consist entirely of the adequately well drained clay to clay loam series, which closely correspond with the majority of actual soil types located in this part of Michigan.

The selection of the product mix was based on the average number of enterprise acres reported by the forty-three Michigan cash-grain farms enrolled in the Michigan

Telfarm project in 1966 [2]. From this data, a typical acre was calculated and defined as the percentage composition of each crop or productive use made of an acre of tillable land. The percentages are based on the reported average number of tillable acres minus the acreage designated as "other crops." For simplicity, and because the oat enterprise is similar in most respects to the wheat enterprise, the relatively small acreage reported as oats was combined with wheat acreage and called the wheat enterprise. As Appendix Table 1 shows, the typical acre was found to consist of 36 percent corn, 15 percent soybeans, 19 percent navy beans, 15 percent wheat, 12 percent diverted, and 3 percent idle.

For purposes of analysis, this study only considered the costs and revenues associated with the productive crops of corn, soybeans, navy beans, and wheat. Because of the wide range of alternative uses and practices for idle and diverted acres, the costs (machinery and labor) and the possible revenues, attributable to these acreages, were ignored.

The level of management (and corresponding production practices and inputs) assumed for the synthetic farm was above average and defined as the level ". . . required to obtain yields intermediate between present average yields and highest yields presently being attained experimentally and by some producers" [3]. The associated crop yields and productive practices are listed in Appendix Table 2.

General Data Sources

Much of the supporting data for this study was obtained from other sources. The majority of the machinery data on new costs, operating costs, and ownerships costs came from an earlier publication by Connor [4] and his supporting unpublished data. Whenever necessary, his data was supplemented by information obtained from the Agricultural Engineering Department at Michigan State University and from farm equipment manufacturers offices located in the Lansing area. Information on current rental and leasing practices in Michigan was obtained by the use of direct mail questionnaires sent out to 375 Michigan farm machinery dealers.

The data for yield losses due to untimely operations, was provided by the efforts of the Crop Science Department at Michigan State University. The United States Weather Bureau and the Agricultural Engineering Department at Michigan State University were helpful in providing data on inclement weather and resulting lost field work time.

USDA, Experiment Station, and Departmental publications were also used, but are too numerous to mention individually. However, an attempt has been made to identify; either in the text or in the supporting Appendix Tables; all relevant informational sources.

Survey on Renting and Leasing

The practice of renting and leasing farm equipment is not new to farm machinery dealers. Trade journals and farm equipment representative association publications have recently explored this practice and found it has been fairly successful for a few dealers located in the Midwest [5, 6, 7]. However, even though most farm equipment manufacturers provide their dealers with appropriate guidelines, the practice of renting and leasing farm machinery is relatively unknown in Michigan. Therefore, in an attempt to learn the exact nature and extent of farm machinery rental and leasing as it applies to Michigan, a mailed survey questionnaire was sent to 375 farm equipment dealers located throughout the state. The following discussion summarizes the results of that questionnaire. A copy of the actual questionnaire used appears in Appendix Table 17.

A total of 375 questionnaires were mailed to the major farm equipment dealers who held membership in the Michigan Farm Power and Equipment Association. Of the 163 questionnaires returned (43 percent) only twenty-six dealers indicated they had programs to rent or lease to farmers.

Eighteen additional dealers reported they had intentions of starting such a program within the next two years while six others indicated they were undecided about starting a rental or lease program.

Short-Term Renting or Leasing

Out of the twenty-six dealers who had rental or lease provisions, only eighteen rented or leased farm machinery on a short-term basis in 1967. Six of these eighteen provided the service on both new and used equipment; ten dealers rented or leased only used equipment, and two dealers rented or leased only new equipment.

Of the dealers responding to the question on whether or not the farmer is required to pay the short-term payments when use of the machine is delayed by inclement weather, 71 percent indicated the farmer did, in fact, have to bear the risk of bad weather by meeting payment obligations whether he did, or did not use the machine. Responses to other short-term responsibilities indicated that a majority of the dealers considered the farmer obligated for the following items; liabilities, operating costs, and transportation costs. Dealers themselves assumed the costs for insurance, taxes, and normal wear and tear. The maintenance responsibility was about evenly divided with 59 percent of the dealers indicating the farmer paid this cost while two other dealers reported that maintenance was handled on a fifty-fifty basis. A summary of the responsibilities appears in Table 4.

The results to the question on the extent and nature of the short-term rental or lease programs in 1967 showed considerable variation in all respects. Although the tractor and tractor-plow combination appeared to be the most popular items placed under short-term contracts, the different items of machinery reported, ranged from manure spreaders to post hole diggers.

Sizes or capacity of the major items also showed considerable variation. For instance, the size of tractors varied from 30 horsepower to 124 horsepower. Considerable differences were also noted in the time period, or calendar period, of the short-term contracts. Although eight weeks was the longest period reported, the majority of responses fell within the one week or less category.

Rates charged for the tillage and planting equipment were, for the most part, fairly comparable. However, the number of these items reported was very limited. Rates charged for tractors and/or plows showed wide variation depending on the size of the tractor and the number of plow bottoms. Generally rates were quoted on a per day, per acre, or per hour basis with a couple of reports charging on a combination of hours and days. The range ran from 3 dollars per hour to 7 dollars per hour plus 5 dollars per day.

TABLE 4.--Summary of questionnaires returned, number of dealers renting or leasing, and short-term contractual responsibilities.

Number of questionnaires mailed	375
Number of questionnaires returned	163
Percent returned	43
Number of dealers with rental or lease programs	26
Number of dealers holding short-term contracts in 1967	18
Number of dealers renting or leasing new and used equipment in 1967 on short-term basis	6
Number of dealers renting or leasing used equipment only in 1967 on short-term basis	10
Number of dealers renting or leasing new equipment only in 1967 on short-term basis	2

Farmer responsible for short-term payments when inclement weather prohibits use of the machine[1] YES 15 NO 6

Responsibilities[1]	Number of Dealers Reporting the	
	Farmer was Responsible	Dealer was Responsible
Insurance	3	16
Taxes	5	12
Liabilities	16	3
Maintenance[2]	10	7
Normal Wear and Tear	4	15
Operating Cost	19	0
Transportation	6	12

[1]Although only 18 dealers had short-term rental or lease programs in 1967, other dealers indicated the provisions within their contracts, by responding to these questions. Hence the number of responses will in some cases exceed 18.

[2]Two dealers indicated this was handled on a 50-50 basis.

Since the results of the extent and nature of short term renting and leasing showed such wide variation, no attempt was made to compute average values. However, Appendix Table 18 gives the complete breakdown of items, sizes, lengths of contract, and rates charged as reported by the eighteen dealers.

Long-Term Renting and Leasing

Of the twenty-six dealers who reportedly had provisions for renting or leasing farm machinery to farmers, only two dealers indicated they actually held farm machinery under long-term contracts [8] in 1967. In addition to this, eleven other dealers indicated that, although they had no machinery placed under long-term arrangements in 1967, they might have facilities for doing so, by answering questions which pertained only to the long-term portion of the questionnaire. Since this led to some doubt [9] as to the validity of the responses, the following discussion summarizes the reports of the two dealers separately from the eleven other dealers.

The two dealers holding long-term contracts in 1967 reported that the agreements applied only to new farm machinery. Both dealers required the farmer to bear 100 percent of the responsibilities listed. Responses to the question on investment credit revealed that one dealer passes this tax benefit on to the farmer while the other makes no provisions. Both dealers were likewise split on the question of a purchase option; one dealer reporting his contracts did not contain the purchase option and the other indicating that such an option was a part of the contract.

The items and sizes of machinery reported as presently under long-term contracts were as follows; one tractor of 130 horsepower; one 12-row planter; one 5 foot stalk chopper; one 13 foot combine; and one chopper. The reported length of the contracts were for three years with one dealer listing an annual rate of 28.7 percent of delivered sales price and other dealer reporting an undeterminable rate.

From the additional information obtained from the other eleven dealers, it appeared that the problem of handling investment credit under long-term lease contracts, posed the least continuity among dealers. The responses to this question were about evenly divided between the dealer taking the investment credit himself, the dealer passing it on to the farmer, and no provisions made. These same dealers were, however, almost unanimous in reporting that their contracts for long-term leasing contain a purchase option. Their responses were fairly even, but slightly in favor of a specific purchase option price, and slightly against applying a percentage of past lease payments to the purchase option price.

The above presents some idea of the current development of farm machinery rental and leasing as it is presently known for Michigan. It appears that this type of a program is in a beginning stage and, aside from the few dealers currently renting and leasing, most dealers have no immediate intentions of expanding this service into their overall program. Dealers and farmers alike are still floundering with the problem of how contracts can be formalized for the mutual benefit of both parties. As more knowledge and experience is obtained in this area, and as the structure of farming changes, the renting and leasing of farm machinery may become a common practice. In the meantime, it will remain a limited means of acquiring machinery services.

For the farmer, renting and leasing of equipment is an expensive alternative and from this standpoint, it can not compete with other alternatives. Current rates severly limit the practicability of renting or leasing those items of equipment which are used extensively in the farming operation. The unpredictability of weather alone places some doubt as to the feasibility of short-term agreements since no farmer wants to pay rent on a tractor for three days only to have it sit idle due to inclement weather. Also, aside from some initial "down payment" benefits, long-run costs, under the long-term contracts, often considerably exceed other alternatives.

Since the results of the farm machinery rental and lease survey showed relatively little of this practice currently being done in Michigan, and because the costs of such an alternative are not comparable to other means of acquiring farm machinery services, the analysis of this study does not include renting and leasing within the machinery systems. Major emphasis is instead, placed more on the current machinery systems used by cash-grain farmers. Chapter V does, however, contain some possible economic implications of the renting and leasing alternative.

The Selection and Description of Various Farm Machinery Systems

The commercial cash-grain farmer of today must have answers to certain questions before he can wisely select a machinery system to till, plant, and harvest his crops. First and foremost, he must determine what crop enterprises are most profitable for his farm business. Secondly, based on the knowledge of the farm organization and recommended technological practices, the farmer should determine what types of machinery are needed to accomplish the recommended practices. Thirdly, in order to determine the number and sizes of machines needed, a comparison should be made between machinery efficiency (or capacity) schedules and the number of acres which have to be covered in the limited time available. The fourth step requires knowledge of alternative means of acquiring machinery services, while step number five requires some knowledge of alternative uses for capital and credit [10].

The over-riding criteria, however, is the importance of analyzing farm machinery needs in terms of a systems approach rather than by the needs for one machine or the machinery needs for one enterprise. The production cycle of a cash-grain farm is typically made up of several separate and distinct field operations which are performed by the same piece of machinery, and which must be performed within certain time periods. The unfortunate problem is that in many cases these separate and distinct operations must be done within the same time period with only one piece of machinery. For instance, a similar problem arose in this study where the optimum harvesting dates for soybeans was October 1-10. This period was overlapped by the October 5-15 optimum harvesting dates for corn. Another example occurs in the early season of field work where optimum dates for planting corn interfer with normal tillage for the soybeans and navy beans.

When such problems as these occur, the analysis procedure which concentrates only on the machinery needs for a particular enterprise would most likely have recommended a combine too small in the first example because it would fail to acknowledge the needed capacity to complete both harvesting operations on time. In the second example, if the analysis procedure were based solely on the needs of a tractor, the results again would under-estimate actual requirements because of a failure to account for the competing time element. In both cases, a far better method of approximating machinery needs to fulfill the requirements of the entire farm situation, rests with the use of a systems approach.

The commercial cash-grain farmer of today is faced with several alternatives for selecting the services of farm machinery systems. His range of choice includes complete ownership, complete custom hiring, a combination of ownership with custom hiring, and a combination of ownership with renting or leasing. As previously indicated, the emphasis of this study is placed on the current machinery systems used by Michigan farmers. Consequently only the first three alternatives above are utilized in the analysis.

Five basic machinery systems were identified in this study. These systems were: (a) 4-row system with complete ownership, (b) 4-row system with a combination of ownership and custom hiring, (c) 6-row system with complete ownership, (d) 6-row system with a combination of ownership and custom hiring, and (e) complete custom hiring [11]. Appendix Table 4 lists the items of machinery included in the 4-row and 6-row systems.

Although the method of complete custom hiring is not currently widely used in Michigan, there are, in some areas of the state, reports that such a practice has been fairly successful [12]. However, the main reason this system was included in the analysis was because of the potential that such a method of acquiring farm machinery services might have in the future. For example, complete custom hiring could be beneficial to the elderly farmer who is nearing retirement or it could be an alternative to the farmer with a limited labor supply or a limited level of technical skills which are required for owning and operating the necessary equipment. Adoption of the complete custom hiring alternative allows farmers to concentrate entirely on the management functions with primary responsibilities devoted to selecting custom operators who have the proper equipment for doing the job right, and scheduling their services into the proper sequence of production practices.

The 4-row and 6-row systems with complete ownership represent the majority of machinery systems currently used on Michigan cash-grain farms. Under these two systems, the farmer owns and operates all of the machinery required to complete the production cycle for all enterprises. Hence he becomes directly responsible for all operating and ownership costs for the entire machinery system.

For the 4-row and 6-row systems, with a combination of ownership and custom hiring, it is assumed that all harvesting operations and the bulk spreading of fertilizer, are completed by custom operators. The farm owner only maintains equity in the power (tractor), tillage, and planting equipment. As a manager, he is responsible for scheduling his own operations and those of the custom operators into a smooth and efficient productive cycle.

General Assumptions

As in any analytical study, several simplifying assumptions must be made in order to designate a workable problem. The assumptions listed below pertain to the budgeting models used in this study.

1. The farm owner was assumed to be the manager and operator for all field work, except for the cases calling for custom operations, in which case the farm owner became strictly a manager.

2. Labor requirements fulfilled by the farm owner were charged at the rate of $1.50 per hour. In the case of custom hiring, all labor was supplied by the custom operators who included the labor charge within the custom rates.

3. The farm, regardless of size, consisted of only one soil type, namely the adequately well drained, clay to clay loam.

4. The cropping plan remained the same as farm size varied. This cropping plan allowed for the following typical productive crop acre: 36 percent corn, 19 percent navy beans, 15 percent soybeans, and 15 percent wheat. The remaining 15 percent consisted of idle and diverted acres.

5. The level of management was assumed to be above average, with yields (and corresponding production practices) intermediate between current average yields and the highest yields being recorded experimentally and by top producers.

6. All field operations had to be completed in the proper sequence of normal operations. Thus late completion of one operation delayed the starting time of the next operation.

7. The five machinery systems included in the analysis remained fixed as farm acreage increased.

8. The number of hours available for field operations by the farmer was limited to 10 hours per day and 6 days per week (i.e. 60 hours per week).

9. All owned farm machinery was assumed to be purchased as new equipment, and depreciated on a basis of the number of years of normal life or the number of years until physically worn out; whichever was shorter.

10. All prices paid for inputs were assumed to approximate current market prices. Prices received were the approximate 1965-66 season average prices received in southern lower Michigan.

11. Custom operators were assumed to be available in sufficient numbers to complete all operations on time, or as soon as biologically possible. Hence, if the corn, navy beans, and soybeans crops were planted on time, they would also be harvested on time. If 10 percent of any of these crops were planted one week late, then 10 percent of the same crop was harvested one week late. (The above does not apply to late planting of wheat because after surviving the dormant winter stage, all wheat will mature at about the same time, regardless of the various planting dates.)

12. All crops were assumed to be transported from the point of harvest to public storage facilities by custom hauling. Hence, the farm machinery systems did not include facilities for crop hauling nor did the labor requirements include time spent for crop storage.

13. Harvesting and planting operations were not permitted to commence before the optimum time periods for maximum possible yields.

14. A constant state of the arts was assumed.

The Analysis Procedure

In an effort to meet the objectives for this study, two budgeting models were utilized in the analysis procedure. The first model was referred to as Budgeting Model I, and the second; Budgeting Model II.

Budgeting Model I

The intent of Budgeting Model I was to relate farm size with power, machinery, and labor costs for the five machinery systems analyzed. To better understand this relationship, budgets and graphs were developed which portrayed these costs on a per acre basis. The procedure assumed that the five machinery systems remained fixed as farm size ranged from 0 to 1000 tillable acres by 40 acre increments.

Machinery costs included both the operating and ownership costs [13]. Operating costs included repairs, fuel, lubrication, oil, and oil filters. Repairs for all items of machinery were based on a percentage of new costs. Lubrication charges for tractors and self-propelled items were estimated as a percentage of new costs while lubrication costs for other items of machinery were computed at 5 cents per hour of use. Fuel rates for tractors were based on an average fuel consumption of .065 gallon of diesel fuel per rated drawbar horsepower [14]. Combine fuel rates were based on an average fuel consumption of .3 gallon per hour per foot of cut. Oil and oil filter costs were based on a rate of 15 percent of fuel costs. These operating costs for selected items of machinery are shown in more detail in Appendix Table 9.

The ownership costs of a machinery system included depreciation, interest, and insurance. Depreciation was calculated on the straight line method over the expected normal life of the machine until technological obsolescence required replacement. In the event that the number of tillable acres at a given farm size required excessive use of any machinery item (i.e., it became worn out before reaching technological obsolescence), the shorter number of years of life which resulted, was used as the base. In all cases, salvage values were estimated to be 10 percent of new costs.

Annual interest and insurance rates were based on the average investment value for each item of machinery within a system. Rates of 6 percent and .7 percent, which approximate current rates, were chosen for the interest and insurance charges, respectively. More complete details of annual machinery ownership costs and expected years of life until technological obsolescence are given in Appendix Table 4. Appendix Tables 5-8 present the annual ownership costs schedules by farm size for excessive machinery use.

For Budgeting Model I, data obtained from farm machinery and labor efficiency tables gave results leading to "direct" [15] labor and machinery hours required per acre. Since all machinery operating costs were based on hourly rates, and labor was charged at the rate of $1.50 per hour [16], these results were easily converted to dollars of operating and labor costs for any given size of farm. Total costs were computed by adding annual ownership costs to the operating and labor costs. Finally, by assuming the enterprise mix and the machinery systems were fixed, an average total cost per acre was calculated by dividing tillable acres into the total costs for each 40 acre incremental increase in farm size. Appendix Tables 10-14 relate the efficiency schedules and the per acre operating costs for selected items of machinery.

Budgeting Model II

Budgeting Model II is a refinement of its counterpart in that this model included two importantly related problems; the problem of inclement weather and the problem of completing operations on time to avoid losses in crop yields. The ultimate objective of Budgeting Model II was to obtain cost:revenue curves showing the traditional segments of decreasing, constant, and increasing costs of production for each of the machinery systems studied. By generating these costs curves, further insights were possible into such areas as break-even analysis, and basic size-efficiency relationships for southern Michigan cash-grain farmers.

The ability to complete field operations on time is important to a cash-grain farmer for two reasons. In the first place, losses in crop yields could reasonably be expected to occur from planting and harvesting crops too early. For instance, a late frost in the spring can stunt or delay the growth of crops planted too early, while a lack of complete maturing or high moisture contents are deterents to early fall harvesting. A second reason for completing operations on time is to avoid late planting and harvesting operations which result in shortened growing seasons and increase the risks of early killing frosts in the fall.

From a practical standpoint, early operations present a small problem relative to late operations. For the most part, crops are planted in the spring as soon as weather permits and harvested in the fall when the crop ripens. Consequently, this study ignored early planting and harvesting by assuming these two operations could not begin before the appropriate calendar dates for maximum possible yields.

Late planting and harvesting operations were, however, considered an important part of Budgeting Model II. As farm acreage increased in 40 acre increments, each of the fixed machinery systems ultimately reached a point of limited capacity; above which late planting and harvesting operation resulted in reduced yields per acre. This study treated the lower yields as reductions in revenue in interpreting the effects of late operations on size-efficiency relationships. The summary for critical planting and harvesting dates and losses in yields resulting from late operations is found in Appendix Table 26.

Complicating the problem of timeliness of operation was the problem of inclement weather and the corresponding lost time available for field work. Because of a lack of data, incorporating this problem into the budgets posed one of the biggest headaches of this study. The method finally adopted was based on a straight line regression between inches of precipitation and field work days lost [17]. For analytical purposes, the field working season from April 1 to November 30, was divided into 35 "climatic weeks," and based on local climatological data, an average weekly precipitation value was calculated for each of the climatic weeks. The corresponding number of work days lost within each week was obtained directly from the regression line. Appendix Table 24 lists the average amounts of precipitation (and corresponding work days lost) by weeks. Appendix Table 25 shows the plotted regression equation.

The end result of Budgeting Model II was to plot total dollar costs per total dollar receipts (i.e., cost: revenue ratio) against farm size [18]. Total receipts consisted entirely of cash sales from the corn, soybean, navy bean, and wheat enterprises. Costs included machinery, labor, custom crop hauling, seed, fertilizer, herbicides, and an opportunity cost of six percent on the land investment. A listing of the prices paid (other than machinery) and received are found in Appendix Table 3.

References

1. For a listing and description of the more common alternatives, see; J. Patrick Madden, Economies of Size in Farming, Agricultural Economic Report No. 107, Economic Research Service, U. S. Department of Agriculture, pp. 24-34.

2. The averages of the 43 farms as a group, were not published, although the information is available from the Department of Agricultural Economics, Michigan State University. For some idea of the averages as published by size of farm investment, see; Cash Grain Farming Today: What It Costs, How It Pays, A. Ec. 68, Cooperative Extension Service, and Department of Agricultural Economics, Michigan State University, 1967.

3. Larry J. Connor, Costs and Returns for Major Cash Crops in Southern Michigan, Agricultural Economics Report No. 87, Department of Agricultural Economics, Michigan State University, 1967.

4. Ibid.

5. "Rental Opens the Door to Increased Sales," Farm and Power Equipment, March 1967, p. 25.

6. Warren Smith, "They've Made Leasing Work," Implement and Tractor, March 21, 1965, p. 20.

7. Bill Fogarty, "A New Enterprise for Leasing Farm Equipment," Implement and Tractor, May 15, 1962, p. 38.

8. A short-term contract was defined as the rental or lease agreement that is binding for less than one year. Long-term contracts were defined as binding for one year or more.

9. The question of doubt was primarily that these 11 dealers might have confused questions on long-term contracts with short-term contracts.

10. Larry J. Connor, Guidelines for Selecting Machinery Systems, unpublished speech given at Farmer's Week, Michigan State University, February 1968.

11. Although some farmers currently operate with basically a two-row system, the number of farmers doing so represent a small percent of the commercial cash-grain farmers in Michigan. This same reasoning applies to the few isolated farmers who operate what could be termed as an 8-row system. Since the extent of these two systems are limited, they are not included in the analysis.

12. Based on an interview with a professional farm manager.

13. These are sometimes referred to as variable and fixed costs.

14. Rated drawbar horsepower is 75 percent of the maximum.

15. Direct hours are defined as the number of actual hours that machinery and labor are utilized while in the field. This includes normal in field repair and adjustments for all equipment. It does not, however, account for the time a farmer spends in traveling from one field to another or for the time spent going from the tool shed to the field. Also, it fails to account for the time required to convert one machine to an alternative operation (i.e., replacing the grain platofrm on a self-propelled combine with the corn head).

16. A rate of $1.50 per hour for labor approximates the average hourly wage rate paid to farm labor.

17. Unpublished data, U. S. Weather Bureau and Agricultural Engineering Department, Michigan State University.

18. Since this study uses a constant enterprise mix, farm size is an acceptable measure of output levels.

CHAPTER IV

THE ANALYSIS

The analysis was completed by using the two budgeting models described in Chapter III. The analysis results for both models are described in the following text. Supporting material is presented in the Appendix.

Budgeting Model I

The intent of Budgeting Model I was to show the relationship between costs and farm size for the five machinery systems analyzed. More specifically, the objective was to show how farm machinery and labor costs per acre decrease as farm acreage increases.

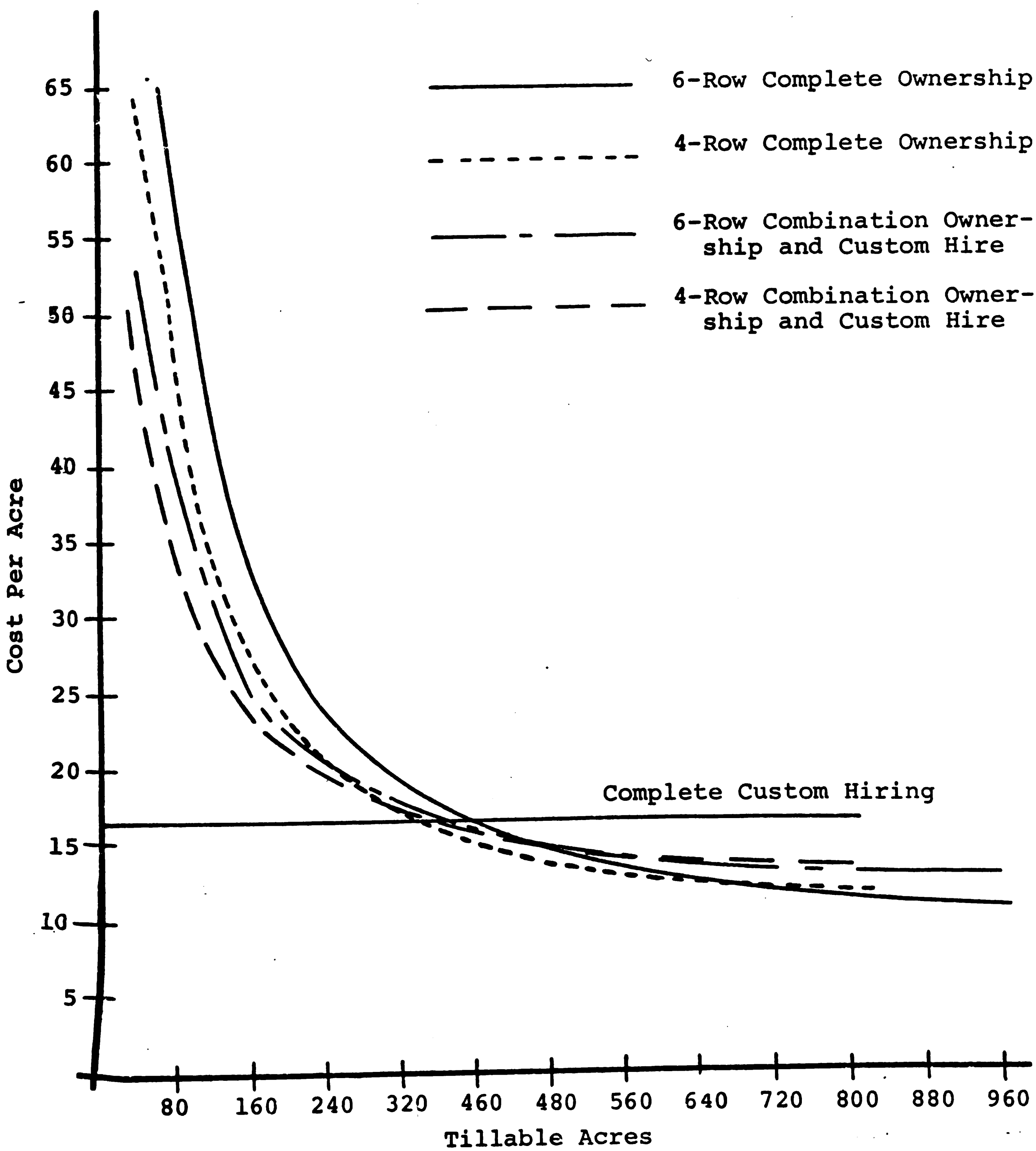
The data supporting Budgeting Model I are presented in the following Appendix Tables: Appendix Tables 5-8 present the annual ownership cost schedule, Appendix Tables 11-14 compute the operating costs per acre by enterprise for the various machinery systems involving ownership, Appendix Table 15 shows custom rates by enterprise for the complete custom hire system. The budgets, which derived the cost per acre statistics for Budgeting Model I, were computed from the above data. These budgets are located in Appendix Tables 19 through 23. The results of the budgets are presented in graphical form in Figure 2 [1].

The results of Budgeting Model I indicated that, from a cost standpoint, complete custom hiring offered the cheapest means of acquiring farm machinery services for farms with 322 tillable or less. Between 323 and 343 tillable acres, the 4-row system with a combination of ownership and custom hiring resulted in the least dollar labor and machinery costs per acre. From 344 to 597 tillable acres, the system of complete ownership of a 4-row system was found to give the lowest per acre costs; while above 597 acres the 6-row system of complete ownership presented the lowest per acre costs for labor and machinery. These findings are summarized in Table 5 below.

TABLE 5.--Summary of Results for Budgeting Model I

Machinery System	Range in Acreage Exhibiting Minimum Cost	Costs Per Acre at The Lower Acreage Level	Costs Per Acre at The Higher Acreage Level
	(acres)	($)	($)
Complete custom hiring	0 - 322	16.68	16.68
Combination ownership & custom hire, 4-row	323 - 343	16.67	16.27
Complete ownership 4-row	344 - 597	16.24	12.57
Complete ownership 6-row	598 - 1000	12.56	10.66

FIGURE 2.--Costs Per Acre for Various Farm Sizes and Machinery Systems



Budgeting Model II

The second budgeting model was used in an attempt to portray the entire picture of both costs and revenues. It incorporated the timeliness of operations into the analysis and charged lost revenues from late operations as a deduction in total revenue. The intent of Budgeting Model II was to derive breakeven points between costs and revenues, and to analyze the size-efficiency relationships for a southern Michigan cash-grain farm.

The costs of this second model included those of Budgeting Model I plus seed, fertilizer, herbicide, an opportunity cost for land investment, and custom hauling. Appendix Table 3 lists the prices paid as used in this study. Appendix Table 16 aggregates the total variable costs per acre by machinery system and enterprise.

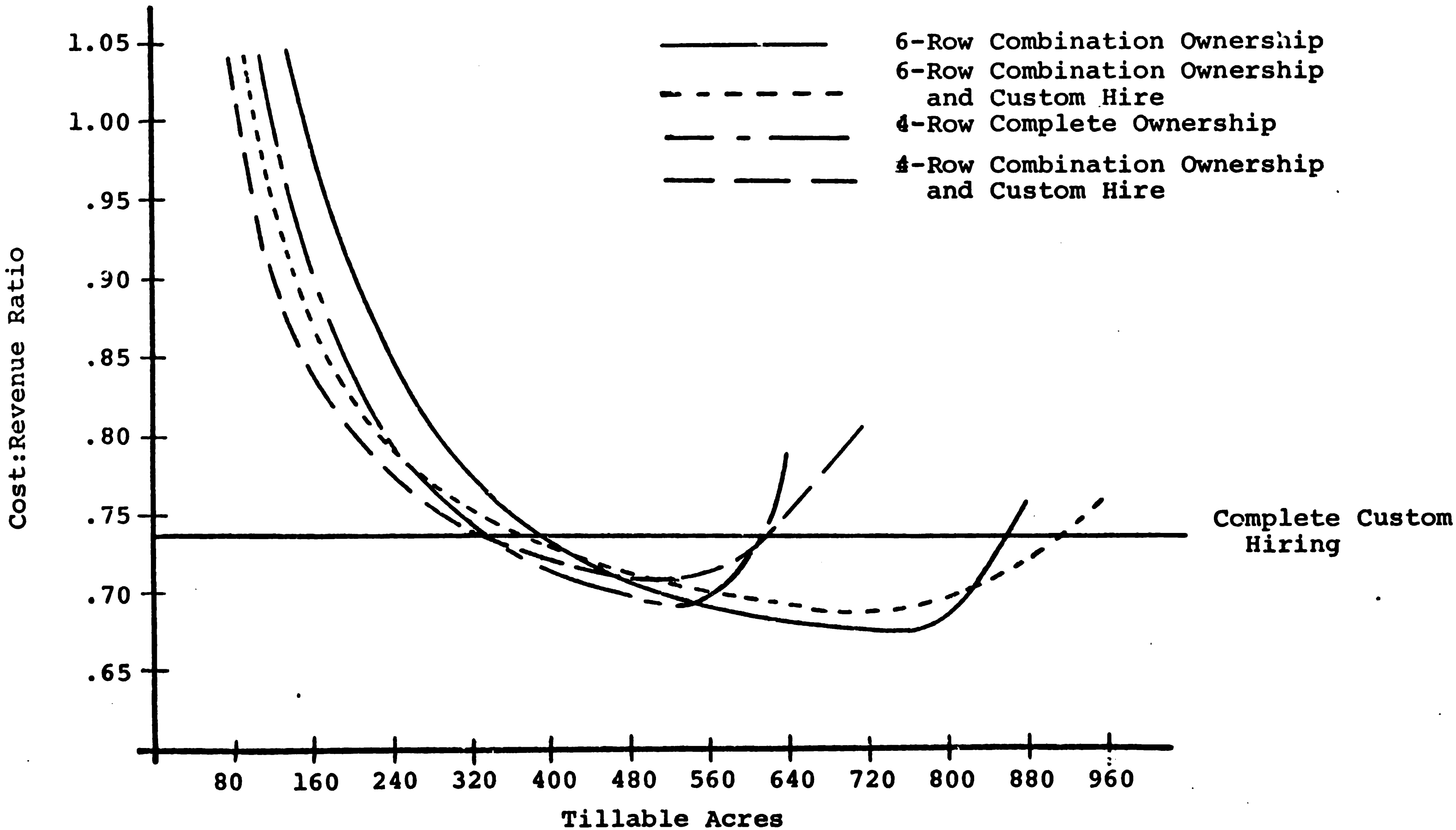
In all cases, receipts were based on sales of harvested crop acreage. For each 40 acre increment, the figure for total receipts is based on a time table of operations whereby each field operation must be completed in a given sequence. Although, no critical time periods were placed on the tillage operations, late tillage resulted in late plantings and harvesting for the larger acreages analyzed. These latter operations were bounded by critical time periods and if late plantings or harvesting occurred, the yields were reduced accordingly. The derivation of the total revenue was based on the rates of reductions in yields for late planting and harvesting (see Appendix Table 26), the required man hours to complete all operations, and the loss of field work days due to inclement weather. Appendix Tables 27 and 28 lists the number of acres planted or harvested late by farm size for the 4-row and 6-row systems, respectively.

The budgets used in Budgeting Model II were calculated from the additional data on costs and timeliness of operations, and appear in Appendix Tables 28 through 31. Figure 3 shows the cost:revenue ratios in graphical form.

In terms of breakeven analysis, the results of Budgeting Model II indicated that a minimum of 89 tillable acres were required before costs would equal revenues for any system other than complete custom hiring. More specifically, this breakeven acreage level was obtained by the use of a 4-row system with a combination of ownership and custom hiring. Other breakeven acreage levels noted were 107, 123, and 152 tillable acres under a 6-row system with a combination of ownership and custom hiring, a 4-row system of complete ownership, and a 6-row system of complete ownership, respectively.

In terms of short-run efficient machinery systems, the alternative of complete custom hiring resulted in the most efficient machinery system for both the smaller (below 326) and the larger (above 937 tillable acres) farm sizes [2].

FIGURE 3.--Cost:Revenue Ratios for Various Farm Sizes and Machinery Systems



Between the levels of 326 and 349 tillable acres, cost:revenue statistics were lowest for the 4-row system with a combination of ownership and custom hiring. From 350 to 537 tillable acres, the 4-row system of complete ownership resulted in the most effieient machinery system, while the 6-row system of complete ownership showed greatest efficiencies for farms of 538 to 822 tillable acres. Between 823 and 937 tillable acres, the 6-row system with a combination of ownership and custom hiring gave the lowest cost:revenue statistics. The results of Budgeting Model II are summarized in the Table 6.

As can be seen from the table, the 6-row complete ownership system resulted in greatest economies of size among the systems studied. Although all of the systems indicated some range in tillable acres for which they were more efficient than the other systems, the costs within these ranges were relatively higher than the costs within the efficient range of the 6-row system of complete ownership. The added capacity of this system (and hence, the added revenues) more than offset the increased costs of this system over either of the 4-row alternatives. Also, at the larger acreage levels, the annual ownership costs of the 6-row system with complete ownership, were spread thinner allowing this system to be relatively more efficient than its counterpart with a combination of ownership and custom hiring.

TABLE 6.--Summary of Results for Budgeting Model II

System	Acres at Break Even Point[1]	Most Efficient Acreage Level[2]	Cost: Revenue Ratio at Efficient Point	Acreage Range Most Efficient	Cost:Revenue Ratio at Low end of efficiency range	Cost:Revenue Ratio at High end of efficiency range
	(acres)	(acres)	(%)	(acres)	(%)	(%)
Complete Custom Hire[3]	---	---	.739	0- 325	.739	.739
4-row, Combination Ownership and Custom Hire	89	520	.707	326- 349	.738	.733
4-row, Complete Ownership	123	560	.694	350- 537	.732	.694
6-row, Complete Ownership	152	760	.676[4]	538- 822	.693	.697
6-row, Combination Ownership and Custom Hire	107	760	.687	823- 937	.698	.738
Complete Custom Hire[3]	---	---	.739	938-1000	.739	.739

[1]Breakeven acreage is defined as that level of farm size for which total costs are equal to total revenue.

[2]Above these acreage levels, marginal revenues are less than marginal costs; hence, the curves start to increase.

[3]Complete custom hiring results in a constant cost:revenue ratio because of the assumption that custom operators are available in sufficient numbers to complete all operations on time.

[4]Although the 6-row system of complete ownership resulted in the most efficient machinery system at 760 tillable acres, the high profit point occurs at 800 tillable acres. See Appendix Table 31.

It is also interesting to point out the fact that even at the most efficient point for each of the machinery systems studied, some losses were apparent because of late operations. For instance, at the 560 tillable acre level, where the 4-row system of complete ownership resulted in its most efficient short-run economies of size, the following late operations occurred (see Appendix Table 27): 71 acres of corn were planted one week late; 74.3 acres of corn were harvested one week late and 43.0 acres of corn were harvested two weeks late, 2.2 acres of navy beans were planted and harvested one week late, and 3.2 acres of wheat were planted one week late. Similar results also occurred at the most efficient points for the other machinery systems studied (excluding complete custom hiring). The important point, however, is that the marginal revenue from expanding to the points of most efficient production for each system still exceeded the marginal cost. Consequently, the cost:revenue ratio at these acreages did not increase.

A second interesting feature of the cost curves presented in Budgeting Model II was the apparently large acreage ranges exhibiting relatively constant costs for each of the machinery systems studied. Table 7 summarizes these ranges in acreage for different definitions of constant costs.

TABLE 7.--Ranges in Farm Size Exhibiting Relatively Constant Costs of Production for Various Definitions of Constant Costs[1] and Various Machinery Systems

Machinery System	Range in Acres for Constant Cost Defined As			
	Within 5%	Within 10%	Within 5¢ of cost per dollar revenue	Within 10¢ of cost per dollar revenue
	(acres)	(acres)	(acres)	(acres)
4-row Complete Ownership	300-600	280-624	322-612	243-645
4-row Combination Ownership and Custom Hire	315-619	227-682	275-638	191-719
6-row Complete Ownership	460-834	348-869	420-851	315-889
6-row Combination Ownership and Custom Hire	435-905	305-962	363-933	250-990

[1]In all cases, constant costs are defined from a base of the most efficient point (lowest cost:revenue ratio) for a given machinery system.

References

1. Close examination of the budgets and cost curves will show that the cost per acre statistics do not result in a smooth function. The explanation for this is based on the increased depreciation charges which occur at the higher acreage levels when a given item of machinery is used more intensively than under normal conditions. This increased cost, at a given 40 acre incremental level, had the tendency to shift the average cost curve in a nonuniform manner. Such a tendency can most easily be seen at the 800 and 1000 acre level for the 4-row and 6-row complete ownership systems, respectively. The results at these points showed increasing cost per acre statistics, rather than the expected continuously decreasing values. However, if the analysis were extended to the next 40 incremental level, the cost statistic would most likely decrease rather than increase. Since only a few isolated points deviated from the function, the cost curves are presented in a smooth function.

2. Although complete custom hiring appeared to give the best efficiencies for farms with more than 937 tillable acres, such efficiencies would only be obtained if the number of custom operators available were sufficient to complete all operations on time.

CHAPTER V

SUMMARY AND CONCLUSIONS

Problem Review and Analysis Results

This study started by recognizing the problems which plague farmers attempting to select the services of farm machinery. Although the current magnitude of per farm machinery investments includes only about 12 percent of total farm investments, there are certain unique characteristics associated with the machinery investment which render it difficult to manage. Some of these characteristics recognized in this study, were (a) rapid technological developments which result in machines becoming obsolete long before it is physically depreciated, (b) the initial high cost of farm machinery and the relatively low disposal value, (c) the changing farm structure which emphasizes large items of machinery that cannot be passed from "first line" machinery to a "second" line, and (d) the relative rapidity of farm machinery turnover.

In an attempt to analyze the problems surrounding methods of acquiring farm machinery services, the following objectives were cited:

1. To describe alternative means of acquiring farm machinery services.

2. To determine the relationship between farm size and per acre power, machinery, and labor costs for selected systems of farm machinery.

3. To examine the effects of inclement weather and untimely field operations on size-efficiency relationships.

4. To determine acreage levels at which total costs and revenues are equal for selected farm machinery systems.

5. To determine an optimum farm size which would achieve minimum costs per dollar of revenue for selected systems of farm machinery.

To meet these objectives, a synthetic one-man farming operation was selected to represent a typical southern Michigan commercial cash-grain farm. For the analysis, farm size varied in 40 acre increments from 0 to 1000 tillable acres. In all cases, the product mix (typical acre), consisting of 36 percent corn, 15 percent soybeans, 19 percent navy beans, 15 percent wheat, 12 percent diverted, and 3 percent idle, was considered fixed.

Five alternative farm machinery systems were defined and assumed to remain fixed as farm size expanded. These five systems were identified as (a) complete custom hiring, (b) 4-row system with complete ownership, (c) 4-row system with a combination of ownership and custom hiring,

(d) 6-row system with complete ownership, and (e) 6-row system with a combination of ownership and custom hiring [1]. Machinery rental and leasing was not included in the analysis because of its apparent lack of popularity in Michigan and because of the relatively high rates.

In order to meet the objectives listed above, two budgeting models were employed in the analysis. Budgeting Model I derived average total power, machinery, and labor costs per acre, while Budgeting Model II included both costs and revenues to derive cost:revenue ratios. The costs of the second model included those of Budgeting Model I, plus seed, fertilizer, herbicide, custom hauling, and an opportunity cost on land investment. Revenues were based entirely on sales from crop production.

The results of Budgeting Model I showed that complete custom hiring offered the lowest costs per acre for farms of less than 323 tillable acres. Although the costs per acre statistics for the other four systems dropped considerably within this range (see graph, page 61) these costs were higher relatively to the costs offered by complete custom hiring. From 323 to 343 tillable acres, the 4-row system with a combination of ownership and custom hiring resulted in the lower costs per acre, while the 4-row system of complete ownership showed the lower costs per acre for a farm of 344 to 597 tillable acres. Above 597 acres the 6-row system with complete ownership gave the lowest costs per acre of all systems studied.

An interesting result of Budgeting Model I was the relatively small variation in per acre costs exhibited at the higher acreage levels studied. For instance, on farm sizes of 400 to 720 tillable acres, the costs per acre varied by less than $1.50 among the farm machinery systems involving some form of ownership. From 760 to 1000 tillable acres, these costs per acre variations were within the range of $1.50 to $2.00.

The results of Budgeting Model II indicated that the greatest economies of size occurred on a farm of 760 tillable acres with a 6-row machinery system of complete ownership. Although each machinery system analyzed showed a range in acreage at which that particular system was more efficient than others (see graph on page 64 and Table 6 on page 66), the cost:revenue ratios at these acreage ranges were relatively higher than at the most efficient point.

In terms of breakeven analysis, Budgeting Model II indicated that the 4-row system with a combination of ownership and custom hiring required a minimum of 89 tillable acres before revenues would equal costs. Other breakeven acreage levels of 107, 123, and 152 tillable acres were noted for the 6-row system with a combination of ownership and custom hiring, the 4-row system of complete ownership, and the 6-row system of complete ownership, respectively.

Depending on the definition used, the cost:revenue curve showed fairly substantial ranges in acreages for which relatively constant costs were observed (see Table 7, page 68). For instance, the 6- and 4-row systems of complete ownership showed a range of 374 and 340 acres respectively, for constant costs defined as cost:revenue ratios falling within 5 percent of the most efficient point.

Implications of the Study

Regardless of whether or not the results of this study are judged as good or bad, several interesting aspects have emerged from the analysis. Primary among these interesting aspects is the degree of importance placed on analyzing farm machinery as a system. Machinery costs are quite substantial on the commercial farms emerging today and it is only natural that farmers are looking for ways of reducing these costs. Research has generally approached this problem in two ways; either it analyzes machinery in separate units, or it analyzes machinery in terms of the needs for one particular enterprise. In either case, the very nature of farming limits the usefulness of the above approaches.

Farms, for the most part, are multi-product firms with different productive cycles for each product. In the case of a cash-grain farm, these productive cycles overlap and often conflict with one another for the limited time and machinery available. To the extent that the limited time and machinery can be used in all enterprises, the conflicting overlaps compete for the same time and same machinery. Consequently, analysis procedures which concentrate on individual machinery items; or on machinery needs for a particular enterprise; often ignore the effects of delayed operations in competing enterprises. Because such late operations result in yield and revenue losses, these two approaches overlook sizeable cost reductions which, in fact, are available. The only alternative to such oversights is the method used in this study which treats farm machinery as a system capable of fulfilling the needs of an entire farm.

The usefulness of the systems approach to machinery analysis can be readily adapted to the individual farmer about to select a machinery system. Primary steps require that the farmer know the kinds (items) of machinery needed, alternative ways for service acquisition, and alternative uses for capital. Based on this knowledge, the final requirements for an efficient machinery system are (a) recommended operations for specific enterprises must be performed, (b) these operations must be completed on time, and (c) a and b must be accomplished in the least-cost manner. Fulfillment of these last requirements necessitate the systems approach in order to determine a "most" efficient machinery system for a given farm. However, as Connor points out, changing levels of technology requires ". . . continuous planning in order to maintain an efficient machinery system for any given farm" [2].

Another important implication of this study pertains to the use of custom hiring as a means of acquiring farm machinery services. The results of Budgeting Model II showed that complete custom hiring was the most economical means of acquiring farm machinery services on farms of 325 tillable acres or less; while the 4-row system with a combination of ownership and custom harvesting expanded the efficiency range up to 350 tillable acres. The significance of custom hiring on these rather large acreage levels was more pronounced by the fact that the average number of tillable acres for smaller cash-grain farms enrolled in the Telfarm project in 1966 was only 291 acres [3]. Although average farm size is expected to increase, certain elements will prohibit many farms from expanding acreages to any significant degree within the relatively near future. Consequently, if custom operators are available, the possibilities are reasonably good that elderly farmers and farmers with a limited supply of capital and labor will find custom hiring to be the most economical short-run means of acquiring farm machinery services.

There are also some implications from this study which indicate that custom operators may, in fact, be available in the future; and in greater numbers. The results indicated that rather large farms are a requirement for economic justification of complete farm machinery ownership. For the individual farmer who has already acquired equity ownership in some of the large and costly items of machinery, there may be no immediate possibilities for expanding farm size. Therefore, the farmer in this situation may decide that the only short-run solution to reducing per acre costs (spreading fixed costs over more acres), rests in his willingness to market the excess capacity by performing the services of a custom operator.

Although the results of the questionnaire on current farm machinery rental and leasing indicated very little of this practice being done in Michigan, there are conditions whereby such alternatives may, indeed, be feasible [4]. For the most part, renting and leasing of farm machinery would appeal to the farmer who suddenly found himself in a pinch for time. For instance, an unseasonably late spring could reduce the normal amount of time for spring field work and, hence, delay planting dates. In such a case, a farmer is faced with the decision as to whether or not it is worth the cost to rent an extra tractor for two weeks in order to catch up with the field work and assure himself that crops will be planted on time. If the added revenues from planting on time to obtain maximum yields exceed the cost of renting the tractor (and the necessary labor to run the tractor) then renting is a feasible solution [5].

There is also one aspect of short-term renting and leasing which should render it feasible to farm machinery dealers. This applies to the area of renting and leasing used farm machinery. Not only would such a service perhaps benefit the farmer, it would also provide a return for a rather large part of the dealer's inventory which traditionally has done nothing but sit idle. As previously indicated, there is little demand for the large items of used farm machinery and consequently dealers are finding that a considerable amount of money is tied up in used equipment inventory. One solution for obtaining revenue from this tied up investment is to provide short-term rental to farmers who need such a service.

The apparent wide range in acreage levels which provides constant costs is another important implication in this study. For instance, the six-row system of complete ownership (which resulted in the most efficient system) showed a range in constant costs of 374 acres (from 460 to 834 tillable acres) when constant costs were defined as cost:revenue ratios within 5 percent of the minimum value for a system. The low end of this range is particularly interesting since it corresponds very closely to the average size of large cash-grain farms (457 tillable acres) enrolled in Telfarm project in 1966 [6]. Based on this comparison, it becomes reasonable to hypothesize that some farmers are operating in the area of least-costs.

Despite the fact of this encouraging implication, the question still remains as to why farmers do not expand acreage to the most efficient point within the area of constant costs. One possible answer to this is that farmers are not willing to take the added risk and uncertainty associated with larger farms when the increased economies from expansion are so relatively low. Partial explanation can also result to the fact that limitations do exist as to the ability of management to handle larger farms and that this limit is possibly reached somewhere below the maximum acreage levels indicated in this study.

Limitations of Study

The results of this study are limited somewhat by insufficient data and by the inflexible nature of the budgeting technique. Insufficient data was found to exist in the three general areas of (a) yield losses from untimely operations, (b) work time lost due to inclement weather, and (c) general farm labor requirements.

In regards to yield losses from untimely operations, it is logical to assume that the tillage, cultivating, and spraying operations can influence crop yields, if such practices are not completed on time. However, without adequate study and research, designating crop losses from these late operations would be purely arbitrary. It may be that such losses are more a function of the "proper" timing concept, in accordance with weather and seasons, rather than a calendar timing function. For example, good spraying habits are not so much that they should be done by the third week of June. Instead, the proper time for spraying is when it is not too wet or too dry; whenever that is.

The critical operations and corresponding yield losses listed in this study, pertained only to late planting and harvesting operations. Since the data obtainable in this area lacked proven research for most of the enterprises, the only alternative, short of extensive research, was to use the limited information that was available. The yield loss functions do, however, leave some room for doubts.

A second limiting aspect of this study pertains to the data on field work time lost due to inclement weather. There is little doubt that rain affects in some manner, all field operations. But, likewise, there is little doubt that rain and field work days lost, are not related in a straight line regression as this study has used. The amount of rain and the corresponding number of work days lost are hinged on other important variables such as soil classification, season of the year, and type of field operation in progress. Soil classification is important because water runoff is determined by slope, soil texture, and soil structure. After an inch of rain, field work will be resumed much sooner on a sandy loam soil with 5 percent slope, than it will on a clay loam soil with 1 percent slope.

Season of the year is an important variable because it corresponds so closely with the water table level. In the spring, water table levels are high and generally become lower as the hot summer months approach. Consequently, one inch of rain in the spring of the year would halt field operations for a relatively longer period of time than the same amount of rain in the late summer. Unfortunately data are not available to correlate season of the year, amounts of precipitation, and work time lost. The straight line regression as used in this study would therefore, bias downward the amount of work time lost in the spring and bias upward the amount of lost time in the summer.

The type of field operation is a third important variable in the relationship between inches of precipitation and work time lost. The importance of this variable is easily pointed out by the fact that precipitation will delay such operations as wheat harvesting considerably longer than it will delay tillage operations. Even a good morning dew will perhaps cut down the hypothesized 10 hour day to an 8 hour work day when wheat harvesting is in its peak season, while on the other hand, dew has hardly no affect on tillage and planting operations.

The inability to separate field work time lost from precipitation, by the type of field operation results again in biased estimates of lost time. In general, lost time for tillage operations are biased upwards, and lost time for harvesting operations are biased downwards.

A third limiting aspect of this study is in the area of "general" farm labor requirements, or sometimes called "indirect labor requirements." Ironically, however, the problem here was not one of insufficient data. Instead, the problem faced by this study was determining at what point indirect labor takes precidence over direct labor. In general, indirect labor has the characteristic of being performed when vital field operations cannot be undertaken. Such items of indirect labor as farm building improvement, major machinery repair, adapting one item of machinery from one crop to another (changing combine heads, or row spacing of planters), etc., are carried out when rain makes field work impossible, or in the evening hours. Hence, in this sense, indirect labor requirements do not directly compete with direct labor requirements. However, there is another aspect of indirect labor which does make it a competitor. For instance, time spent on moving machinery from one field to another, or from the tool shed to the field, both compete with precious in field work time. Likewise, time spent in refueling, oil changes, and general lubrication also compete with direct in field labor requirements.

Since this study could not readily include indirect labor requirements in a proper timing sequence with direct labor requirements, the cost:revenue curves are again subject to some bias. Proper specification of this variable would most likely adjust the curves slightly upwards and to the left with the corresponding efficiency points occurring at a somewhat lower acreage level [7].

Further shortcomings of this study are evident from the limiting nature of the budgeting technique. More specifically, there is a limit as to the number of variables which can be readily handled in budgeting procedures, and to overcome this, requires several simplifying assumptions. This study in three particular areas, has used simplifying assumptions which detract somewhat from the overall results. In the first place, a constant enterprise mix was assumed throughout the study to be the most efficient cropping program for a southern Michigan cash-grain farm. The limitation, here, is that a most efficient cropping program is something that must be determined farm by farm according to the particular characteristics of each farm. If this study could have varied the enterprise mix, the results would most likely point to more efficient farm organization as well as efficient machinery systems. Also, by varying enterprise mix, the results most likely would show a more uniform utilization of the machinery units within a given system.

A second simplifying assumption, which departed from the real life situation, was the assumption of one soil type regardless of farm size. It takes considerable ignorance to advocate that soils are uniform and that one farming area is just as good as any other. On the other hand, it takes tremendous ingeniousness to understand the relationship of southern Michigan soils and to know required practices and treatments for each of the various soil classifications which exist. Since this study could not take the latter route, the assumption as stated had to be made explicit. Such an assumption, however, does not completely deny the results, but it does require certain adjustments be made before the results are implemented into any farming program.

A third simplification which limits the usefulness of this study, is the assumption of fixed prices for all inputs and products. This limitation is particularly inhibiting in the area of land price where a constant opportunity cost of 6 percent was assumed, but in real life, land values are again a function of individual characteristics for a given farm. At any rate, the use of 6 percent for land price would place the cost in its maximum with the more realistic price falling between 0 to 6 percent.

The main point to be made about the constant price relationships among all resources and products as assumed by this study, is that the relationships refer to present conditions. Consequently, there is no real basis for extending the analysis results into future predictions.

A further limitation pertains to a comparison of the results of this study and what farmers are actually doing. For example, at the 440 tillable acre farm size, results of Budgeting Model I showed machinery and labor costs per acre of $14.00 and $15.02 for the 4-row and 6-row systems with complete ownership, respectively as compared with 1966 Telfarm data, where large farms with an average of 457 tillable acres reported $30.74 of machinery and labor cost per acre. This discrepancy can be explained in either of two ways; either severe limitations exist in the analysis, or farmers currently prepare themselves for the unexpected with considerable excess machinery capacity. In all probability, both explanations are pertinent to the discrepancy, but to say in what proportions would be impossible.

Indications for Further Study

Each of the limitations discussed in the previous section indicate possibilities for further study. There are, however, other important areas which also require continuous improvements. For instance, the whole concept of machinery costs, while not currently lacking in data, need continuous reevaluation as levels of knowledge and technology change. Standards which fit the current situation will most likely be obsolete within five to ten years unless efforts are made to keep abreast with farm machinery developments.

Another need for further study lies within the management process of selecting farm machinery systems. Such questions as, what factors dictate the items of machinery needed to complete a system, or what organizational problems confront farmers attempting to maximize the farm machinery investment, are all relevant to continuous managerial studies.

Also within the area of management, there is a need for research directed primarily at determining what management is, and what influence it has on the productivity of a given farm. More specifically, answers are needed for such things as determining what the capacity of farm management is and how new knowledge and technology influence the capacity of management.

Another important area for further research is the continuous application of the systems approach to farm machinery investment. Such analysis is pertinent to all machinery systems under all types of farms and farming situations. And, as indicated in the previous section, a better and more flexible approach than the budgeting process would likely result in more worthwhile results. Linear programming or some directly related approach, offers a faster and better method for handling various product mixes and other problems which plague manual budgeting.

As the structure of farming continues to change, each of the points listed above indicate interesting and significant research possibilities. To the individual interested in farm management, economies of size studies present tremendous challenges and offer intriguing areas for improvement.

References

1. In the 4-row and 6-row alternatives with a combination of ownership and custom hiring, custom operators were obtained for the harvesting operations and for bulk spreading of fertilizer.

2. Larry J. Connor, Guidelines for Selecting Machinery Systems, speech given at Farmer's Week, Michigan State University, February 1968.

3. Cash-Grain Farming Today: What it Costs, How it Pays, A. Ec. 68, Cooperative Extension Service and Department of Agricultural Economics, Michigan State University, 1967, p. 6.

4. It should be pointed out that the feasibility of short-term renting and leasing is most likely subject to the availability and rates of custom operators. If no custom operators are available--short-term rental and leasing may be worthwhile. On the other hand, if custom operators are sufficiently available then custom hiring would most likely be a better choice than short-term rental or lease.

5. In this case, the operating costs for renting a tractor should not enter into the decision as to whether or not to rent, since the operating costs are not in addition to what would normally be required anyway in order to plant the crop. In other words, if the decision were not to rent--then the farmer would consume the operating cost with his own tractor, because the same amount of work would have to be done. If the decision were to rent, then the operating costs on the rented tractor decrease the operating cost for the owned tractor because less work will be done with the owned tractor.

6. Cash-Grain Farming Today; What it Costs, How it Pays, A. Ec. 68, Cooperative Extension Service and Department of Agricultural Economics, Michigan State University, 1967, p. 10.

7. Perhaps it would be wise to point out that all is not lost by excluding indirect labor in the analysis. By using the assumption of a 10 hour day-6 day work week, it is quite logical to assume that most of the indirect labor can be completed outside of the actual work day. However, exactly how much is done outside of the actual work day is not known.

APPENDIX TABLE 1.--Estimated typical acre for a cash-grain farm in southern Michigan.

Crop	Average Acres Reported	Adjusted Base	Percent of Adjusted Base
	(acres)	(acres)	(percent)
Corn	120.4	120.4	36.1
Soybeans	50.7	50.7	15.2
Navy Beans	63.2	63.2	18.9
Wheat[1]	49.6	49.6	14.9
Diverted	38.9	38.9	11.6
Idle	11.1	11.1	3.3
Other	14.7	0	
Total Tillable Acres	348.6	333.9	100.0
Nontillable Acres	41.3		
Total Acres	389.9		

[1]The wheat acreage includes a small amount of acreage reported for the oat enterprise.

Source: Unpublished data from 43 cash-grain farms enrolled in the Michigan Telfarm Project, 1966.

APPENDIX TABLE 2.--Crop yields, fertilizer and herbicide requirements, and other productive practices for the synthetic cash-grain farm.

Crop[1]	Maximum Assumed Possible Yield	Seed Require-ments	Fertilizer Requirements $N-P_2O_5-K_2O$[2]	Herbicide Require-ments	Other Productive Practices: Operation	Times Over	Critical Time Period for Maximum Possible Yields[3]
	(bu./acre)	(bu./acre)	(lbs./acre)	(lbs./acre)			(Dates)
Corn	85		80-0-0		bulk spread fertilizer	1	
					plow	1	
		.21	10-50-25		plant and fertilize	1	May 1-May 10
				2 lbs. atrazine	spray	1	
					cultivate	1	
					harvest	1	Oct. 5-Oct. 15
Soybeans	28				plow	1	
					harrow	1	
		.83	30-50-15	1 lb. amiben	plant, fertilize, spray	1	May 15-May 25
					cultivate	1	
					harvest	1	Oct. 1-Oct. 10

APPENDIX TABLE 2.--Continued.

Crop[1]	Maximum Assumed Possible Yield	Seed Require-ments	Fertilizer Requirements $N-P_2O_5-K_2O$[2]	Herbicide Require-ments	Other Productive Practices: Operation	Times Over	Critical Time Period for Maximum Possible Yields[3]
	(bu./acre)	(bu./acre)	(lbs./acre)	(lbs./acre)			(Dates)
Navy Beans	23				plow	1	
				2 lbs. eptam	disc and spray	1	
		.67	30-50-15		plant and fertilize	1	June 1-June 10
					cultivate	2	
					pull and windrow	1	
					harvest	1	Aug. 25-Sept. 15
Wheat	45				plow	1	
					disc	1	
					harrow	1	
		1.75	45-75-25		drill and fertilize	1	Sept. 16-Sept. 25
					harvest	1	July 10-July 20

[1]Corn was planted in 38-inch rows; soybeans and navy beans in 28-inch rows.

[2]Quantities shown refer to actual pounds of nitrogen, phosphate, and potash, respectively.

[3]Unpublished data, Department of Crop Science, Michigan State University.

Source: Larry J. Connor, Cost and Returns for Major Cash Crops in Southern Michigan, Agricultural Economics Report No. 87, Department of Agricultural Economics, Michigan State University.

APPENDIX TABLE 3.--Assumed prices paid and received.[1]

Item	Unit	Price[2]
		(dollars)
PRICES PAID		
SEED:		
corn for grain	bu.	13.50
wheat	bu.	3.25
soybeans	bu.	4.50
navy beans	bu.	5.50
FUEL AND LUBRICANTS:		
gasoline	gal.	.174
diesel	gal.	.154
motor oil	gal.	.90
lubricant	lb.	.22
FERTILIZER (bulk):		
nitrogen	lb.	.105
phosphate	lb.	.087
potash	lb.	.043
FERTILIZER (bag):		
nitrogen	lb.	.113
phosphate	lb.	.092
potash	lb.	.046
CHEMICALS:		
atrazine	lb.	2.90
amiben	lb.	5.00
eptam	lb.	2.83
HAULING:		
corn, soybeans, and navy beans	bu.	.06
wheat	bu.	.05
LAND:	acre	300.
annual opportunity cost at 6%	acre	18.
LABOR:	hour	1.50
PRICES RECEIVED[3]		
Corn[4]	bu.	1.20
Soybeans	bu.	2.60
Navy beans	bu.	3.75
Wheat	bu.	1.55

[1]Machinery prices are located in Appendix Table 4.

[2]These price assumptions are not to be interpreted as predictions or prospective prices.

[3]Approximate 1965-66 season average price.

[4]In the analysis a discount of 13 cents per bushel was assumed for drying. Hence the net return per bushel was $1.07.

Source: Larry J. Connor, Cost and Returns for Major Crops in Southern Michigan, Agricultural Economics Report No. 87, Department of Agricultural Economics, Michigan State University.

APPENDIX TABLE 4.--Items, capacity, new cost, ownership costs, and expected life of farm machinery for the four-row and six-row machinery systems.

Machinery Items	4-Row System: Capacity or Size	4-Row System: New Cost	4-Row System: Annual Ownership Costs till Normal Obsolescence[1]	4-Row System: Expected Life to Normal Obsolescence[2]		6-Row System: Capacity or Size	6-Row System: New Cost	6-Row System: Annual Ownership Costs till Normal Obsolescence[1]	6-Row System: Expected Life to Normal Obsolescence[2]	
		($)	($)	(Hrs.)	(Yrs.)		($)	($)	(Hrs.)	(Yrs.)
Tractor	51 HP	5185	658	6500	10	64 HP	6205	787	6500	10
Tractor	64 HP	6205	787	6500	10	74 HP	6810	864	6500	10
Plow	4-16"	1060	133	1500	10	5-16"	1250	159	1500	10
Disc	12 ft.	1000	112	1200	12	16 ft.	1325	148	1200	12
Harrow	12 ft.	250	24	1500	15	16 ft.	350	34	1500	15
Planter (with fertilizer attach.)	4 row	1075	136	1000	10	6 row	1840	233	1000	10
Drill	15-7"	1100	123	800	12	17-7"	1200	134	800	12
Cultivator	4 row	875	111	2000	10	6 row	1500	190	2000	10
Sprayer (pull type)	6 row	575	73	1200	10	6 row	575	73	1200	10
Sprayer attachment	4 row	170	21	1000	10	6 row	380	48	1000	10
Fertilizer spreader	10 ft.	400	51	1000	10	30 ft.	600	76	1000	10
Combine (SP) with		5390		2000	10		6975		2000	10
grain platform	10 ft.	850		2000	10	14 ft.	1225		2000	10
corn head	2 row	1985	1158	1000	10	3 row	3400	1585	1000	10
bean pickup		900		1000	10		900		1000	10

APPENDIX TABLE 4.--Continued.

Machinery Items	4-Row System: Capacity or Size	4-Row System: New Cost	4-Row System: Annual Ownership Costs till Normal Obsolescence[1]	4-Row System: Expected Life to Normal Obsolescence[2]		6-Row System: Capacity or Size	6-Row System: New Cost	6-Row System: Annual Ownership Costs till Normal Obsolescence[1]	6-Row System: Expected Life to Normal Obsolescence[2]	
		($)	($)	(Hrs.)	(Yrs.)		($)	($)	(Hrs.)	(Yrs.)
Bean puller	4 row	475	174	1000	10	4 row	475	174	1000	10
Bean windrower	4 row	900		1000	10	4 row	900		1000	10
Total Annual Ownership[3]			3561					4505		
Total Annual Ownership[4]			2178					2670		

[1]Ownership costs include depreciation, interest on investment, and insurance. Depreciation was based on a salvage or tradein value of 10 percent for all items, and constant amounts of annual depreciation (straight-line) were used provided the farm size was small enough to allow the item to become technologically obsolete before it becomes physically worn out. The formula for depreciation costs was as follows:

$$\frac{\text{(New Cost)} - \text{(Salvage value of 10\%)}}{\text{Years of use until item becomes technologically obsolete or physically worn out; (whichever is shorter)}}$$

The opportunity cost of 6 percent on the average value of a machine over its life on the farm was used: The yearly charge was computed as follows:

$$\frac{\text{(New Cost + Salvage Value)}}{2} \times .06$$

(Footnotes continued on next page)

APPENDIX TABLE 4, Footnotes, Continued.

Insurance was charged at the rate of $7 per $1000 of value over the life of the machine. The yearly charge was computed as follows:

$$\frac{\text{(New Cost + Salvage Value)}}{2} \times .007$$

[2]Normal obsolescence is considered the length of time until the item becomes technologically obsolete. However, when farm acreage is increased, a point is ultimately reached whereby the machine will be used so much each year that it will become physically worn out before it is technologically obsolete. Appendix Tables 5 to 8 give the complete ownership cost schedules for the entire range of acreage studied.

[3]This figure applies only to the complete ownership alternative and is the sum of the column.

[4]This figure applies to the combination ownership-custom hire alternative and is computed by subtracting the figure for the combine, the bean puller and windrower, and the fertilizer spreader from the figure above it.

Sources: Published and Unpublished data supporting Larry J. Connor's Costs and Returns for Major Cash Crops in Southern Michigan, Agricultural Economics Report No. 87, November 1967, Department of Agricultural Economics, Michigan State University.

Local dealers and farm equipment manufacturers.

APPENDIX TABLE 5.--Schedule of annual ownership costs by farm size with a 4-row system of complete ownership.[1]

1	2	3	4	5	6	7	8	9	10	11	12	13	14
				Annual Ownership Costs With Excessive Machinery Use at:									
Machinery Items	Size	Years of Life to Obsolescence	Annual Ownership Cost to Obsolescence	440A.	480A.	520A.	560A.	600A.	640A.	680A.	720A.	760A.	800A.
		(years)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)
Tractor	51 HP	10	658										
Tractor	64 HP	10	787										
Plow	4-16"	10	133	145	158	175	175	198	198	198	230	230	230
Disc	12 ft.	12	112										
Harrow	12 ft.	15	24										
Planter	4 row	10	136	147	161	161	178	178	200	200	200	233	233
Drill	15-7"	12	123										
Cultivator	4 row	10	111									120	120
Sprayer (pull type)	6 row	10	73										
Sprayer attachment	4 row	10	21	23	25	25	28	28	32	32	32	37	37
Fertilizer spreader	10 ft.	10	51										
Combine		10											
grain platform	10 ft.	10	1158		1249	1363	1363	1509	1509	1705	1705	1705	1979
corn head	2 row	10											
bean attachment		10											
Bean puller	4 row	10	174										
Bean windrower	4 row	10											
TOTALS			3561	3586	3706	3837	3857	4026	4052	4248	4280	4327	4601

See footnote at bottom of Appendix Table 8.

APPENDIX TABLE 6.--Schedule of annual ownership costs by farm size with a 4-row system using a combination of ownership and custom hiring.[1]

1	2	3	4	5	6	7	8	9	10	11	12	13	14
				Annual Ownership Costs With Excessive Machinery Use At:									
Machinery Items	Size	Years of Life to Obsolescence	Annual Ownership Cost to Obsolescence	440A.	480A.	520A.	560A.	600A.	640A.	680A.	720A.	760A.	800A.
		(years)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)
Plow	4-16"	10	133	145	158	175	175	198	198	198	230	230	230
Planter	4-row	10	136	147	161	161	178	178	200	200	200	233	233
Sprayer	6-row	10	73										
Cultivator	4-row	10	111									120	120
Harrow	12 ft.	15	24										
Sprayer Attach.	4-row	10	21	23	25	25	28	28	32	32	32	37	37
Disc	12 ft.	12	112										
Drill	15-7"	12	123										
Tractor	51 HP	10	658										
Tractor	64 HP	10	787										
TOTALS			2178	2203	2232	2249	2269	2292	2318	2318	2350	2397	2397

See footnote at bottom of Appendix Table 8.

APPENDIX TABLE 7.--Schedule of annual ownership costs by farm size with a 6-row system of complete ownership.[1]

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
				Annual Ownership Cost With Excessive Machinery Use At:												
Machinery Items	Size	Years of Life to Obsolescence	Annual Ownership Cost to Obsolescence	520A.	560A.	600A.	640A.	680A.	720A.	760A.	800A.	840A.	880A.	920A.	960A.	1000A.
		(years)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)
Tractor	64 HP	10	787													
Tractor	74 HP	10	864													
Plow	5-16"	10	159	171	171	187	207	207	207	234	234	234	271	271	271	271
Disc	16 ft.	12	148													
Harrow	16 ft.	15	34													
Planter (w/fert)	6 row	10	233					252	275	275	275	304	304	304	344	344
Drill (w/fert)	17-7"	12	134													
Cultivator	6 row	10	190													
Sprayer	6 row	10	73													
Sprayer Attach.	6 row	10	48					52	54	54	54	63	63	63	71	71
Fert. Spreader	30 ft.	10	76													

APPENDIX TABLE 7.--Continued.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
			Annual	Annual Ownership Cost With Excessive Machinery Use At:												
Machinery Items	Size	Years of Life to Obsoles-cence	Ownership Cost to Obsoles-cence	520A.	560A.	600A.	640A.	680A.	720A.	760A.	800A.	840A.	880A.	920A.	860A.	1000A.
		(years)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)
Combine		10														
grain platform	14 ft.	10	1585			1711	1867	1867	2068	2068	2068	2336	2336	2336	2336	2711
corn head	3 row	10														
bean attach.		10														
Bean Puller	4 row	10	174													
Bean wind-rower	4 row	10														
TOTALS			4505	4517	4517	4659	4835	4858	5084	5111	5111	5417	5454	5454	5502	5877

See footnote at bottom of Appendix Table 8.

APPENDIX TABLE 8.--Schedule of annual ownership costs by farm size with a 6-row system using a combination of ownership and custom hiring.[1]

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
				Annual Ownership Cost With Excessive Machinery Use At:												
Machinery Items	Size	Years of Life to Obsoles-cence	Annual Ownership Cost to Obsoles-cence	520A.	560A.	600A.	640A.	680A.	720A.	760A.	800A.	840A.	880A.	920A.	960A.	1000A.
		(years)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)
Plow	5-16"	10	159	171	171	187	207	207	207	234	234	234	271	271	271	271
Planter	6 row	10	233					252	275	275	275	304	304	304	344	344
Sprayer Attach.	6 row	10	48					52	54	54	54	63	63	63	71	71
Sprayer	6 row	10	73													
Cultiva-tor	6 row	10	190													
Drill	17-7"	12	134													
Harrow	16 ft.	15	34													
Disc	16 ft.	12	148													
Tractor	74 HP	10	864													
Tractor	64 HP	10	787													
TOTALS			2670	2682	2682	2698	2718	2741	2764	2791	2791	2829	2866	2866	2914	2914

[1]Ownership costs include depreciation, interest, and insurance. In all cases, depreciation is based on the number of years until a machine becomes technologically obsolete, or until it becomes physically worn out; whichever is shorter. Figures in Column 4 represent annual ownership costs when farms are small enough to allow the machinery to reach obsolescence. Figures in Columns 5 and above, represent annual ownership costs on farms so large that excessive use of the machine is required and it becomes worn out before becoming obsolete.

APPENDIX TABLE 9.--Operating costs per hour of use for selected farm machinery items.

Machinery Items	Capacity or Size	Total Repair Cost as a Percent of New Cost	Repair Cost Per Hour[3]	Gallons of Fuel Per Hour	Cost of Fuel Per Hour[4]	Lubrication, Oil, and Oil Filter Cost Per Hour[5]	Total Operating Cost Per Hour of Use
		(%)	($)	(gallon)	($)	($)	($)
Tractor (diesel)	51 HP	50	.40	2.2	.34	.18	.92
Tractor (diesel)	64 HP	50	.48	2.8	.43	.21	1.12
Tractor (diesel)	74 HP	50	.52	3.2	.49	.25	1.26
Combine (w/grain plat.)	10 ft.	40	1.25	3.0	.52	.13	1.90
Combine (w/grain plat.)	14 ft.	40	1.64	4.2	.73	.16	2.53
Combine (w/corn head)	2 row	40	1.87	3.0	.52	.13	2.52
Combine (w/corn head	3 row	40	2.76	4.2	.73	.16	3.65
Combine[1] (w/bean pickup)	4 row	40	1.44	3.0	.52	.13	2.09
Combine[2] (w/bean pickup)	4 row	40	1.76	4.2	.73	.16	2.65
Fertilizer spreader	10 ft.	25	.10	---	---	.05	.15
Fertilizer spreader	30 ft.	25	.15	---	---	.05	.20
Plow	4-16"	75	.53	---	---	.05	.58
Plow	5-16"	75	.63	---	---	.05	.68
Planter	4 row	30	.32	---	---	.05	.37
Planter	6 row	30	.55	---	---	.05	.60
Planter (w/ sprayer)	4 row	30	.41	---	---	.05	.46

APPENDIX TABLE 9.--Continued

Machinery Items	Capacity or Size	Total Repair Cost as a Percent of New Cost	Repair Cost Per Hour[3]	Gallons of Fuel Per Hour	Cost of Fuel Per Hour[4]	Lubrication, Oil, and Oil Filter Cost Per Hour[5]	Total Operating Cost Per Hour of Use
		(%)	($)	(gallon)	($)	($)	($)
Planter (w/ sprayer)	6 row	30	.67	---	---	.05	.72
Sprayer	6 row	30	.14	---	---	.05	.19
Cultivator	4 row	40	.18	---	---	.05	.23
Cultivator	6 row	40	.30	---	---	.05	.35
Disc	12 ft.	30	.25	---	---	.05	.30
Disc	16 ft.	30	.33	---	---	.05	.38
Disc and spray	12 ft.	30	.39	---	---	.05	.44
Disc and spray	16 ft.	30	.48	---	---	.05	.53
Harrow	12 ft.	40	.07	---	---	.05	.12
Harrow	16 ft.	40	.09	---	---	.05	.14
Drill	15-7"	25	.34	---	---	.05	.39
Drill	15-7"	25	.37	---	---	.05	.42
Pull and windrow	4 row	40	.55	---	---	.05	.60

[1]The figure given is for the bean pickup attachment on the combine used in the 4-row system.

[2]The figure given is for the bean pickup attachment on the combine used in the 6-row system.

[3]Repair costs are based on the following formula:

$$\frac{\text{(New Cost)(Total Repairs as Percent of New Cost)}}{\text{Total Hours of Use}}$$

APPENDIX TABLE 9, Footnotes, Continued.

[4]Fuel costs for tractors are based on an average diesel fuel consumption of .065 gallon per rated drawbar horsepower. Rated drawbar horsepower is 74 percent of the maximum. Combine fuel costs are based on an average fuel consumption of .3 gallon per hour per foot of cut.

[5]Lubrication costs for tractors and self-propelled items are estimated as a percentage of new cost. Lubrication for other machinery items are computed at 5 cents per hour of use. The costs of oil and oil filters are computed as 15 percent of the fuel costs.

Source: Published and unpublished data supporting "Costs and Returns for Major Cash Crops in Southern Michigan," Agricultural Economics Report Number 87, by Larry J. Connor, Department of Agricultural Economics, Michigan State University.

APPENDIX TABLE 10.--Factors used to estimate machine, power, and labor requirements for specified field operations in Southern Michigan.

Item of Machinery and Operation	Capacity or Size	Width of Machine	Field Operating Speed	Field Efficiency[1]	Acres Per Machine Hour[2]	Machine Hours Per Acre, Per Time Over[3]	Man Hours as a Percent of Power Hours	Man Hours Per Acre, Per Time Over
		(in.)	(MPH)	(%)	(acres)	(hours)	(%)	(hours)
Plow	4-16"	64	4.0	85	2.18	.46	102	.47
Plow	5-16"	80	4.0	85	2.72	.37	102	.38
Disc	12 ft.	144	4.5	85	5.51	.18	102	.18
Disc and spray	12 ft.	144	4.2	80	4.84	.21	110	.23
Disc	16 ft.	192	4.2	85	6.85	.15	102	.15
Disc and spray	16 ft.	192	4.2	80	6.45	.16	110	.18
Harrow	12 ft.	144	5.0	80	5.76	.17	108	.19
Harrow	16 ft.	192	5.0	80	7.68	.13	108	.14
Plant & fertilize								
28 in. row	4 row	112	3.8	60	2.55	.39	124	.48
38 in. row	4 row	152	3.8	60	3.47	.29	124	.36
Plant & fertilize								
28 in. row	6 row	168	3.8	60	3.83	.26	124	.32
38 in. row	6 row	228	3.8	60	5.20	.19	124	.24
Plant, Fert. and Spray								
28 in. row	4 row	112	3.6	55	2.22	.45	132	.59
28 in. row	6 row	168	3.6	55	3.33	.30	132	.40
Cultivate								
28 in. row	4 row	112	3.0	85	2.86	.35	104	.36
38 in. row	4 row	152	3.0	85	3.88	.26	104	.27
Cultivate								
28 in. row	6 row	168	3.0	85	4.28	.23	104	.24
38 in. row	6 row	228	3.0	85	5.81	.17	104	.18
Spray								
38 in. row	6 row	228	5.0	65	7.41	.13	125	.16
Spread fertilizer	10 ft.	120	5.0	80	4.80	.21	130	.28

APPENDIX TABLE 10.--Continued.

Item of Machinery and Operation	Capacity or Size	Width of Machine	Field Operating Speed	Field Efficiency	Acres Per Machine Hour[2]	Machine Hours Per Acre, Per Time Over[3]	Man Hours as a Percent of Power Hours	Man Hours Per Acre, Per Time Over
		(in.)	(MPH)	(%)	(acres)	(hours)	(%)	(hours)
Spread fertilizer	30 ft.	360	5.0	80	14.40	.07	130	.09
Drill & fertilize	15-7"	105	3.3	65	2.25	.44	119	.52
Drill & fertilize	17-7"	119	3.5	65	2.71	.37	111	.41
Harvest corn								
38 in. row	2 row	78	3.0	70	1.60	.63	111	.70
38 in. row	3 row	114	3.0	65	2.22	.45	111	.50
Harvest soybeans								
28 in. row	4 row	112	2.5	65	1.82	.55	111	.61
28 in. row	5 row	140	2.5	65	2.28	.44	111	.49
Harvest wheat	10 ft.	120	3.0	70	2.52	.40	111	.44
Harvest wheat	14 ft.	168	3.0	70	3.53	.28	111	.31
Pull and windrow beans	4 row	112	3.0	75	2.52	.39	110	.43
Harvest beans	4 row	112	2.5	65	1.82	.55	111	.61

[1]Field efficiency refers to the percentage of field time remaining for effective production after "lost time" has been deducted for such items as adjustments, repairs, lubrication, and turning at ends.

[2]The capacity of field machine was computed as follows:

$$\frac{(\text{Machine width in inches})(\text{Speed in MPH})(\text{Field efficiency})}{100}$$

[3]Hours of machine and power time to cover one acre.

Source: Larry J. Connor, "Costs and Returns for Major Cash Crops in Southern Michigan," Agricultural Economics Report No. 87, Department of Agricultural Economics, Michigan State University, November, 1967.

APPENDIX TABLE 11.--Machinery, power, and labor operating costs per acre by enterprise and operation using a 4-row system with complete ownership.

Enterprise and Operation	Equipment Size	Operating Cost Per Hour	Per Acre: Labor Requirements	Per Acre: Machine Hour Requirements	Per Acre: Operating Cost
		($)	(hours)	(hours)	($)
Corn					
spread fertilizer	10 ft.	.15	.28	.21	.032
plow	4-16"	.58	.47	.46	.267
plant and fertilize	4 row	.37	.36	.29	.107
spray	6 row	.19	.16	.13	.025
cultivate	4 row	.23	.27	.26	.060
combine	2 row	2.52	.70	.63	1.588
power[1]	64 HP	1.12	---	.67	.750
power[1]	51 HP	.92	---	.68	.626
labor		1.50	2.24		3.360
		Total Operating Cost Per Acre			6.82
Soybeans					
plow	4-16"	.58	.47	.46	.267
harrow	12 ft.	.12	.19	.17	.020
plant, fert. and spray	4 row	.46	.59	.45	.207
cultivate	4 row	.23	.36	.35	.080
combine	10 ft.	1.90	.61	.55	1.045
power[1]	64 HP	1.12	---	.71	.795
power[1]	51 HP	.92	---	.72	.662
labor		1.50	2.22		3.330
		Total Operating Cost Per Acre			6.41

APPENDIX TABLE 11.--Continued.

Enterprise and Operation	Equipment Size	Operating Cost Per Hour	Per Acre: Labor Requirements	Per Acre: Machine Hour Requirements	Per Acre: Operating Cost
		($)	(hours)	(hours)	($)
Navy Beans					
plow	4-16"	.58	.47	.46	.267
disc and spray	12 ft.	.44	.23	.21	.092
plant and fertilize	4 row	.37	.48	.39	.144
cultivate (2 times)	4 row	.23	.72	.70	.161
pull and windrow	4 row	.60	.43	.39	.234
combine	4 row	2.09	.61	.55	1.150
power[1]	64 HP	1.12	---	1.07	1.198
power[1]	51 HP	.92	---	1.08	.994
labor		1.50	2.94		4,410
		Total Operating Cost Per Acre			8.65
Wheat					
plow	4-16"	.58	.47	.46	.267
disc	12 ft.	.30	.18	.18	.054
harrow	12 ft.	.12	.19	.17	.020
drill and fertilize	15-7"	.39	.52	.44	.172
combine	10 ft.	1.90	.44	.40	.760
power[1]	64 HP	1.12	---	.62	.694
power[1]	51 HP	.92	---	.63	.580
labor		1.50	1.80		2.700
		Total Operating Cost Per Acre			5.25

See footnote at bottom of Appendix Table 14.

APPENDIX TABLE 12.--Machinery, power, and labor operating costs per acre by enterprise and operation using a 4-row system with a combination of ownership and custom hiring.

Enterprise and Operation	Equipment Size	Operating Cost Per Hour	Per Acre: Labor Requirements	Per Acre: Machine Hour Requirements	Per Acre: Operating Cost
		($)	(hours)	(hours)	($)
Corn					
spread fertilizer	(custom)	---	---	---	1.050
plow	4-16"	.58	.47	.46	.267
plant and fertilize	4 row	.37	.36	.29	.107
spray	6 row	.19	.16	.13	.025
cultivate	4 row	.23	.27	.26	.060
combine	(custom)	---	---	---	7.000
power[1]	64 HP	1.12	---	.57	.638
power[1]	51 HP	.92	---	.57	.524
labor		1.50	1.26		1.890
		Total Operating Cost Per Acre			11.56
Soybeans					
plow	4-16"	.58	.47	.46	.267
harrow	12 ft.	.12	.19	.17	.020
plant, fert. and spray	4 row	.46	.59	.45	.207
cultivate	4 row	.23	.36	.35	.080
combine	(custom)	---	---	---	6.000
power[1]	64 HP	1.12	---	.71	.795
power[1]	51 HP	.92	---	.72	.662
labor		1.50	1.61		2.415
		Total Operating Cost Per Acre			10.45

APPENDIX TABLE 12.--Continued.

Enterprise and Operation	Equipment Size	Operating Cost Per Hour	Per Acre: Labor Requirements	Per Acre: Machine Hour Requirements	Per Acre: Operating Cost
		($)	(hours)	(hours)	($)
Navy Beans					
plow	4-16"	.58	.47	.46	.267
disc and spray	12 ft.	.44	.23	.21	.092
plant and fertilize	4 row	.37	.48	.39	.144
cultivate (2 times)	4 row	.23	.72	.70	.161
pull and windrow	(custom)	---	---	---	2.000
combine	(custom)	---	---	---	7.000
power[1]	64 HP	1.12	---	.88	.986
power[1]	51 HP	.92	---	.88	.810
labor		1.50	1.90		2.850
		Total Operating Cost Per Acre			14.24
Wheat					
plow	4-16"	.58	.47	.46	.267
disc	12 ft.	.30	.18	.18	.054
harrow	12 ft.	.12	.19	.17	.020
drill and fertilize	15-7"	.39	.52	.44	.172
combine	(custom)	---	---	---	6.000
power[1]	64 HP	1.12	---	.62	.694
power[1]	51 HP	.92	---	.63	.580
labor		1.50	1.36		2.040
		Total Operating Cost Per Acre			9.80

See footnote at bottom of Appendix Table 14.

APPENDIX TABLE 13.--Machinery, power, and labor operating costs per acre by enterprise and operation using a 6-row system with complete ownership.

Enterprise and Operation	Equipment Size	Operating Cost Per Hour	Per Acre: Labor Requirements	Per Acre: Machine Hour Requirements	Per Acre: Operating Cost
		($)	(hours)	(hours)	($)
Corn					
spread fertilizer	30 ft.	.20	.09	.07	.014
plow	5-16"	.68	.38	.37	.252
plant and fertilize	6 row	.60	.24	.19	.114
spray	6 row	.19	.16	.15	.028
cultivate	6 row	.35	.18	.17	.060
combine	3 row	3.65	.50	.34	1.241
power[1]	74 HP	1.26	---	.47	.592
power[1]	64 HP	1.12	---	.48	.538
labor		1.50	1.55		2.325
		Total Operating Cost Per Acre			5.16
Soybeans					
plow	5-16"	.68	.38	.37	.252
harrow	16 ft.	.14	.14	.13	.018
plant, fert. and spray	6 row	.72	.40	.30	.216
cultivate	6 row	.35	.24	.23	.080
combine	14 ft.	2.53	.49	.44	1.113
power[1]	74 HP	1.26	---	.51	.643
power[1]	64 HP	1.12	---	.52	.582
labor		1.50	1.65		2.475
		Total Operating Cost Per Acre			5.38

APPENDIX TABLE 13.--Continued.

Enterprise and Operation	Equipment Size	Operating Cost Per Hour	Per Acre: Labor Requirements	Per Acre: Machine Hour Requirements	Per Acre: Operating Cost
		($)	(hours)	(hours)	($)
Navy Beans					
plow	5-16"	.68	.38	.37	.252
disc and spray	16 ft.	.53	.18	.16	.085
plant and fertilize	6 row	.60	.22	.18	.108
cultivate (2 times)	6 row	.35	.48	.46	.161
pull and windrow	4 row	.60	.43	.39	.234
combine	4 row	2.65	.61	.55	1.458
power[1]	74 HP	1.26	---	.78	.983
power[1]	64 HP	1.12	---	.78	.874
labor		1.50	2.30		3.450
		Total Operating Cost Per Acre			7.60
Wheat					
plow	5-16"	.68	.38	.37	.252
disc	16 ft.	.38	.15	.15	.057
harrow	16 ft.	.14	.14	.13	.018
drill and fertilize	17-7"	.42	.41	.37	.155
combine	14 ft.	2.53	.31	.28	.708
power[1]	74 HP	1.26	---	.51	.643
power[1]	64 HP	1.12	---	.51	.571
labor		1.50	1.39		2.085
		Total Operating Cost Per Acre			4.49

See footnote at bottom of Appendix Table 14.

APPENDIX TABLE 14.--Machinery, power, and labor operating costs per acre by enterprise and operation using a 6-row system with a combination of ownership and custom hiring.

Enterprise and Operation	Equipment Size	Operating Cost Per Hour	Per Acre: Labor Requirements	Per Acre: Machine Hour Requirements	Per Acre: Operating Cost
		($)	(hours)	(hours)	($)
Corn					
spread fertilizer	(custom)	---	---	---	1.050
plow	5-16"	.68	.38	.37	.252
plant and fertilize	6 row	.60	.24	.19	.114
spray	6 row	.19	.16	.15	.028
cultivate	6 row	.35	.18	.17	.060
combine	(custom)	---	---	---	7.000
power[1]	74 HP	1.26	---	.44	.554
power[1]	64 HP	1.12	---	.44	.493
labor		1.50	.96		1.440
		Total Operating Cost Per Acre			10.99
Soybeans					
plow	5-16"	.68	.38	.37	.252
harrow	16 ft.	.14	.14	.13	.018
plant, fert. and spray	6 row	.72	.40	.30	.216
cultivate	6 row	.35	.24	.23	.080
combine	(custom)	---	---	---	6.000
power[1]	74 HP	1.26	---	.51	.643
power[1]	64 HP	1.12	---	.52	.571
labor		1.50	1.16		1.740
		Total Operating Cost Per Acre			9.52

APPENDIX TABLE 14.--Continued.

Enterprise and Operation	Equipment Size	Operating Cost Per Hour	Per Acre: Laboe Requirements	Per Acre: Machine Hour Requirements	Per Acre: Operating Cost
		($)	(hours)	(hours)	($)
Navy Beans					
plow	5-16"	.68	.38	.37	.252
disc and spray	16 ft.	.53	.18	.16	.085
plant and fertilize	6 row	.60	.22	.18	.108
cultivate (2 times)	6 row	.35	.48	.46	.161
pull and windrow	(custom)	---	---	---	2.000
harvest	(custom)	---	---	---	7.000
power[1]	74 HP	1.26	---	.58	.731
power[1]	64 HP	1.12	---	.59	.661
labor		1.50	1.26		1.890
		Total Operating Cost Per Acre			12.89
Wheat					
plow	5-16"	.68	.38	.37	.252
disc	16 ft.	.38	.15	.15	.057
harrow	16 ft.	.14	.14	.13	.018
drill and fertilize	17-7"	.42	.41	.37	.155
combine	(custom)	---	---	---	6.000
power[1]	74 HP	1.26	---	.51	.643
power[1]	64 HP	1.12	---	.51	.571
labor		1.50	1.08		1.620
		Total Operating Cost Per Acre			9.32

[1]Hourly power requirements per acre were divided evenly between the two tractors.

APPENDIX TABLE 15.--Custom rates per acre and per forty-acre increments by enterprise and operation.

Enterprise and Operation	Custom Rates Per Acre	Custom Rates Per Forty-Acre Increments[1]
	($)	($)
Corn		
spread fertilizer	1.05	15.12
plow	5.50	79.20
plant and fertilize	2.30	36.00
spray	1.50	21.60
cultivate	2.00	28.80
harvest	7.00	100.80
Total for Corn	19.55	281.52
Soybeans		
plow	5.50	33.00
harrow	1.50	9.00
plant, fert. and spray	2.50	15.00
cultivate	2.00	12.00
harvest	6.00	36.00
Total for Soybeans	17.50	105.00
Navy Beans		
plow	5.50	41.80
disc and spray	2.50	19.00
plant and fertilize	2.50	19.00
cultivate (2 times)	4.00	30.40
pull and windrow	2.00	15.20
harvest	7.00	53.20
Total for Navy Beans	23.50	178.60
Wheat		
plow	5.50	33.00
disc	2.00	12.00
harrow	1.50	9.00
drill and fertilize	2.00	12.00
harvest	6.00	36.00
Total for Wheat	17.00	102.00

[1]Forty-acre increments are made up of 36 percent corn, 15 percent soybeans, 19 percent navy beans, and 15 percent wheat.

Sources: Doane Agricultural Service, Inc., 1967 Machinery Custom Rates, Vol. 30, No. 7-8, March, 1967.

Rates for Custom Work in Michigan, Extension Bulletin E-485. Cooperative Extension Service, Michigan State University.

Clyde May, Professional Farm Manager.

APPENDIX TABLE 16.--Computation of variable cost per acre by enterprise and machinery systems.

Machinery System and Enterprise	Machinery and Labor Oper. Cost	Seed	Fertilizer	Herbicide	Land Invest.	Custom Hauling	Total Variable Cost
	($)	($)	($)	($)	($)	($)	($)
6-row Complete Ownership							
Corn	5.60	2.84	15.28	5.80	18.00	5.10	52.62
Soybeans	5.38	3.74	8.68	5.00	18.00	1.68	42.48
Navy beans	7.60	3.69	8.68	5.66	18.00	1.38	45.01
Wheat	4.49	5.69	13.14	----	18.00	2.25	43.57
6-row Combination Ownership-Custom Hire							
Corn	10.99	2.84	15.28	5.80	18.00	5.10	58.01
Soybeans	9.52	3.74	8.68	5.00	18.00	1.68	46.62
Navy beans	12.89	3.69	8.68	5.66	18.00	1.38	50.30
Wheat	9.32	5.69	13.14	----	18.00	2.25	48.40
4-row Complete Ownership							
Corn	6.82	2.84	15.28	5.80	18.00	5.10	53.84
Soybeans	6.41	3.74	8.68	5.00	18.00	1.68	43.51
Navy beans	8.65	3.69	8.68	5.66	18.00	1.38	46.06
Wheat	5.25	5.69	13.14	----	18.00	2.25	44.33
4-row Combination Ownership-Custom Hire							
Corn	11.56	2.84	15.28	5.80	18.00	5.10	58.58
Soybeans	11.45	3.74	8.68	5.00	18.00	1.68	47.55
Navy beans	14.24	3.69	8.68	5.66	18.00	1.38	51.65
Wheat	9.80	5.69	13.14	----	18.00	2.25	48.88
Complete Custom Hire							
Corn	19.55	2.84	15.28	5.80	18.00	5.10	66.57
Soybeans	17.50	3.74	8.68	5.00	18.00	1.68	54.60
Navy beans	23.50	3.69	8.68	5.66	18.00	1.38	60.91
Wheat	17.00	5.69	13.14	----	18.00	2.25	56.08

APPENDIX TABLE 17.--Copy of rental and leasing questionnaire.

Confidential:
For Research
Purposes Only

Department of Agricultural Economics
Michigan State University

Questionnaire On Farm Machinery Rental and Leasing

1. Do you as a farm machinery dealer have a program whereby you rent or lease farm machinery to farmers?
Yes_____ No_____

1a. If you presently are not renting or leasing farm machinery, do you have any plans or intentions of doing so within the next two years?
Yes_____ No_____

If you checked "No" in question 1, disregard the remainder of this questionnaire and return it in the enclosed envelope.

SHORT-TERM: Questions 2 through 6 pertain to short-term (less than one year) rental or lease agreements.

2. Have you rented or leased new farm machinery on short-term arrangements since January 1, 1967?
Yes_____ No_____

3. Have you rented or leased used farm machinery on short-term arrangements since January 1, 1967?
Yes_____ No_____

4. Under your short-term rental or lease agreements, is the farmer required to make rental or lease payments when the item of machinery sets idle due to inclement weather?
Yes_____ No_____

5. Under your short-term rental or lease arrangements, who is responsible for the following and what is the percentage of responsibility between the dealer and the farmer?

Responsibility	Dealer	Farmer
	(Percent)	(Percent)
Insurance (fire, wind, theft)		
Taxes (where applicable)		
Liabilities (personal injury)		

APPENDIX TABLE 17.--Continued.

Responsibility	Dealer	Farmer
	(Percent)	(Percent)
Maintenance and Repairs		
"Normal" wear and tear		
Operating Costs (fuel, oil, lubrication)		
Transportation Costs (between farmer and dealer)		
Other____________________		

6. Please indicate below the extent and nature of your short-term rental or lease program which you have carried on <u>since January 1, 1967</u>:

   a. The items of farm machinery which you have rented or leased on a short-term basis.
   b. The "average" or typical capacity of each item rented or leased.
   c. The number of units of each item.
   d. The "average" or typical time period of rental or lease for each item.
   e. The rate (in dollars) charged per time period or unit measure, i.e., acre, ton, bu., hour, day, week, month, etc.
   f. The delivered sales price of the item rented or leased.

(a)	(b)	(c)	(d)	(e)	(f)
Item of Equipment	Average Capacity	Number of Units	Average Time Period of Contract (hrs., days, week, mo.)	Rate Per Time Period or Unit ($ per acre, hr., week, mo.)	Delivered Sales Price ($)
Farm Tractors	HP				
Planters	rows				
Drills	ft.				
Balers					
Combines (small grain)	ft.				
Combines (corn)	rows				
Corn Pickers	rows				

APPENDIX TABLE 17.--Continued.

(a) Item of Equipment	(b) Average Capacity	(c) Number of Units	(d) Average Time Period of Contract (hrs., days, week, mo.)	(e) Rate Per Time Period or Unit ($ per acre, hr., week, mo.)	(f) Delivered Sales Price ($)
Choppers	rows				
Plows	bottoms				
Discs	ft.				
Harrows	ft.				
Manure Spreaders	bu.				
Cultivators	rows				
Sprayers	ft.				
Fertilizer Spreaders	ft.				
Dryers	bu.				
Other____					
__________					

LONG-TERM: Questions 7 through 12 pertain to long-term (one year or more) leasing arrangements. If you have no long-term lease arrangements, please disregard the remainder of this questionnaire and return it in the enclosed envelope.

7. Are you presently leasing new farm machinery on long-term arrangements?

   Yes_____ No_____

8. Are you presently leasing used farm machinery on long-term arrangements?

   Yes_____ No_____

9. Of the following alternatives, which best describes your policy of handling the investment credit tax benefit applicable to new machinery?

   Take It Myself__ Pass On To The Farmer__ No Provisions Made__

10. Do your long-term lease contracts contain a purchase option?

    Yes_____ No_____

APPENDIX TABLE 17.--Continued.

10a. Does the purchase option identify a specific purchase option price?

Yes_____ No_____

10b. Does the purchase option specify a percentage of past lease payments that will apply if the item is purchased?

Yes_____ No_____

11. Under your long-term lease arrangements, who is responsible for the following and what is the percentage of responsibility between the dealer and the farmer?

Responsibility	Dealer	Farmer
	(Percent)	(Percent)
Insurance (fire, wind, theft)		
Taxes (where applicable)		
Liabilities (personal injury)		
Maintenance and Repairs		
"Normal" wear and tear		
Operating Costs (fuel, oil, lubrication)		
Transportation Costs (between farmer and dealer)		
Other________________________		

12. Please indicate below the extent and nature of your <u>long-term</u> leasing program <u>applicable to the present</u>:

a. The items of farm machinery you are currently leasing on long-term arrangements.
b. The "average" or typical capacity of each item.
c. The number ofunits of each item.
d. The formula for establishing the amount of lease payment, i.e., a percent of retail value, etc.
e. The required frequency of lease payments.

(a) Item of Equipment	(b) Average Capacity	(c) Number of Units	(d) Formula for Rates	(e) Frequency of Payments

Additional Comments:____

____

Please return the questionnaire in the self-addressed envelope. Thank you.

APPENDIX TABLE 18.--Items, capacity, number of units, time period of contract, rates charged, and delivered sales price as reported by 18 farm machinery dealers holding short term rental or lease contracts in 1967.

Items	Size	Number of Units	Time Period of Contract	Rates	Sales Price ($)
Tractor	45 HP	1		$25/day	2,500
		2		$3/hour	3,600
	124 HP	1	2 days	$7/hour	
	65 HP	1	1-2 days	$3.50/hour	3,000
	40 HP	1		$3.00/hour	
		1 or more		10% of cost/month	8,000
		5		$4.50/hr. + $5/day	
	30 HP	2			1,700
	30 HP	5	1 week	$15/day	1,500
	44 HP	1	days	$25/day	1,500
	64 HP	2	1/2-4 days	$3/hour	5,000
Tractor and Plow		5	1-7 weeks	$3-$8/hour	
60 HP	4 bott	1	3 days	$6/acre	2,500
66 HP	5 bott	1		$6.50/hour	6,000
	6 bott	1		$7/hr. + $5/day	
Plow	2 bott	1		$1/hour	
	3 bott	1			
	4 bott	1	3 days	$1/acre	500
Disc	10 ft.	1	3 days	$1/acre	475
	8 ft.	1		$1/hour	
		2	1-7 weeks		
	8 ft.	2	2 days	$1/acre	
Harrow	8 ft.			$1/hour	
	12 ft.	1	3 days	$1/acre	100
Planters	4 row	1		$1/acre	500
	4 row	1	3 days	$1/acre	400
	4 row	1	1 day	$1/acre	600
Choppers	3 row	1	1 day	$2/acre	675

APPENDIX TABLE 18.--Continued.

Items	Size	Number of Units	Time Period of Contract	Rates	Sales Price ($)
Post Hole Digger	12 in.	1		$2/hour	
		1		$.25/hole	
Rotary Chopper	5 ft.	3		$2/hour	
	5 ft.	2		$1.50/acre	
		1		$1.50/acre	
Balers		1	1-7 days	$.03/bale	
		2	60 days	10% of cost	1,960
		1	1 month	$.04/bale	500
Corn Picker		2	1-4 weeks	$3/acre	
Manure Spreader		1	1-3 days	$5/day	
	125 bu.	1		$.75/load	
Fertilizer Spreader		1	1-3 days	$5/run	300
Fork Lift		3	5-8 weeks	$125/short week	
				$175/long week	7,500
Hay Conditioner		1		$2/acre	
Beet Top Beater		1	month	$3/acre	1,900
Subsoiler		1	month	$60/month	600
Stalk Chopper	2 row	1			
Combine	10 ft.	1		$3/acre	1,000
	10 ft.	1	3-7 days	$4/acre	4,700
Drills	15 and 12 hole	2	2-3 days	$1/acre	500

APPENDIX TABLE 19.--Budget for computing machinery, power, and labor costs per acre using a 4-row system with complete ownership.

Enterprise	Operating Cost/Acre	Operating Cost Per Typical Acre[1]	Operating Costs Per 40 Acre Increments[2] 40A.	80A.	120A.	160A.	200A.	240A.	280A.	320A.	360A.	400A.
	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)
Corn	6.82	2.4552	98	196	295	393	491	589	687	786	884	982
Soybeans	6.41	.9615	38	77	115	153	192	231	269	308	346	385
Navy beans	8.65	1.6435	66	131	197	263	329	394	460	526	592	657
Wheat	5.25	.7875	32	63	94	126	158	189	220	252	284	315
		5.8477										
Total Annual Operating Cost			234	468	702	936	1170	1403	1637	1871	2105	2339
Plus Annual Ownership Cost			3561	3561	3561	3561	3561	3561	3561	3561	3561	3561
Total Cost			3795	4029	4263	4497	4731	4964	5198	5432	5666	5900
Cost Per Acre			94.88	50.36	35.52	28.11	23.66	20.68	18.56	16.98	15.74	14.75

Enterprise	Operating Cost/Acre	Operating Cost Per Typical Acre[1]	Operating Costs Per 40 Acre Increments[2] 440A.	480A.	520A.	560A.	600A.	640A.	680A.	720A.	760A.	800A.
	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)
Corn	6.82	2.4552	1080	1178	1277	1375	1473	1571	1670	1768	1866	1964
Soybeans	6.41	.9615	423	462	500	538	577	615	654	692	731	769
Navy beans	8.65	1.6435	723	780	855	920	986	1052	1118	1183	1249	1315
Wheat	5.25	.7875	346	378	410	441	472	504	536	567	598	630
		5.8477										
Total Annual Operating Cost			2573	2807	3041	3275	3509	3743	3976	4210	4444	4678
Plus Annual Ownership Cost			3586	3706	3837	3857	4026	4052	4248	4280	4327	4601
Total Cost			6159	6513	6878	7132	7535	7795	8224	8490	8771	9279
Cost Per Acre			14.00	13.57	13.25	12.74	12.56	12.18	12.09	11.79	11.54	11.60

See footnotes at bottom of Appendix Table 22.

APPENDIX TABLE 20.--Budget for computing machinery, power, and labor costs per acre using a 4-row system with a combination of ownership and custom hiring.

Enterprise	Operating Cost/Acre	Operating Cost Per Typical Acre[1]	Operating Costs Per 40 Acre Increments[2]									
			40A.	80A.	120A.	160A.	200A.	240A.	280A.	320A.	360A.	400A.
	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)
Corn	11.56	4.1616	166	333	499	666	832	999	1165	1332	1498	1665
Soybeans	10.45	1.5675	63	125	188	251	314	376	439	502	564	627
Navy beans	14.24	2.7056	108	216	325	433	541	649	758	866	974	1082
Wheat	9.80	1.4700	59	118	176	235	294	353	412	470	529	588
		9.9047										
Total Annual Operating Cost			396	792	1189	1585	1981	2377	2773	3170	3566	3962
Plus Annual Ownership Cost			2178	2178	2178	2178	2178	2178	2178	2178	2178	2178
Total Cost			2574	2970	3367	3763	4159	4555	4951	5348	5744	6130
Cost Per Acre			64.35	37.12	28.06	23.52	20.80	18.98	17.68	16.71	15.96	15.32

Enterprise	Operating Cost/Acre	Operating Cost Per Typical Acre[1]	Operating Costs Per 40 Acre Increments[2]									
			440A.	480A.	520A.	560A.	600A.	640A.	680A.	720A.	760A.	800A.
	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)
Corn	11.56	4.1616	1831	1998	2164	2330	2497	2663	2830	2996	3163	3329
Soybeans	10.45	1.5675	690	752	815	878	940	1003	1066	1129	1191	1254
Navy beans	14.24	2.7056	1190	1299	1407	1515	1623	1732	1840	1948	2056	2164
Wheat	9.80	1.4700	647	706	764	823	882	941	1000	1058	1117	1176
		9.9047										
Total Annual Operating Cost			4358	4754	5150	5547	5943	6339	6735	7131	7528	7924
Plus Annual Ownership Cost			2203	2232	2249	2269	2292	2318	2318	2350	2397	2397
Total Cost			6561	6986	7399	7816	8235	8657	9053	9481	9925	10321
Cost Per Acre			14.91	14.55	14.23	13.96	13.72	13.53	13.31	13.17	13.06	12.90

See footnotes at bottom of Appendix Table 22.

APPENDIX TABLE 21.--Budget for computing machinery, power, and labor costs per acre using a 6 row system with complete ownership.

Enterprise	Operating Cost/Acre	Operating Cost Per Typical Acre[1]	Operating Costs Per 40 Acre Increments[2] 40A.	80A.	120A.	160A.	200A.	240A.	280A.	320A.
	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)
Corn	5.16	1.8576	74	149	223	297	372	446	520	594
Soybeans	5.38	.8070	32	65	97	129	161	194	226	258
Navy beans	7.60	1.4440	58	116	173	231	289	347	404	462
Wheat	4.49	.6735	27	54	81	108	135	162	189	216
		4.7821								
Total Annual Operating Cost			191	383	574	765	956	1148	1339	1530
Plus Annual Ownership Cost			4505	4505	4505	4505	4505	4505	4505	4505
Total Cost			4696	4888	5079	5270	5461	5653	5844	6035
Cost Per Acre			117.40	61.10	42.32	32.94	27.30	23.55	20.87	18.86

Enterprise	Operating Cost/Acre	Operating Cost Per Typical Acre[1]	Operating Costs Per 40 Acre Increments[2] 360A.	400A.	440A.	480A.	520A.	560A.	600A.	640A.
	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)
Corn	5.16	1.8576	669	743	817	892	966	1040	1115	1189
Soybeans	5.38	.8070	291	323	355	387	420	452	484	516
Navy beans	7.60	1.4440	520	578	635	693	751	809	866	924
Wheat	4.49	.6735	242	269	296	323	350	377	404	431
		4.7821								
Total Annual Operating Cost			1722	1913	2104	2295	2487	2678	2869	3061
Plus Annual Ownership Cost			4505	4505	4505	4505	4517	4517	4659	4835
Total Cost			6227	6418	6609	6800	7004	7195	7528	7896
Cost Per Acre			17.30	16.04	15.02	14.17	13.47	12.85	12.55	12.34

APPENDIX TABLE 21.--Continued.

Enterprise	Operating Cost/Acre	Operating Cost Per Typical Acre[1]	Operating Cost Per 40 Acre Increments[2]								
			680A.	720A.	760A.	800A.	840A.	880A.	920A.	960A.	1000A.
	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)
Corn	5.16	1.8576	1263	1337	1412	1486	1560	1635	1709	1783	1858
Soybeans	5.38	.8070	549	581	613	646	678	710	742	775	807
Navy beans	7.60	1.4440	982	1040	1097	1155	1213	1271	1328	1386	1444
Wheat	4.49	.6735	458	485	512	539	566	593	620	647	674
		4.7821									
Total Annual Operating Cost			3252	3443	3634	3826	4017	4208	4400	4591	4782
Plus Annual Ownership Cost			4858	5084	5111	5111	5417	5454	5454	5502	5877
Total Cost			8110	8527	8745	8937	9434	9662	9854	10093	10659
Cost Per Acre			11.93	11.84	11.51	11.17	11.23	10.98	10.71	10.51	10.66

See footnotes at bottom of Appendix Table 22.

APPENDIX TABLE 22.--Budget for computing machinery, power, and labor costs per acre using a 6-row system with a combination of ownership and custom hiring.

Enterprise	Operating Cost/Acre	Operating Cost Per Typical Acre[1]	Operating Costs Per 40 Acre Increments[2]							
			40A.	80A.	120A.	160A.	200A.	240A.	280A.	320A.
	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)
Corn	10.99	3.9564	158	317	475	633	791	950	1108	1266
Soybeans	9.52	1.4280	57	114	171	228	286	343	400	457
Navy beans	12.89	2.4491	98	196	294	392	490	588	686	784
Wheat	9.32	1.3980	56	112	168	224	280	336	391	447
		9.2315								
Total Annual Operating Cost			369	739	1108	1477	1846	2216	2585	2954
Plus Annual Ownership Cost			2670	2670	2670	2670	2670	2670	2670	2670
Total Cost			3039	3409	3778	4147	4516	4886	5255	5624
Cost Per Acre			75.98	42.61	31.48	25.92	22.58	20.36	18.77	17.58

Enterprise	Operating Cost/Acre	Operating Cost Per Typical Acre[1]	Operating Costs Per 40 Acre Increments[2]							
			360A.	400A.	440A.	480A.	520A.	560A.	600A.	640A.
	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)
Corn	10.99	3.9564	1424	1583	1741	1899	2057	2216	2374	2532
Soybeans	9.52	1.4280	514	571	628	685	743	800	857	914
Navy beans	12.89	2.4491	882	980	1078	1176	1274	1371	1469	1567
Wheat	9.32	1.3980	503	559	615	671	727	783	839	895
		9.2315								
Total Annual Operating Cost			3323	3693	4062	4431	4800	5170	5539	5908
Plus Annual Ownership Cost			2670	2670	2670	2670	2682	2682	2698	2718
Total Cost			5993	6363	6732	7101	7482	7852	8237	8626
Cost Per Acre			16.65	15.91	15.30	14.79	14.39	14.02	13.73	13.48

APPENDIX TABLE 22.--Continued.

Enterprise	Operating Cost/Acre	Operating Cost Per Typical Acre[1]	Operating Cost Per 40 Acre Increments[2]								
			680A.	720A.	760A.	800A.	840A.	880A.	920A.	960A.	1000A.
	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)
Corn	10.99	3.9564	2690	2849	3007	3165	3323	3482	3640	3798	3956
Soybeans	9.52	1.4280	971	1028	1085	1142	1200	1257	1314	1371	1428
Navy beans	12.89	2.4491	1665	1763	1861	1959	2057	2155	2253	2351	2449
Wheat	9.32	1.3980	951	1007	1062	1118	1174	1230	1286	1342	1398
		9.2315									
Total Annual Operating Cost			6277	6647	7016	7385	7754	8124	8493	8862	9232
Plus Annual Ownership Cost			2741	2764	2791	2791	2829	2866	2866	2914	2914
Total Cost			9018	9411	9807	10176	10583	11090	11359	11776	12146
Cost Per Acre			13.26	13.07	12.90	12.72	12.60	12.60	12.35	12.27	12.15

[1]A typical acre consists of 36 percent corn, 15 percent soybeans, 19 percent navy beans, and 15 percent wheat.

[2]Figures may not add due to rounding.

APPENDIX TABLE 23.--Budget for computing cost per acre for complete custom hiring.

Enterprise	Custom Rates Per Acre	Custom Rates Per Typical Acre[1]	Custom Rates Per 40 Acres
	($)	($)	($)
Corn	19.55	7.0380	281.52
Soybeans	17.50	2.6250	105.00
Navy beans	23.50	4.4650	178.60
Wheat	17.00	2.5500	102.00
		16.6780	667.12
Cost Per Acre[2]			16.678

[1]A typical acre consists of 36 percent corn, 15 percent soybeans, 19 percent navy beans, and 15 percent wheat.

[2]Under the assumptions, this figure will remain the same regardless of farm size.

APPENDIX TABLE 24.--Estimated number of days lost in a 6-day work week due to inclement weather.

Climatic Week: Calendar Period	Climatic Week: No.	Ten Year Average Precipitation[1]	Number of Ten Hour Days Lost Per Week[2]	Number of Hours Lost Per Week	Average Number of Hours Lost Per Day	Number of Days Lost in a Six-Day Work Week[3]
		(inch)	(days)	(hours)	(hours)	(days)
April 1-7	1	.75	1.8	18	2.57	1.54
April 8-14	2	.28	.8	8	1.14	.68
April 15-21	3	.66	1.6	16	2.29	1.37
April 22-28	4	.73	1.8	18	2.57	1.54
April 29-May 5	5	.40	1.0	10	1.43	.86
May 6-12	6	.68	1.7	17	2.43	1.46
May 13-19	7	.42	1.0	10	1.43	.86
May 20-26	8	.30	.8	8	1.14	.68
May 27-June 2	9	.33	.8	8	1.14	.68
June 3-9	10	1.16	2.7	27	3.86	2.32
June 10-16	11	.91	2.2	22	3.14	1.88
June 17-23	12	.60	1.5	15	2.14	1.28
June 24-30	13	.36	.9	9	1.29	.77
July 1-7	14	.66	1.6	16	2.29	1.37
July 8-14	15	.44	1.1	11	1.57	.94
July 15-21	16	.57	1.4	14	2.00	1.20
July 22-28	17	.50	1.2	12	1.71	1.03
July 29-Aug. 4	18	.75	1.8	18	2.57	1.54
Aug. 5-11	19	.56	1.4	14	2.00	1.20
Aug. 12-18	20	.64	1.6	16	2.29	1.37
Aug. 19-25	21	.84	2.0	20	2.86	1.71
Aug. 26-Sept. 1	22	.70	1.7	17	2.43	1.46
Sept. 2-8	23	.41	1.0	10	1.43	.86

APPENDIX TABLE 24.--Continued.

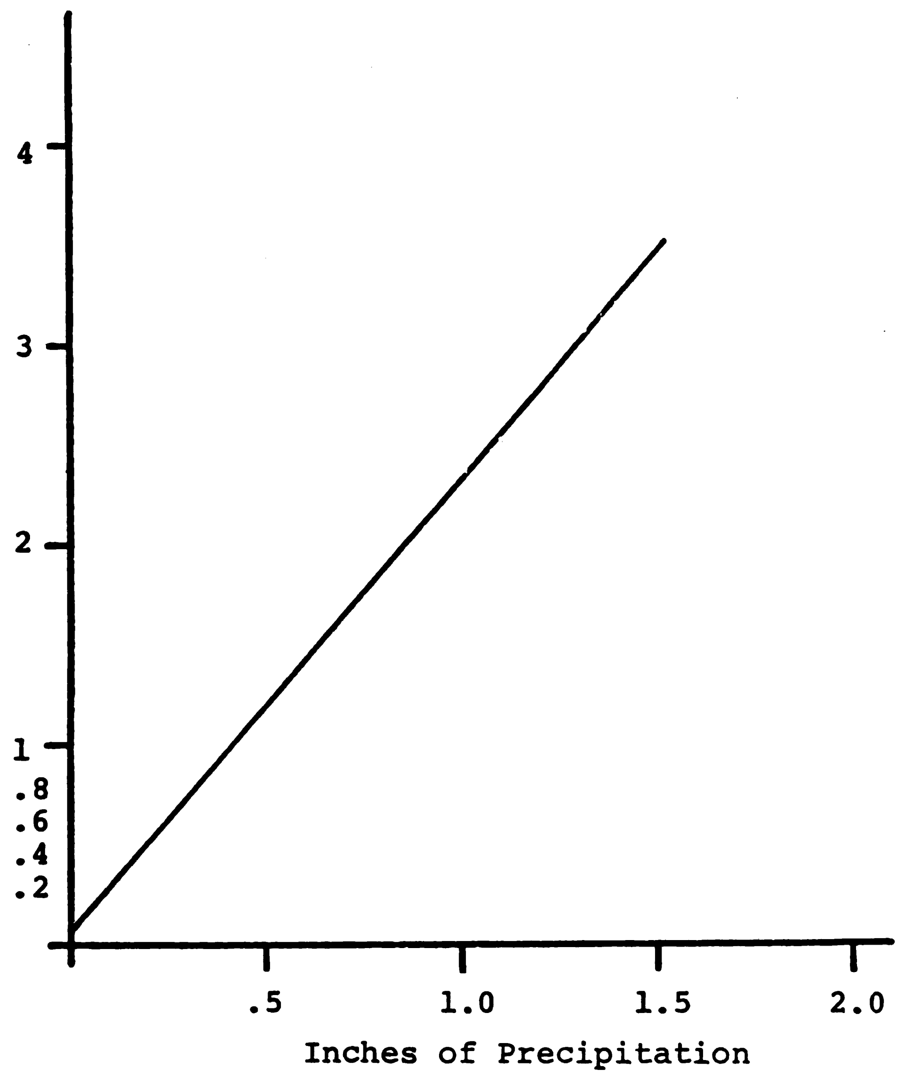
Climatic Week		Ten Year Average Precipitation[1]	Number of Ten Hour Days Lost Per Week[2]	Number of Hours Lost Per Week	Average Number of Hours Lost Per Day	Number of Days Lost in a Six-Day Work Week[3]
Calendar Period	No.					
		(inch)	(days)	(hours)	(hours)	(days)
Sept. 9-15	24	.63	1.5	15	2.14	1.28
Sept. 16-22	25	.99	2.4	24	3.43	2.06
Sept. 23-29	26	.69	1.7	17	2.43	1.46
Sept. 30-Oct. 6	27	.50	1.2	12	1.71	1.03
Oct. 7-13	28	.45	1.1	11	1.57	.94
Oct. 14-20	29	.37	.9	9	1.29	.77
Oct. 21-27	30	.42	1.0	10	1.43	.86
Oct. 28-Nov. 3	31	.43	1.1	11	1.57	.94
Nov. 4-10	32	.47	1.2	12	1.71	1.03
Nov. 11-17	33	.60	1.5	15	2.14	1.28
Nov. 18-24	34	.26	.7	7	1.00	.60
Nov. 25-Dec. 1	35	.58	1.5	15	2.14	1.28

[1]Data pertains to the years 1958 to 1967. The information was obtained from the U.S. Weather Bureau, East Lansing, Michigan.

[2]Based on the regression, Appendix Table 25.

[3]Values in this column are 6/10 of the values in the preceding column. Multiply by 6 to get the number of hours lost in a 6-day work week and divide by 10 to convert hours lost into days lost.

APPENDIX TABLE 25.--Relationship between inches of precipitation and field work days lost.



Y = .04 + 2.34X

Y = Days Lost

X = Inches of Precipitation

Source: Unpublished data U.S. Weather Bureau and Department of Agricultural Engineering, Michigan State University.

APPENDIX TABLE 26.--Critical planting and harvesting periods and losses in yield resulting from late planting and harvesting.

Crop and Maximum Yield	Critical Period to Obtain Maximum Yield		Late Operations Causing Reductions in Yield	Yield Reductions: Number of Weeks Operation is Late								
	Planting	Harvesting		1	2	3	4	5	6	7	8	9
				(bu.)	(bu.)	(bu.)	(bu.)	(bu.)	(bu.)	(bu.)	(bu.)	(bu.)
Corn	May 1-10	Oct. 5-15	planting	5	10	14						
85 bu.			harvesting	1	2	3	5	7	10	15	20	25
Soybeans	May 15-25	Oct. 1-10	planting	1	2	5	13					
28 bu.			harvesting	1.5	3.5	6.5	11.5	17.0				
Navy beans	June 1-10	Aug. 25-	planting	1	2	5	13	20				
23 bu.		Sept. 15	harvesting	1.5	3.5	6.5	11.5	20	23			
Wheat	Sept. 16-25	July 10-20	planting	2	4	8	16	35	45			
45 bu.			harvesting	2	4	9	20					

Source: Unpublished data, Department of Crop Science, Michigan State University.

APPENDIX TABLE 27.--Summary of late planting and harvesting operations by farm size and 4-row machinery systems.[1]

Farm Size (Tillable acres)	Crop[2]	Complete Ownership: Acres Planted Late	Complete Ownership: Number of Weeks Late[3]	Complete Ownership: Acres Harvested Late	Combination Ownership and Custom Hire: Acres Planted Late	Combination Ownership and Custom Hire: Number of Weeks Late[3]	Combination Ownership and Custom Hire: Acres Harvested Late
		(acre)	(week)	(acre)	(acre)	(week)	(acre)
240[4]	C		1	3.0			
280	C		1	17.4			
320	C		1	31.8			
360	C		1	46.2			
400	C		1	60.6			
440	C		1	74.3			
			2	.7			
480	C		1	74.3			
			2	15.1			
520	C	15.0	1	74.3	15.0	1	15.0
			2	28.6			
560	C	71.0	1	74.3	71.0	1	71.0
			2	43.0			
	N	2.2	1	2.2	2.2	1	2.2
	W	3.2	1				
600	C	124.3	1	74.3	124.3	1	124.3
			2	72.9			
			3	48.8			
	S	37.5	1	37.5	37.5	1	37.5
	N	64.0	1	37.5	64.0	1	64.0
			2	26.5			
	W	50.0	1				
		40.0	2				

APPENDIX TABLE 27.--Continued.

Farm Size (Tillable acres)	Crop[2]	Complete Ownership			Combination Ownership and Custom Hire		
		Acres Planted Late	Number of Weeks Late[3]	Acres Harvested Late	Acres Planted Late	Number of Weeks Late[3]	Acres Harvested Late
		(acre)	(week)	(acre)	(acre)	(week)	(acre)
640	C	136.1	1		136.1	1	136.1
		41.5	2	72.9	41.5	2	41.5
			3	71.4			
			4	70.0			
			5	16.1			
	S	89.9	1	36.1	89.9	1	89.9
		4.4	2	59.9	4.4	2	4.4
	N	62.5	1	37.5	62.5	1	62.5
		59.1	2	43.3	59.1	2	59.1
			3	40.8			
	W	25.0	2				
		71.0	3				
680	C	136.1	1		136.1	1	136.1
		99.3	2	40.0	99.3	2	99.3
			3	71.4			
			4	70.0			
			5	63.4			
	S	74.6	1		74.6	1	74.6
		27.4	2	72.1	27.4	2	27.4
			3	29.9			
	N	43.8	1	37.5	43.8	1	43.8
		85.4	2	43.3	85.4	2	85.4
			3	48.4			
	W	71.0	3				
		31.0	4				

APPENDIX TABLE 27.--Continued.

Farm Size (Tillable acres)	Crop[2]	Complete Ownership: Acres Planted Late	Complete Ownership: Number of Weeks Late[3]	Complete Ownership: Acres Harvested Late	Combination Ownership and Custom Hire: Acres Planted Late	Combination Ownership and Custom Hire: Number of Weeks Late[3]	Combination Ownership and Custom Hire: Acres Harvested Late
		(acre)	(week)	(acre)	(acre)	(week)	(acre)
720	C	119.4	1		119.4	1	119.4
		139.8	2		139.8	2	139.8
			3	30.0			
			4	70.0			
			5	70.0			
			6	74.3			
			7	14.9			
	S	40.0	1		40.0	1	40.0
		68.0	2	1.3	68.0	2	68.0
			3	83.6			
			4	23.1			
	N	100.0	2	43.3	100.0	2	100.0
		36.8	3	48.1	36.8	3	36.8
			4	45.4			
	W		1	106.4			
		100.0	4				
		8.0	5				
760	C	55.6	1		55.6	1	55.6
		147.2	2		147.2	2	147.2
		70.8	3	1.1	70.8	3	70.8
			4	70.0			
			5	70.0			
			6	74.3			
			7	58.2			
	S	64.4	2		64.4	2	64.4

APPENDIX TABLE 27.--Continued.

		Complete Ownership			Combination Ownership and Custom Hire		
Farm Size (Tillable acres)	Crop[2]	Acres Planted Late	Number of Weeks Late[3]	Acres Harvested Late	Acres Planted Late	Number of Weeks Late[3]	Acres Harvested Late
		(acre)	(week)	(acre)	(acre)	(week)	(acre)
760		49.6	3	57.4	49.6	3	49.6
(Cont.)			4	56.6			
	N	29.2	2	29.2	29.2	2	29.2
		106.2	3	48.1	106.2	3	106.2
		9.0	4	49.0	9.0	4	9.0
			5	18.1			
	W		1	1.8			
			2	102.3			
			3	9.9			
		69.2	4				
		44.8	5				
800	C	38.9	1		38.9	1	38.9
		147.2	2		147.2	2	147.2
		101.9	3		101.9	3	101.9
			4	1.0			
			5	70.0			
			6	74.3			
			7	67.0			
			8	67.0			
			9	8.7			
	S	37.3	2		37.3	2	37.3
		50.8	3		50.8	3	50.8
		31.9	4	70.5	31.9	4	31.9
			5	49.5			

APPENDIX TABLE 27.--Continued.

Farm Size (Tillable acres)	Crop[2]	Complete Ownership: Acres Planted Late	Complete Ownership: Number of Weeks Late[3]	Complete Ownership: Acres Harvested Late	Combination Ownership and Custom Hire: Acres Planted Late	Combination Ownership and Custom Hire: Number of Weeks Late[3]	Combination Ownership and Custom Hire: Acres Harvested Late
		(acre)	(week)	(acre)	(acre)	(week)	(acre)
800 (Cont.)	N	43.7	3	43.7	43.7	3	43.7
		97.9	4	49.0	97.9	4	97.9
		10.4	5	50.0	10.4	5	10.4
			6	9.3			
	W		3	106.8			
			4	13.2			
		84.6	5				
		35.4	6				

[1]The system of complete custom hiring is not included because of the assumption that custom operators are available in sufficient numbers to complete all operations on time.

[2]C = corn; S = soybeans; N = navy beans; W = wheat.

[3]Numbers in this column refer to both late plantings and harvestings.

[4]No late plantings or harvestings occurred on farms smaller than this.

APPENDIX TABLE 28.--Summary of late planting and harvesting operations by farm size and 6-row machinery systems.[1]

Farm Size (Tillable acres)	Crop[2]	Complete Ownership: Acres Planted Late	Complete Ownership: Number of Weeks Late[3]	Complete Ownership: Acres Harvested Late	Combination Ownership and Custom Hire: Acres Planted Late	Combination Ownership and Custom Hire: Number of Weeks Late[3]	Combination Ownership and Custom Hire: Acres Harvested Late
		(acre)	(week)	(acre)	(acre)	(week)	(acre)
440[4]	C		1	10.4			
480	C		1	28.8			
520	C		1	47.2			
560	C		1	67.6			
600	C		1	86.0			
640	C		1	104.0			
			2	.4			
	N		1	.4			
680	C		1	104.0			
			2	18.8			
	N		1	8.0			
720	C		1	104.0			
			2	37.2			
	N		1	15.6			
	W	5.6	1				
760	C	15.3	1	104.0	15.3	1	15.3
			2	65.6			
	N		1	23.2			
	W	50.6	1				
800	C	79.7	1	104.0	79.7	1	79.7
			2	96.0			
	N	17.6	1	30.8	17.6	1	17.6
	W	90.7	1				

APPENDIX TABLE 28.--Continued.

Farm Size (Tillable acres)	Crop[2]	Complete Ownership: Acres Planted Late	Complete Ownership: Number of Weeks Late[3]	Complete Ownership: Acres Harvested Late	Combination Ownership and Custom Hire: Acres Planted Late	Combination Ownership and Custom Hire: Number of Weeks Late[3]	Combination Ownership and Custom Hire: Acres Harvested Late
		(acre)	(week)	(acre)	(acre)	(week)	(acre)
840	C	127.4	1	60.0	127.4	1	127.4
			2	102.0			
			3	100.0			
			4	40.4			
	S	13.5	1	104.1	13.5	1	13.5
			2	11.7			
	N	84.6	1	37.5	84.6	1	84.6
			2	43.3			
			3	3.8			
	W	122.0	2				
		4.0	3				
880	C	183.5	1		183.5	1	183.5
			2	42.0			
			3	100.0			
			4	98.0			
			5	76.8			
	S	54.5	1	106.1	54.5	1	54.5
			2	25.9			
	N	131.2	1	37.5	131.2	1	131.2
		4.8	2	43.3	4.8	2	4.8
			3	48.1			
			4	7.1			
	W	124.4	3				
		7.6	4				

APPENDIX TABLE 28.--Continued.

Farm Size (Tillable acres)	Crop[2]	Complete Ownership: Acres Planted Late	Complete Ownership: Number of Weeks Late[3]	Complete Ownership: Acres Harvested Late	Combination Ownership and Custom Hire: Acres Planted Late	Combination Ownership and Custom Hire: Number of Weeks Late[3]	Combination Ownership and Custom Hire: Acres Harvested Late
		(acre)	(week)	(acre)	(acre)	(week)	(acre)
920	C	204.2	1		204.2	1	204.2
		18.7	2		18.7	2	18.7
			3	60.0			
			4	98.0			
			5	98.0			
			6	75.2			
	S	98.0	1		98.0	1	98.0
			2	24.9			
			3	104.1			
			4	9.0			
	N	115.6	1	37.5	115.6	1	115.6
		59.2	2	43.3	59.2	2	59.2
			3	48.1			
			4	45.9			
	W	17.1	3				
		120.9	4				
960	C	204.2	1		204.2	1	204.2
		87.2	2		87.2	2	87.2
			3	14.0			
			4	98.0			
			5	98.0			
			6	104.0			
			7	31.6			
	S	125.0	1		125.0	1	125.0

APPENDIX TABLE 28.--Continued.

Farm Size (Tillable acres)	Crop[2]	Complete Ownership			Combination Ownership and Custom Hire		
		Acres Planted Late	Number of Weeks Late[3]	Acres Harvested Late	Acres Planted Late	Number of Weeks Late[3]	Acres Harvested Late
		(acre)	(week)	(acre)	(acre)	(week)	(acre)
960 (Cont.)	S	19.0	2		19.0	2	19.0
			3	85.7			
			4	58.3			
	N	31.3	1	31.3	31.3	1	31.3
		151.1	2	43.3	151.1	2	151.1
			3	48.1			
			4	49.0			
			5	10.7			
	W		1	5.3			
		104.9	4				
		39.1	5				
1000	C	204.2	1		204.2	1	204.2
		155.8	2		155.8	2	155.8
			4	16.0			
			5	98.0			
			6	104.0			
			7	94.0			
			8	48.0			
	S	85.0	1		85.0	1	85.0
		65.0	2		65.0	2	65.0
			4	95.9			
			5	54.1			
	N	96.9	2	43.3	96.9	2	96.9
		93.1	3	48.1	93.1	3	93.1

APPENDIX TABLE 28.--Continued

Farm Size (Tillable acres)	Crop[2]	Complete Ownership			Combination Ownership and Custom Hire		
		Acres Planted Late	Number of Weeks Late[3]	Acres Harvested Late	Acres Planted Late	Number of Weeks Late[3]	Acres Harvested Late
		(acre)	(week)	(acre)	(acre)	(week)	(acre)
1000 (Cont.)	N		4	49.0			
			5	49.6			
	W		1	124.2			
		126.8	5				
		23.2	6				

[1]The system of complete custom hiring is not included because of the assumption that custom operators are available in sufficient numbers to complete all operations on time.

[2]C = corn; S = soybeans; N = navy beans; W = wheat.

[3]Numbers in this column refer to both late plantings and harvestings.

[4]No late planting or harvesting occurred on farms smaller than this.

APPENDIX TABLE 29.--Budget for computing cost: revenue ratios for a 4-row system with complete ownership.

Enterprise	Variable Cost Per Acre	Variable Cost Per Typical Acre[1]	Variable Costs Per 40 Acre Increments[2]						
			40A.	80A.	120A.	160A.	200A.	240A.	280A.
	($)	($)	($)	($)	($)	($)	($)	($)	($)
Corn	53.84	19.3824	775	1551	2326	3101	3876	4652	5427
Soybeans	43.51	6.5265	261	522	783	1044	1305	1566	1827
Navy beans	46.06	8.7514	350	700	1050	1400	1750	2100	2450
Wheat	44.33	6.6495	266	532	798	1064	1330	1596	1862
		41.3098							
Total Annual Variable Cost			1652	2305	4957	6610	8262	9914	11567
Plus Annual Ownership Cost			3561	3561	3561	3561	3561	3561	3561
Total Cost			5213	6866	8518	10171	11823	13475	15128
Total Receipts			2820	5641	8461	11282	14102	16920	19725
Dollar Cost/Dollar Receipt			1.849	1.217	1.007	.902	.858	.796	.767

Enterprise	Variable Cost Per Acre	Variable Cost Per Typical Acre[1]	Variable Costs Per 40 Acre Increments[2]						
			320A.	360A.	400A.	440A.	480A.	520A.	560A.
	($)	($)	($)	($)	($)	($)	($)	($)	($)
Corn	53.84	19.3824	6202	6978	7753	8528	9304	10079	10854
Soybeans	43.51	6.5265	2088	2350	2611	2872	3133	3394	3655
Navy beans	46.06	8.7514	2800	3151	3501	3851	4201	4551	4901
Wheat	44.33	6.6495	2128	2394	2660	2926	3192	3458	3724
		41.3098							
Total Annual Variable Cost			13219	14872	16524	18176	19829	21481	23133
Plus Annual Ownership Cost			3561	3561	3561	3586	3706	3837	3857
Total Cost			16780	18433	20085	21762	23535	25318	26990
Total Receipts			22529	25334	28140	30945	33734	36445	38904
Dollar Cost/Dollar Receipt			.745	.728	.714	.703	.698	.694	.694

APPENDIX TABLE 29.--Continued.

Enterprise	Variable Cost Per Acre	Variable Cost Per Typical Acre[1]	Variable Costs Per 40 Acre Increments[2]					
			600A.	640A.	680A.	720A.	760A.	800A.
	($)	($)	($)	($)	($)	($)	($)	($)
Corn	53.84	19.3824	11629	12405	13180	13955	14731	15506
Soybeans	43.51	6.5265	3916	4177	4438	4699	4960	5221
Navy beans	46.06	8.7514	5251	5601	5951	6301	6651	7001
Wheat	44.33	6.6495	3990	4256	4522	4788	5054	5320
		41.3098						
Total Annual Variable Cost			24786	26438	28091	29743	31395	33048
Plus Annual Ownership Cost			4026	4052	4248	4280	4327	4601
Total Cost			28812	30490	32339	34023	35722	37649
Total Receipts			39804	38646	39083	35841	32251	23509
Dollar Cost/Dollar Receipts			.724	.789	.827	.949	1.108	1.601

[1]A typical acre consists of 36 percent corn, 15 percent soybeans, 19 percent navy beans, and 15 percent wheat.

[2]Figures in columns may not add due to rounding.

APPENDIX TABLE 30.--Budget for computing cost: revenue ratios for a 4-row system with a combination of ownership and custom hiring.

Enterprise	Variable Cost Per Acre	Variable Cost Per Typical Acre[1]	Variable Costs Per 40 Acre Increments[2]						
			40A.	80A.	120A.	160A.	200A.	240A.	280A.
	($)	($)	($)	($)	($)	($)	($)	($)	($)
Corn	58.58	21.0888	844	1687	2531	3374	4218	5061	5905
Soybeans	47.55	7.1325	285	571	856	1141	1426	1712	1997
Navy beans	51.65	9.8135	393	785	1178	1570	1963	2355	2748
Wheat	48.88	7.3320	293	587	880	1173	1466	1760	2053
		45.3668							
Total Annual Variable Cost			1815	3629	5444	7259	9073	10888	12703
Plus Annual Ownership Cost			2178	2178	2178	2178	2178	2178	2178
Total Cost			3993	5807	7622	9437	11251	13066	14881
Total Receipts			2820	5641	8461	11282	14102	16923	19743
Dollar Cost/Dollar Receipt			1.416	1.029	.901	.836	.798	.772	.754

Enterprise	Variable Cost Per Acre	Variable Cost Per Typical Acre[1]	Variable Costs Per 40 Acre Increments[2]						
			320A.	360A.	400A.	440A.	480A.	520A.	560A.
	($)	($)	($)	($)	($)	($)	($)	($)	($)
Corn	58.58	21.0888	6748	7592	8436	9279	10123	10966	11810
Soybeans	47.55	7.1325	2282	2568	2853	3138	3424	3709	3994
Navy beans	51.65	9.8135	3140	3533	3925	4318	4710	5103	5496
Wheat	48.88	7.3320	2346	2640	2933	3226	3519	3813	4106
		45.3668							
Total Annual Variable Cost			14517	16332	18147	19961	21776	23591	25405
Plus Annual Ownership Cost			2178	2178	2178	2203	2232	2249	2269
Total Cost			16695	18510	20325	22164	24008	25840	27674
Total Receipts			22564	25384	28205	31025	33846	36570	39010
Dollar Cost/Dollar Receipt			.740	.729	.721	.714	.709	.707	.709

APPENDIX TABLE 30.--Continued.

Enterprise	Variable Cost Per Acre	Variable Cost Per Typical Acre[1]	Variable Costs Per 40 Acre Increments[2] 600A.	640A.	680A.	720A.	760A.	800A.
	($)	($)	($)	($)	($)	($)	($)	($)
Corn	58.58	21.0888	12653	13497	14340	15184	16027	16871
Soybeans	47.55	7.1325	4280	4565	4850	5135	5421	5706
Navy beans	51.65	9.8135	5888	6281	6673	7066	7458	7851
Wheat	48.88	7.3320	4399	4692	4986	5279	5572	5866
		45.3668						
Total Annual Variable Cost			27220	29035	30849	32664	34479	36293
Plus Annual Ownership Cost			2292	2318	2318	2350	2397	2397
Total Cost			29512	31353	33167	35014	36876	38690
Total Receipts			40665	41269	42750	43325	41691	37188
Dollar Cost/Dollar Receipts			.726	.760	.776	.808	.884	1.040

[1]A typical acre consists of 36 percent corn, 15 percent soybeans, 19 percent navy beans, and 15 percent wheat.

[2]Figures in columns may not add due to rounding

APPENDIX TABLE 31.--Budget for computing cost: revenue ratios for a 6-row system with complete ownership.

Enterprise	Variable Cost Per Acre	Variable Cost Per Typical Acre[1]	Variable Costs Per 40 Acre Increments[2]							
			40A.	80A.	120A.	160A.	200A.	240A.	280A.	320A.
	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)
Corn	52.62	18.9432	758	1515	2273	3031	3789	4546	5304	6062
Soybeans	42.48	6.3720	255	510	765	1020	1274	1529	1784	2039
Navy beans	45.01	8.5519	342	684	1026	1368	1710	2052	2395	2737
Wheat	43.57	6.5355	261	523	784	1046	1307	1569	1830	2091
		40.4026								
Total Annual Variable Cost			1616	5232	4848	6464	8081	9697	11313	12929
Plus Annual Ownership Cost			4505	4505	4505	4505	4505	4505	4505	4505
Total Cost			6121	7737	9353	10969	12586	14202	15818	17434
Total Receipts			2820	5641	8461	11282	14102	16923	19743	22564
Dollar Cost/Dollar Receipts			2.171	1.372	1.105	.972	.892	.839	.801	.773

Enterprise	Variable Cost Per Acre	Variable Cost Per Typical Acre[1]	Variable Costs Per 40 Acre Increments[2]							
			360A.	400A.	440A.	480A.	520A.	560A.	600A.	640A.
	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)
Corn	52.62	18.9432	6820	7577	8335	9093	9850	10608	11366	12124
Soybeans	42.48	6.3720	2294	2545	2804	3059	3313	3568	3723	4078
Navy beans	45.01	8.5519	3079	3421	3763	4105	4447	4789	5131	5473
Wheat	43.57	6.5355	2353	2614	2876	3137	3398	3660	3921	4183
		40.4026								
Total Annual Variable Cost			14545	16161	17777	19393	21009	22625	24242	25858
Plus Annual Ownership Cost			4505	4505	4505	4505	4517	4517	4659	4935
Total Costs			19050	20666	22282	23898	25526	27142	28901	30693
Total Receipts			25384	28205	31015	33816	36615	39414	42216	45015
Dollar Costs/Dollar Receipts			.750	.733	.718	.707	.697	.689	.685	.682

APPENDIX TABLE 31.--Continued.

Enterprise	Variable Cost Per Acre	Variable Cost Per Typical Acre[1]	Variable Costs Per 40 Acre Increments[2] 680A.	720A.	760A.	800A.	840A.	880A.	920A.	960A.	1000A.
	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)
Corn	52.62	18.9432	12881	13639	14397	15155	15912	16670	17428	18185	10943
Soybeans	42.48	6.3720	4333	4588	4843	5098	5352	5607	5862	6117	6372
Navy beans	45.01	8.5519	5815	6157	6499	6842	7184	7526	7868	8210	8552
Wheat	43.57	6.5355	4444	4706	4967	5228	5490	5751	6013	6274	6536
		40.4026									
Total Annual Variable Cost			27474	29090	30706	32322	33938	35554	37170	38786	40405
Total Annual Ownership Cost			4859	5084	5111	5111	5417	5454	5454	5502	5877
Total Costs			32332	34174	35817	37433	39355	41008	42624	44288	46280
Total Receipts			47753	50473	52968	55148	55187	54250	50794	48353	38926
Dollar Costs/Dollar Receipt			.677	.677	.676	.679	.713	.756	.839	.916	1.189

[1] A typical acre consists of 36 percent corn, 15 percent soybeans, 19 percent navy beans, and 15 percent wheat.

[2] Figures in columns may not add due to rounding.

APPENDIX TABLE 32.--Budget for computing cost: revenue ratios for a 6-row system with a combination of ownership and custom hiring.

Enterprise	Variable Cost Per Acre	Variable Cost Per Typical Acre[1]	Variable Costs Per 40 Acre Increments[2]							
			40A.	80A.	120A.	160A.	200A.	240A.	280A.	320A.
	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)
Corn	58.01	20.8836	835	1671	2506	3341	4177	5012	5847	6683
Soybeans	46.62	6.9930	280	559	839	1119	1399	1678	1958	2238
Navy beans	50.30	9.5570	382	765	1147	1529	1911	2294	2676	3058
Wheat	48.40	7.2600	290	581	871	1162	1452	1742	2033	2323
		44.6936								
Total Annual Variable Cost			1788	3575	5363	7151	8939	10726	12514	14302
Plus Annual Ownership Cost			2670	2670	2670	2670	2670	2670	2670	2670
Total Cost			4458	6245	8033	9821	11609	13396	15184	16972
Total Receipts			2820	5641	8461	11282	14102	16923	19743	22564
Dollar Cost/Dollar Receipts			1.581	1.107	.949	.870	.823	.792	.769	.752

Enterprise	Variable Cost Per Acre	Variable Cost Per Typical Acre[1]	Variable Costs Per 40 Acre Increments[2]							
			360A.	400A.	440A.	480A.	520A.	560A.	600A.	640A.
	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)
Corn	58.01	20.8836	7518	8353	9189	10024	10859	11695	12530	13366
Soybeans	46.62	6.9930	2517	2797	3077	3357	3636	3916	4196	4476
Navy beans	50.30	9.5570	3441	3823	4205	4587	4970	5352	5734	6116
Wheat	48.40	7.2600	2614	2904	3194	3485	3775	4066	4356	4646
		44.6936								
Total Annual Variable Cost			16090	17877	19665	21453	23241	25028	26816	28604
Plus Annual Ownership Cost			2670	2670	2670	2670	2682	2682	2698	2718
Total Cost			18760	20547	22335	24123	25923	27710	29514	31322
Total Receipts			25384	28205	31025	33846	36662	39487	42307	45128
Dollar Cost/Dollar Receipts			.739	.728	.720	.713	.707	.702	.698	.694

APPENDIX TABLE 32.--Continued.

Enterprise	Variable Cost Per Acre	Variable Cost Per Typical Acre[1]	Variable Costs Per 40 Acre Increments[2]								
			680A.	720A.	760A.	800A.	840A.	880A.	920A.	960A.	1000A.
	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)
Corn	58.01	20.8836	14201	15036	15872	16707	17542	18378	19213	20048	20884
Soybeans	46.62	6.9930	4755	5035	5315	5594	5874	6154	6434	6713	6993
Navy beans	50.30	9.5570	6499	6881	7263	7646	8028	8410	8792	9175	9557
Wheat	48.40	7.2600	4937	5227	5518	5808	6098	6389	6679	6970	7260
		44.6936									
Total Annual Variable Cost			30392	32179	33967	35755	37543	39330	41118	42906	44694
Plus Annual Ownership Cost			2741	2764	2791	2791	2829	2866	2866	2914	2914
Total Cost			33133	34943	36758	38546	40372	42196	43984	45820	47608
Total Receipts			47948	50769	53490	55733	57531	59190	60379	60766	59704
Dollar Cost/Dollar Receipt			.691	.688	.687	.692	.702	.713	.728	.754	.797

[1]A typical acre consists of 36 percent corn, 15 percent soybeans, 19 percent navy beans, and 15 percent wheat.

[2]Figures in columns may not add due to rounding.

APPENDIX TABLE 33.--Budget for computing cost: revenue ratios for complete custom hiring.

Enterprise		Variable Cost Per Acre	Variable Cost[1] Per Typical Acre	Variable Cost Per 40 Acre
Corn	(36%)	66.57	23.9652	958.608
Soybeans	(15%)	54.60	8.1900	328.600
Navy beans	(19%)	60.91	11.5729	462.916
Wheat	(15%)	56.08	8.4120	336.480
Total Cost			52.1401	2085.604
Total Receipts				2820.48
Dollar Cost/Dollar Receipts				.739

[1]A typical acre consists of 36 percent corn, 15 percent soybeans, 19 percent navy beans, and 15 percent wheat.

BIBLIOGRAPHY

Books

Bradford, Lawerence A., and Johnson, Glenn L., Farm Management Analysis. New York: John Wiley & Sons, Inc., 1963.

Cochrane, Willard W. The City Man's Guide to the Farm Problem. New York: McGraw Hill Book Company, 1963.

Hathaway, Dale E. Government and Agriculture. New York: Macmillan Company, 1963.

Articles and Bulletins

Buxton, Boyd M. Economics of Size in Dairy Farming. Farm Business Notes 467, University of Minnesota, 1964.

Cash Grain Farming Today: What It Costs, How It Pays. A. Ec. 68, Cooperative Extension Service and Department of Agricultural Economics, Michigan State University, 1967.

Connor, Larry J. Costs and Returns for Major Cash Crops in Southern Michigan. Agricultural Economics Report No. 87. Department of Agricultural Economics, Michigan State University, 1967.

Dean, Gerald W., and Carter, Harold O. Economics of Scale in California Cling Peach Production. Bulletin No. 793, California Agricultural Experiment Station, University of California, (Davis), 1963.

Fogarty, Bill. "A New Enterprise for Leasing Farm Equipment." Implement and Tractor, May 15, 1962, p. 38.

Hopkin, John A. "Economies of Size in the Cattle Feeding Industry of California." Journal of Farm Economics, Vol. 40 (1958), pp. 417-429.

Ihnen, Loren and Heady, Earl O. Cost Functions in Relation to Farm Size and Machinery Technology in Southern Iowa. Research Bulletin 527, Agriculture and Home Economics Experiment Station, Iowa State University, 1964.

Madden, J. Patrick, and Davis, Bob. Economies of Size on Irrigated Cotton Farms of the Texas High Plains. Bulletin B-1037, Texas Agricultural Experiment Station, Texas A & M University, 1965.

Martin, William E. and Hill, James S. Cost-Size Relationships for Central Arizona Dairies. Technical Bulletin No. 149, Arizona Agricultural Experiment Station, University of Arizona, 1962.

Michigan Farm Business Report (by years), Department of Agricultural Economics, Michigan State University.

"Project '80 Rural Michigan Now and in 1980." Research Report 47, Agricultural Experiment Station, and Cooperative Extension Service, Michigan State University, 1964.

"Rental Opens the Door to Increased Sales." Farm and Power Equipment, March, 1967, p. 25.

Smith, Warren. "They've Made Leasing Work." Implement and Tractor, March 21, 1965, p. 20.

Van Arsdall, Roy M. Labor Requirements, Machinery Investments, and Annual Costs for the Production of Selected Field Crops in Illinois, 1965. AE-4112, Illinois Agricultural Experiment Station, University of Illinois, 1965.

Walker, Odell L. Machinery Combinations for Oklahoma Panhandle Grain Farms. Bulletin B-630, Experiment Station, Oklahoma State University, 1964.

Government Publications

Hunter, Elmer C., and Madden, J. Patrick. Economies of Size for Specialized Beef Feedlots in Colorado. Agricultural Economics Report No. 91, ERS, U.S. Department of Agriculture, Washington, D.C., U.S. Government Printing Office, 1966.

Madden, J. Patrick. Economies of Size in Farming. Agricultural Economics Report No. 107, ERS, U.S. Department of Agriculture, Washington, D.C., U.S. Government Printing Office, 1967.

U.S. Department of Agriculture. The Balance Sheet of Agriculture. Agriculture Information Bulletin No. 329, Washington, D.C., U.S. Government Printing Office, 1967.

U.S. Department of Commerce, Bureau of the Census, _United States Census of Agriculture_ (by years), Washington, D.C., U.S. Government Printing Office.

Unpublished Sources

Connor, Larry J. _Guidelines for Selecting Machinery Systems_. Unpublished speech given at Farmer's Week, Michigan State University, February, 1968.

Morris, W.H.M. _Farm Machinery Replacement_. Unpublished manuscript, Purdue University.