FARM MACHINERY AND ITS RELATION TO EFFICIENT FARM MANAGEMENT

Thesis for the Degree of M. S.

MICHIGAN STATE COLLEGE

Kenneth Albin Swanson

1948

This is to certify that the

thesis entitled

"Farm Machinery and Its Relation to Efficient Farm Management"

presented by

Kenneth Albin Swanson

has been accepted towards fulfillment of the requirements for

M. S. degree in Farm Management

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Date July 29, 1948

M-795

FARM MACHINERY AND ITS RELATION TO EFFICIENT FARM MANAGEMENT

by

KENNETH ALBIN SWANSON

A THESIS

Submitted to the School of Graduate Studies of Michigan State College of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Department of Farm Management

1948

THESIS

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Morley High School, Morley, Michigan, graduated 1931.
Ferris Institute, Big Rapids, Michigan, completed a stenographic course in 1932.
Central Michigan College of Education, Mt. Pleasant, Michigan, 1936-38.
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Reared on a general farm in Mecosta County, Michigan.
Five season's work and partial management of a 36-acre cherry orchard in Mecosta County, 1933-37.
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ACKNOWLEDGMENT

Grateful acknowledgment is given to Dr. K. T. Wright, Professor E. B. Hill and to other members of the Farm Management Department of Michigan State College for assistance in the conduct of this study and in giving advice and counsel in the preparation of this manuscript. Also to William B. Lutz, formerly a graduate student in Farm Management at Michigan State College and now Extension Specialist in Dairy Husbandry assigned to the Upper Peninsula, for early work done in gathering data for the study.

Appreciation is expressed to farmers from whose farm accounting records basic data was obtained for use in this study.

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INTRODUCTION

The Problem

Michigan farmers are buying large amounts of machinery. Investments in certain types of machinery are so high as to cause concern among farmers and others as to just how much it is practical to invest in machinery on different sizes of farms. What are the effects of increased investments in machinery on labor costs? On the volume of farm business? On farm expenses? and finally, on farm earnings?

The answers to these problems depend on a number of involved factors. It is hoped that this study of the machinery situation on 285 farms in south central Michigan will, however, supply information which will provide some basis for answering the general problem of "How much machinery can a farmer afford?"

In addition to the specific data presented in this report, the amount of machinery a farmer can afford depends somewhat on whether it is being bought for cash or on time, alternative uses for his money, the future of the general price level and the relationship of prices of farm and non-farm products.

The Need for the Study

In the years between the depression of the early 1930's and the beginning of World War II, farm prices and incomes were so low that most farmers were unable to buy as much machinery as they needed for efficient operation. The war time wear and tear on machinery and the inability to get replacements during that time has resulted in abnormal demands for farm machinery. The progressive decline in numbers of horses and mules and their replacement by tractor power and equipment have increased the importance of machinery on farms.

Available farm labor is now limited and expensive and farmers are anxious to know to what extent the increased use of machinery would offset these higher labor costs. Michigan farmers now have the purchasing power and are buying farm machines in large numbers again. Their problems in selection of the right kind and amounts of machinery reveal a need for this study of the effects of the machinery investment on farm expenses and earnings.

The Purpose of the Study

Most studies have shown the principal purpose of having farm machinery is to reduce farm labor requirements per unit of output. This increase in labor efficiency could be utilized to shorten the length of the work day and make farm life more enjoyable, or to increase the volume of business per worker and, therefore, farm earnings. The purpose of this study is to determine if an increase in the use of

farm machinery on Michigan farms actually does result in improved labor efficiency and increased farm earnings.

Specific objectives of this study are as follows:

(1) To determine the effect of varying amounts and kinds of machinery upon labor efficiency on a farm.

(2) To determine if increased investments in farm machinery result in increased farm earnings.

(3) To determine the effect of machinery operating expense upon farm earnings and labor efficiency.

(4) To study the trends in the mechanization of Michigan farms.

The Source of Data

Farm accounting records on 285 farms in south central Michigan for the year 1946, provided the basic information for this study. The farm account books were kept by the farm operators in cooperation with the Farm Management Department Extension Service of Michigan State College.

The farms were located in Type of Farming Areas 1 "Corn and Livestock", 2 "Small grains and Livestock", and 3 "Dairy and General Farming". The location and numbers of farms by counties are shown in Figure 1. All farms in these areas on which records were kept were used in this study with the exception of a few farms specializing in enterprises such as orcharding or truck crops.

These farms averaged 160 tillable acres per farm. According to the U. S. Census Reports for 1945 on these

same counties, the average number of acres per farm was 104 acres and 68 percent of the farm land was tillable, making an average of 71 tillable acres per farm. Therefore, the farms in this study were about 225 percent above the average size of farms in south central Michigan.

The data for each farm consists of a summary sheet showing acreages, receipts, machinery expenses, labor incomes and a number of efficiency factors. In addition, there was a complete machinery and equipment inventory for each farm, a list of all machinery purchases in 1946, and a record of receipts from custom work performed off the farm. Copies of these forms are in the appendix.

Type of Farming Areas in Michigan

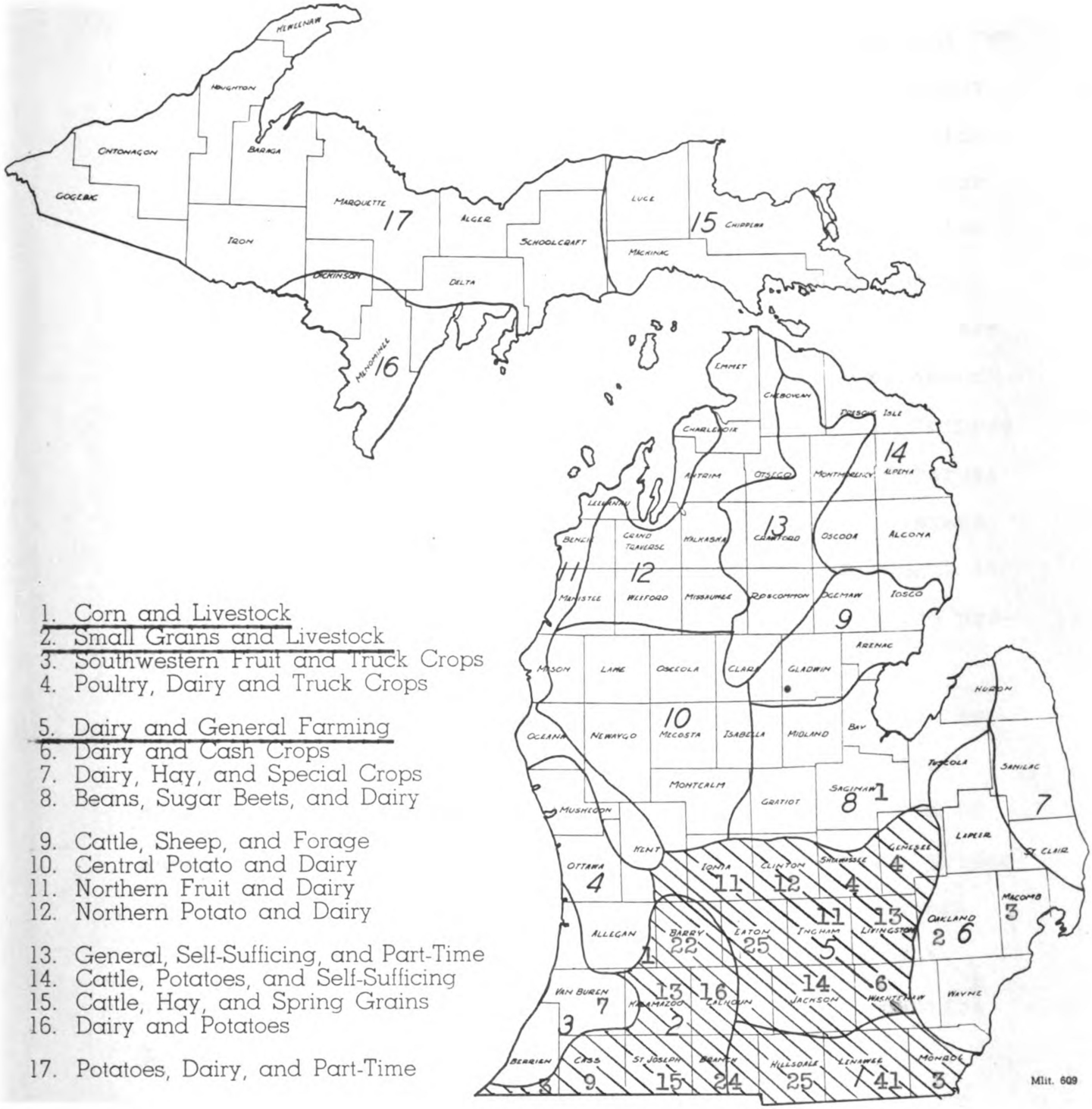

Fig. 1 - Location by counties of farms used in this study.

A REVIEW OF THE LITERATURE

Trends in Farm Mechanization -- During the past few years of high farm incomes, farmers have been buying about all the machinery that has been available. Farmers in the United States spent approximately $800,000,000 in 1946 for farm machinery other than tractors, according to estimates by the U. S. Department of Agriculture[1/]. This is about twice as much as their annual average expenditure for these machines in 1935-39, and is almost twelve times that amount spent in the bottom year of the depression in 1932. Farmers' cash outlay for new equipment in 1946 totaled over 5 percent of their net income. This compares with an annual average of 7 or 8 percent in 1935-39. More machinery was bought in 1946, but net incomes were also much higher than in the pre-war years of 1930-39.

The increasing use of labor-saving machines such as combines, pick-up hay balers, and milking machines gives farmers enough equipment to do about twice as much work by machine as they could before the war. Farm machinery prices on June 15,1947 were 38 percent above the 1935-39 average but farm wage rates as a whole had risen six times that much[2/]. As a result, it is good farm management practice to make full use of labor-saving machinery.

In considering whether or not to invest in a major

1/ A. R. Kendall, $800,000,000 For New Farm Machinery, Agricultural Situation, 31 (8): 11.
2/ Ibid., p. 11.

type of farm machinery, proper weight should be given to prices of farm products. Farmers are now getting about two and one-half times the pre-war prices for farm products. Therefore, only about half as much farm output is needed compared to pre-war prices to buy most kinds of farm machinery. On July 15,1947 the proceeds from 171 pounds of butterfat would pay for a cream separator, but at 1935-39 prices a farmer had to sell 315 pounds. About 82 bushels of corn would buy a two-bottom tractor plow in 1946, and at pre-war prices he had to sell 175 bushels to pay for the plow.

Since the beginning of World War II farm machinery prices have increased only about one-half as much as the index of all prices paid by farmers. This means that some other things farmers buy have increased relatively more than the price of most farm machines. Because of the improved financial conditions many farmers are now in a position to pay cash for their machinery. This reduces risks, as debt payments that seem reasonable at present incomes could be burdensome if incomes fell off sharply.

Operating expenses for tractors have gone up much less than feed costs for animal power in the past decade. Because of the greater size of power unit and speed of tractors far less labor is required to operate them than when using horses or mules. High wage rates for farm labor in itself would make animal power comparatively much higher in cost.

Horse and mule numbers reached their peak during World War I and have since decreased two-thirds. As a result more than 55 million acres of crop land are now available to grow food and fiber for human use which once was used for growing horse and mule feed. Production from these released acres accounted for about 30 percent of the increase in output of farm products for human use during the period between the two World Wars [3/].

Figure 2 shows the almost continuous decrease in number of horses and mules on farms in the United States and the corresponding increase in numbers of tractors. In recent years, approximately four head of work stock that have disappeared from farms have been replaced by one tractor. This ratio will gradually decrease as work stock numbers decrease. An estimate made by the U. S. Department of Agriculture states that tractors on farms in the United States will probably number 3.5 million by 1955, and by 1974, about 5.0 million [4/].

Reflecting the smaller demand for horses and mules, prices per head in 1947 were below pre-war. Large exports and increased slaughter have contributed to the high rate of decline of horse and mule numbers in recent years. Only 255,000 colts were raised in the United States in 1946, the smallest crop in more than a century. Many farmers who

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3/ M. R. Cooper, G. T. Barton, and A. P. Brodell, Progress of Farm Mechanization, U. S. Department of Agriculture, Miscellaneous Publication No. 630, 1947, p. 26

4/ Ibid., p. 79

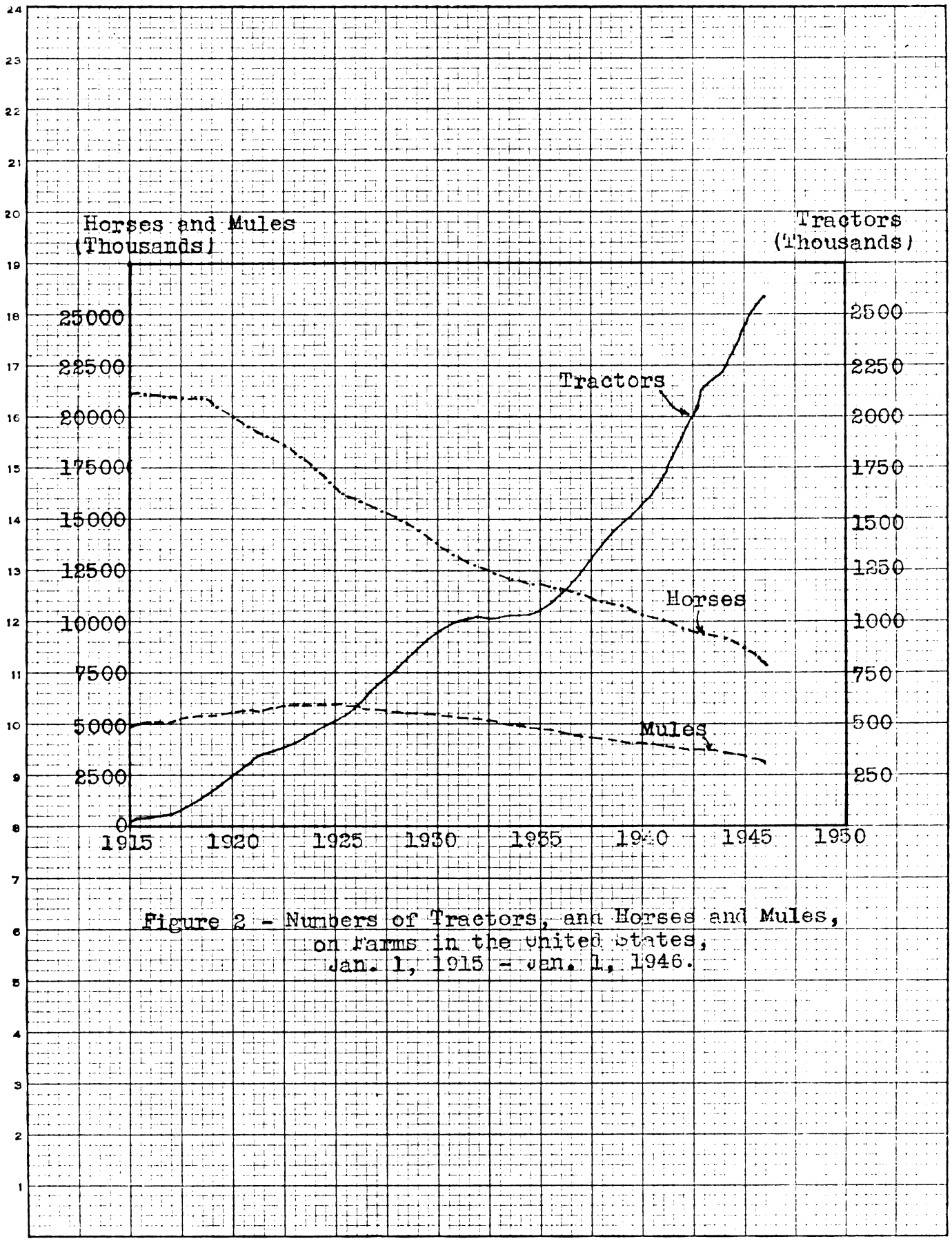

Figure 2 - Numbers of Tractors, and Horses and Mules, on farms in the United States, Jan. 1, 1915 - Jan. 1, 1946.

formerly produced workstock now find it more profitable to use their feed and other resources for producing meat animals or animal products for sale. Despite the decrease in numbers of work animals on farms in the past two decades, the flow of tractors and other machines onto farms has given to farmers an increasing volume of power and machinery. Volume of power and equipment now on farms is probably about 40 percent above the 1935-39 average [5/].

The tremendous advance in the mechanization of so many farms in recent years is an important factor in increasing agricultural production. In 1947 there were over 2 million tractors on farms in the United States, which is more than double the number a decade ago. Today at least a third of the farmers have tractors compared with 14 percent in 1930 and the proportion is increasing rapidly [6/]. The increasing use of the tractor as motive power is an important influence affecting both the changes in field machines and the amount of labor required for crop production. In general, the tractor has made for the adoption of wider machines and for higher operating speeds. It has also enabled farmers to plant and harvest crops that would otherwise be lost by permitting a longer workday in critical seasons of unfavorable weather.

Development of the general-purpose tractor and its

5/ A. P. Brodell, Farm Machinery Prospects, Agricultural Situation, 32 (1): 1.

6/ S. E. Johnson, The Revolution in Farming, Agricultural Situation, 30 (10): 1

complement of tools in the 1920's, and the extensive use of rubber tires on tractors and implements in the 1930's helped greatly in advancing the speed and effectiveness of farm machines. Demand for modern farm machinery has far exceeded the supply since the beginning of the World War II. The biggest demand has been for harvesting machines such as small combines adaptable to a variety of crops and field conditions, corn pickers suitable for small acreages, and other major labor-saving machines. Pick-up hay balers or field choppers, with special wagon boxes for hauling and an elevator or blower, that almost completely mechanize hay harvesting are sought by farmers with large acreages and by custom operators.

According to the U. S. Department of Agriculture, the types of farm machines that increased in numbers most rapidly in the United States from 1942 to 1945 were hay balers (67%), milking machines (49%), combines (36%), corn pickers (29%), and tractor drawn or mounted mowing machines (26%), cultivators (31%), and planters (24%) [7/]. Although pick-up hay balers have had the greatest percentage increase they are a comparatively recent development and are still few in number. Numbers of milking machines on farms in 1946 were about double those in 1942. Milking machines often reduce labor needs about 50 percent so they were especially helpful during the severe labor shortage of World War II.

7/ Cooper, op. cit., Table 20, p. 37

Some of the major farm machinery manufacturing companies have recently introduced tractor models with a full complement of adapted tools which are smaller than any made previously and are designed to replace a team of horses on our smallest farms. These are expected to open new markets for farm machinery and may considerably hasten the end of animal power on our farms. There has been a great expenditure for research in recent years to solve the problems involved in mechanizing cotton and sugarbeet growing and harvesting. Self-propelled combines and corn-pickers are a recent development. There is much interest among machinery designers to consider the tractor as a powered platform, which will run equally well backward or forward, and on which all kinds of tillage and harvesting units can be quickly mounted as needed. We can expect as great improvements in farm machinery in the future as we have seen in the past. Progressive farmers will always be on the alert to adopt new machines that will increase the efficiency of their labor supply.

Effects of Mechanization on Labor Efficiency and Farm Earnings -- The goal of farm mechanization is to accomplish more productive work in less time with less human effort. It has been estimated that in 1820 one farm worker supported himself and only about 3 other persons. By 1920 this had increased to himself and 9 other persons. In 1945 each farm worker in the United States produced enough food and fiber to support himself and 13 other persons. In the 5-year period from 1940 to 1945 there was an increase in productive output per farm worker of nearly 45 percent 9/.

Not all of this increase in production per worker was due to mechanization. About 52 percent of the saving in man-hours per unit of production was due to increased production per acre of cropland, increase in size of livestock enterprise, increase in production per animal, spreading of overhead over a larger business, and several other factors 10/.

As mechanization of farms progresses the time required for various farm operations has become less and less. For example, a corn farmer can prepareand plant three acres of land with tractor and power equipment in the same time he could do only one acre with horse equipment. If in rush seasons he wishes to put the tractor on a 24-hour schedule,

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9/ Cooper, op. cit., p. 4
10/ Ibid., p. 18

not feasible with work animals, he can do the job 7 times faster than with animal power[11].

According to one source, "A modern tractor and its equipment now saves about 850 man-hours of labor compared with the time required with the animal power and equipment used a generation ago. On the average, each automobile or truck saves the farmer more than 400 man-hours a year, compared with the time it would take to do the same hauling with horses or mules[12]."\. This illustration indicates why mechanization has been the most important single factor in the rapid rise in productivity of farm labor.

Figure 3 illustrates the estimated man-hours used to produce an acre of wheat and corn from 1840 over the period of a century until 1940. Labor requirements for wheat are now reduced to nearly as low as it is possible to go. Much further progress in reducing labor requirements can be made in sugar beet growing and in haying operations. The greatest gains in the future can be expected in reducing man-hours required to care for livestock. In spite of all the advances so far made, 60 percent of all farm work is still done with the hands or with hand tools. Further mechanization of farm jobs will reduce the amount of hand work used in farming and the greatest challenge will be in livestock work, 75 percent of which is now hand labor[13].

12/ Cooper, op. cit., p. 19
13/ Ibid., p. 28

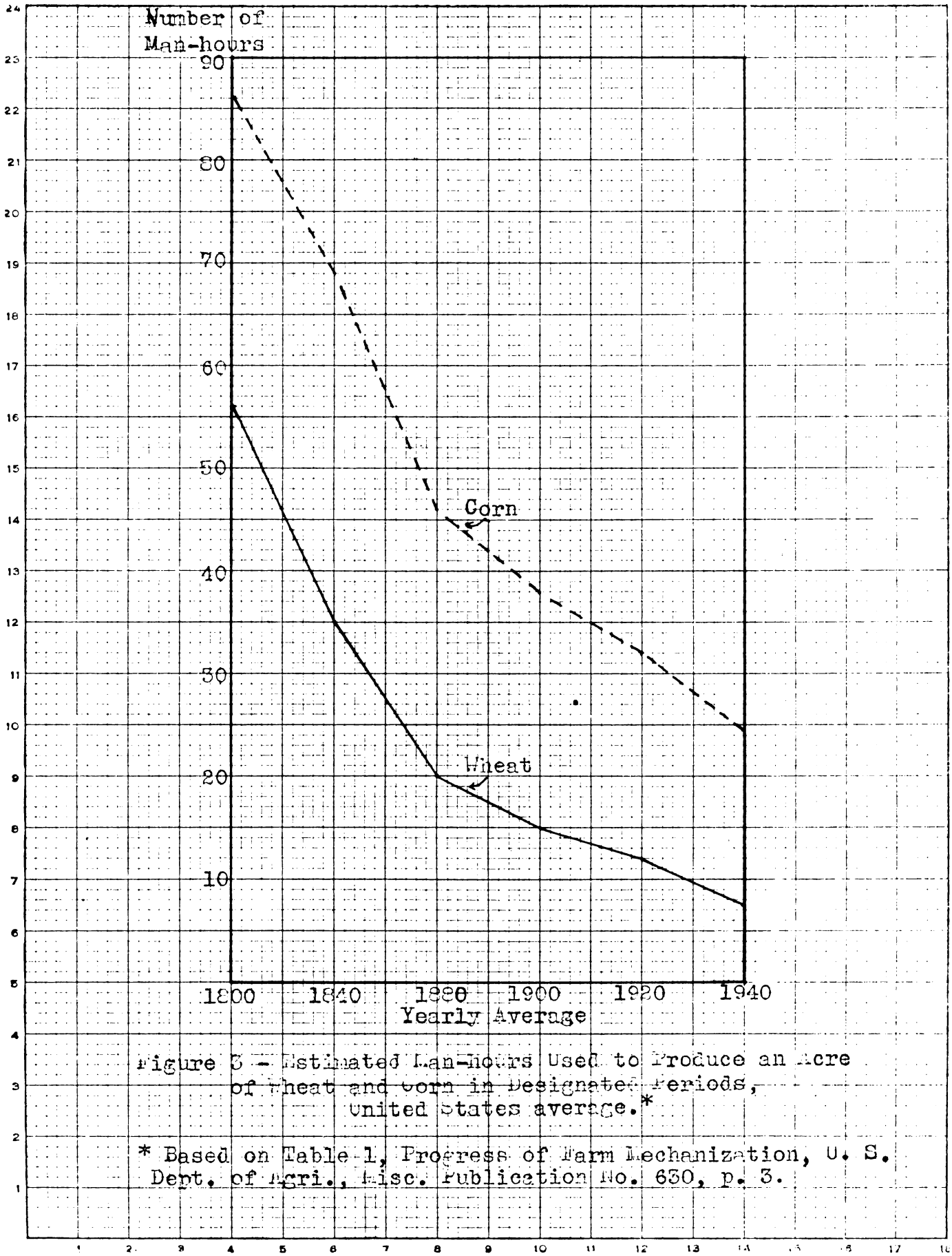

Figure 3 – Estimated Man-hours Used to Produce an Acre of Wheat and Corn in Designated Periods, United States average.*

* Based on Table 1, Progress of Farm Mechanization, U. S. Dept. of Agri., Misc. Publication No. 630, p. 3.

According to Dr. K. T. Wright, "The principal purposes of having machinery is to reduce the amount of man labor needed to operate the farm or to do more work with the same labor. Sometimes machinery is purchased to get the job done quicker or better. In this study the farms having the highest machinery investment had about 15 percent more workers per farm and there was 25 to 35 percent more work on the farm. Therefore, the work units accomplished per man were about 10 percent higher where the machinery investment was highest than where the lowest. . . . Having a higher investment in machinery improved the labor efficiency, made possible the handling of a larger business, and seemed to be associated with higher crop yields, and higher labor incomes. It should be pointed out, however, that these are averages, and that some individual farmers had too much machinery and too high machinery expenses[14/]."

In this same study it was also revealed that labor incomes on farms with tractors averaged $144 higher on small farms and $426 more on large farms. Dr. Wright was extremely cautious though about attributing the higher labor incomes to a result of using tractors, as shown in the following remarks. "It should be pointed out that this difference in earnings was the result of several things, and

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14/ K. T. Wright, Dollars and Sense in Farming, Michigan Special Bulletin 324, p. 31

not just that of the tractor alone. The men with tractors operated business about a fourth larger as a result of farming more acres and keeping more livestock, and increased their labor efficiency at least 10 per cent. If these results are not accomplished, getting a tractor will not give the increased earnings shown." 15/

In another study in Michigan by Kebman entitled, "Improving Farm Labor Efficiency", there was found to be a close relation between the use of labor-saving equipment and labor efficiency. The author states, "The principal method of increasing labor efficiency in crop production, is by the greater use of labor-saving equipment." This greater efficiency was ascribed to both a larger amount and greater width of equipment used. On the high labor efficiency group of farms plows 6 inches wider and harrows that averaged 2 feet wider than the average for the low labor efficiency group were used. This enabled the high group to complete a season's tillage operations in 20 per-cent less time than the low group with their smaller equip-ment.

The same author concludes, "For those farms that lack labor-saving machinery and equipment, the purchase or use of this equipment will go a long way toward greater labor efficiency. Outright purchase in some cases, however, is entirely out of the question from the standpoint of the investment. In such cases, going into partnership with

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15/ Wright, op cit., pp. 32-33

a neighbor or two is sometimes the solution as it will spread the investment and cost over more acres. The other alternative is to hire a neighbor who has this equipment to do the particular job. Whatever system is employed, however, labor efficiency will be improved and also the net farm income."[16/]

The labor efficiency of farm machinery can be greatly increased by the selection of machines of large capacity. It requires no more labor to operate a three-plow than a one-plow size tractor. The capacity of a farm machine is dependent upon rate of travel and the width of the implement. The acceptance of rubber tires on tractors and implements has greatly increased their speed of operation. Most tillage operations with tractors in preparing the soil for planting are about twice the speed of horse operations. Small combines have only a 5 or 6-foot width of cut, but depend upon high speeds for their remarkable capacity.

There are practical limitations to the speed that can be used on some farming operations. When cultivating, human reaction time in dodging small plants will limit speeds, and excessive coverage caused by high speeds will affect the quality of work. High speed plowing results in greater pulverization of the soil but also increases power requirements. The tricycle type of general purpose tractor is easily

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16/ E. F. Rebman, Improving Farm Labor Efficiency, Michigan Special Bulletin 334, pp. 11-13

upset if turned sharply at high hauling speeds. Most field operations will continue to be limited to about 5 or 6 miles per hour.

Width of implement is important in increasing capacity but also has limitations. Wide machines are difficult to house, inconvenient at gates and lanes, and a hazard on the highways. Each unit of working width added to a machine results in a decreased saving in time. This is because when one unit of a machine is in need of servicing, such as for a broken plowshare, this stops the whole machine and it is therefore operating a lower percentage of the time. Excessively wide machines may cause poor quality of work unless the topography is almost level. The principal advantage of large capacity machines is in reduced labor requirements and greater timeliness. Timeliness is of great importance in some years of wet springs, when the increase in length of growing season by a few days can have great effects on yields.

Methods of Lowering Machinery Costs -- Machinery expense was the second highest expense item on farms in 1946 according to farm accounting records kept on 838 farms in cooperation with the Farm Management Department of Michigan State College. Power and machinery expense per tillable acre averaged $6.92 and there was a machinery investment of $2,872 per farm from these records [17]. Because machinery expense was second only to labor costs, and also has a direct influence on labor costs as well, it is important to give careful consideration to methods of lowering machinery costs, consistent with good farm management.

Some of the different methods by which use of farm machines may be obtained at reduced costs are by purchase of secondhand equipment, cooperative use of machines, hiring, and by exchanging use of machines with a neighbor. Some studies have shown that 40 to 45 percent of machinery on farms was bought secondhand, usually at auctions [18]. If bought wisely with regard to price and quality and kept in good repair, it will usually give cheaper service than new machines because the overhead costs of interest on the investment and depreciation are so much lower. The principal drawbacks to cooperative use of machines are uncertainty of tenure of the owners, disagreements between neighbors as to care and repair of machines and who is to use it first.

17/ J. Doneth, N. Smith and E. Elwood, Farm Business Report for 1946, Quarterly Bulletin, Michigan, 30 (2): 213.

18/ J. P. Hertel and P. Williamson, Costs of Farm Power and Equipment, Cornell Bulletin, 1941, No. 751, pp. 25-30.

Owners of small farms can benefit most from cooperative ownership, as their operations are so small they could not otherwise acquire ownership.

An Iowa bulletin states, "It is easily recognized that the two most effective ways to reduce the cost of farm machines per day, which is so largely dependent upon overhead or fixed charges, is first to extend the life of the machine and second to extend the use of the machine in number of day's service per year [19]." To extend the use of a machine it is necessary to increase the size of farm so the fixed costs may be spread over more acres, or to do custom work off the farm. If a farm is now operating with the most efficient combination of enterprises it may not be either practical or desirable to increase the size by buying or renting additional land. Depreciation and interest charges are the two largest items of expense in figuring costs of farm machinery. These are fixed charges and are little affected by days use per year, but must be prorated accordingly. The number of days use per year does not affect the life of a machine as much as might be supposed.

To extend the life of machines they should be always well lubricated, adjusted, and promptly repaired. Adequate housing is usually justified but studies have shown it does not pay to house some kinds of machines if they are kept painted or oiled [20].

19/ J. B. Davidson and S. Henderson, Life, Service and the Cost of Service of Farm Machines on 400 Iowa Farms, Iowa Bulletin P37, 1942, p. 297.

20/ Ibid., p. 289

RELATIONSHIP OF MACHINERY INVESTMENT TO FARM EARNINGS, LABOR EFFICIENCY, AND OTHER FACTORS

In this section of the study the 285 farms on which records were available were first ranked in order from the smallest to largest according to number of tillable acres. The three largest farms were then ranked by size of total machinery investment, then the three next largest farms were similarly divided into these low, medium and high machinery investment groups, and this was continued until all farms were so arranged. This procedure held the size of farm, as measured by number of tillable acres, constant within a range of two acres for each of the three groups. following this sort into three groups, tabulations were made on various factors which would be of interest in a study of farm machinery investments.

Machinery investment on the one-third of the farms with the most machinery was $4,170, or twice the investment of those with the least, $2,098. Machinery investment per tillable acre ranged from $13.22 on the low machinery investment farms to $25.80 on those farms with the most machinery. This is a really significant variation and provides a good basis for this section of the study. The annual machinery expense per farm was about 50 percent greater on the farms with the most machinery. This operating expense ranged from $5.24 per tillable acre on the farms with the

Table 1 - Relationship of Machinery Investment to Other Factors with Tillable Acres Held Constant on 285 Farms in Southern Michigan, 1946.

Item	Total machinery investment per farm		
	Low 1/3	Medium 1/3	High 1/3
Number of farms	95	95	95
Tillable acres	159	160	161
Machinery investment	$2,098	$3,023	$4,170
Machinery investment per tillable acre	$13.22	$18.95	$25.80
Machinery operating expense .	$831	$989	$1,198
Machinery expense per tillable acre	$5.24	$6.20	$7.41
Number of tractors per farm .	1.0	1.2	1.4
Number of horses per farm . .	1.2	1.0	1.0
Number of farms without horses	37	47	48
Number of men	1.6	1.6	2.0
P.M.W.U. per man	316	338	306
Crop P.M.W.U.	200	216	210
Livestock P.M.W.U.	288	303	375
Total man labor charge . . .	$1,852	$2,030	$2,622
Value of unpaid family labor	$264	$321	$428
Total productive man work units	505	540	612
Labor income	$3,411	$3,477	$4,054
Total receipts	$8,426	$9,081	$12,046
Custom work receipts	$127	$100	$391
Custom work receipts per farm doing the work (only)	$309	$306	$744
Age of operator (years) . . .	43.6	42.5	44.2

lowest machinery investment to $7.41 on those farms with the most machinery.

One cause of the higher machinery investment and expenses is indicated by the fact that the high machinery investment farms had 35 percent more tractors. Farms with the low machinery investment had 22 percent more horses than the high group. About 30 percent more of the farms with the most machinery were without any horses. Having more tractors and fewer horses did not show a need for fewer men on those farms, nor improve the productive man work units accomplished per man.

Labor efficiency: The high machinery investment group had more men, 2.0 compared to 1.6 for the low group (25 percent greater), which cancelled the advantage of a higher total number of productive man work units. Productive man work units per man were lowest of all on those farms with the most machinery, and were highest on the middle group of farms. If a large machinery investment were actually labor-saving, then the productive man work units per man should be higher on those farms with the most machinery, whereas in this study they actually showed less work accomplished per man. These results do not agree with those reported in studies made by Wright related on page 16, and by Rebman on page 17 of this report.

Apparently farmers are not buying machinery only, or even principally, to reduce labor costs or increase the

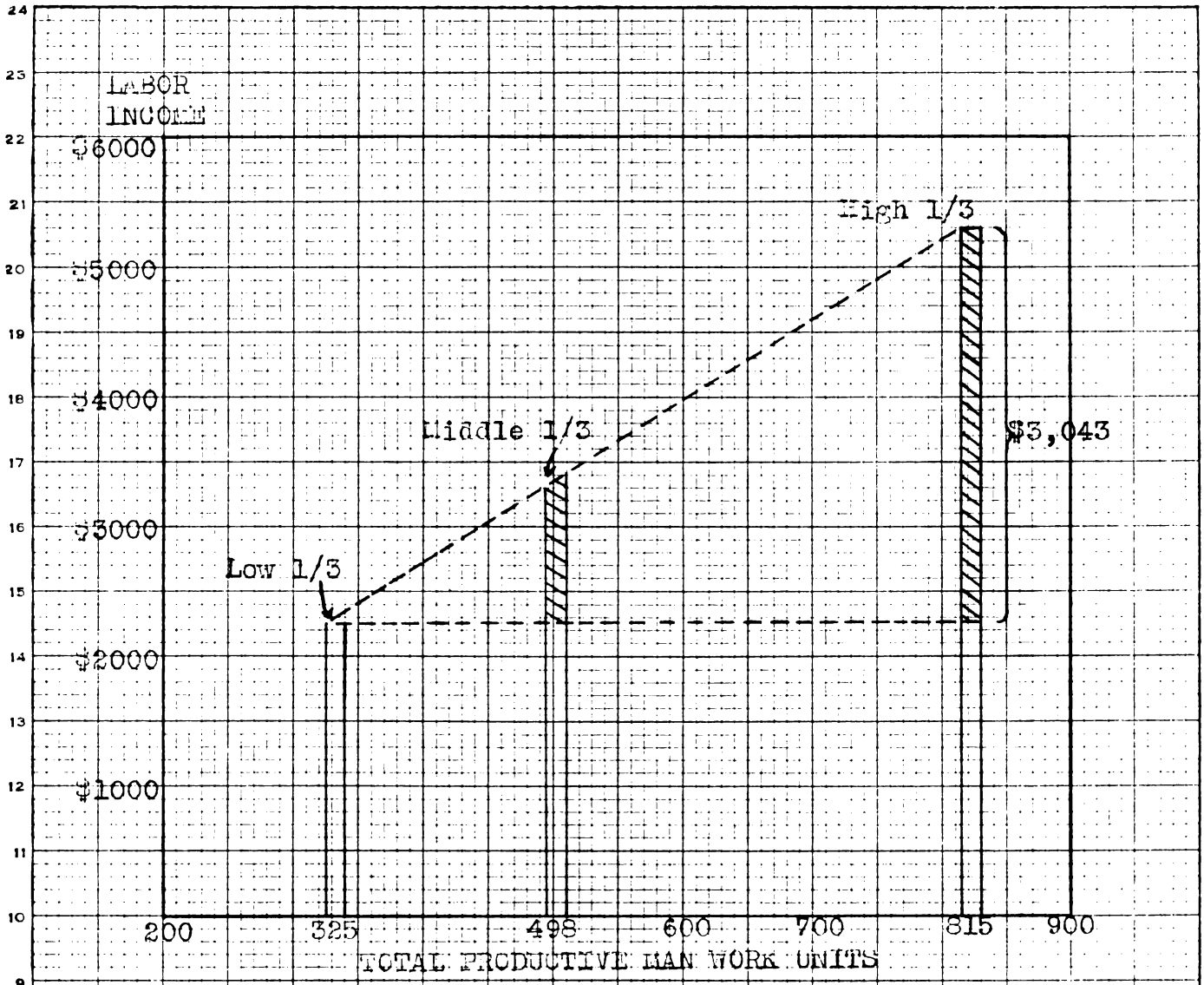

Figure 4 - Effect of increasing the size of business on Labor income in Areas 1, 2 and 5, 1946*.

100 P.M.W.U. increase = $621 more labor income

* Based on Table 5, "Relation of Size of Business to Farm Earnings", Farm Business Reports, Farm Management Department, Michigan State College, Areas 1, 2 and 5, 1946.

amount of work accomplished per man. Perhaps farmers are more concerned with reducing drudgery or having more leisure time to enjoy. Certainly, many farmers buy milking machines not only to save time and reduce labor costs but also because they just, plainly, hate to milk cows by hand. A small grain elevator may not always save much time but it surely eases an arduous task and does a lot to make farm life more enjoyable. We cannot know from the source of the data in this study whether a farmer bought a machine to make a larger income, or if it was because he had a large income that he was therefore able to buy expensive machinery. A special study would be required to know whether a large machinery investment is the cause or the result of a large labor income. Unless we recognize these intangible values we are ignoring one of the principal reasons why farmers buy machinery.

There was little difference between the groups in crop productive man work units per farm. Most farm machinery is used in crop production but having more machinery on these farms did not result in increasing crop production. The increase in total productive man work units per farm on the high machinery group was due to having more or more intensive types of livestock, about 30 percent more livestock productive man work units.

Labor incomes on those farms with the most machinery were also about 18 percent higher than the low group. This may have been due almost entirely to a larger volume of bus-

iness, as those farms with most machinery also had about 18 percent more total productive man work units.

Figure 4 shows the effect of increasing the number of total productive man work units on labor incomes. These data were taken from summaries of farm accounting records kept by farmers in connection with the Farm Management Department Extension Service of Michigan State College in 1946, covering Type of Farming Areas 1, 2 and 5. The data, when averaged, shows that each additional 100 productive man work units above the average for the lowest one-third of the farms was associated with an average increase of $621 in labor income ($3,043 divided by 4.9 equals $621). This assumes that other factors remained constant and the total number of productive man work units was the sole cause of the increased labor incomes.

As the above data are for the same year and Type of Farming Areas, comparisons may be made with the data on the 285 farms of this study on machinery investments. In this study on machinery investments there was a difference of 107 total productive man work units and $643 labor income between the one-third of the farms with the lowest investment in machinery and the one-third of the farms with highest machinery investment. If the assumption is true that 100 total productive man work units caused a $621 increase in labor income, then the increased labor income on the high investment farms would be completely cancelled out and no increased labor income could be attributed to having a higher machinery investment.

The value of unpaid family labor was higher on farms with most machinery but this was not a large item in any group. The extra family labor was probably utilized in doing more livestock chores as there was more livestock on this group of farms. Total receipts were nearly 50 percent higher on the farms with most machinery. This larger gross income would well permit a higher machinery expense per farm.

Custom work receipts were three times as great on farms with most machinery as those with the least, but lowest of all were those farms in the middle group. This high receipts is to be expected and is part of the reason why although machinery investment is nearly 100 percent higher, machinery expenses were only about 50 percent higher on those farms with most machinery. When only those farms are considered which actually did custom work, the high machinery group receipts are 2½ times greater than on the low machinery investment group of farms.

The age of operators ranged from 42.5 to 44.2 years of age so there was no significant difference between the groups. It might be thought that younger operators would use and demand more machinery. If this were true it was possibly offset by the fact that many farms which had accumulated the capital to purchase large amounts of machinery were operated by father-and-son partnerships and the father was considered as the operator.

RELATIONSHIP OF MACHINERY EXPENSES TO FARM EARNINGS AND OTHER FACTORS

In this study of the relation of machinery expenses to other factors in the farm organization the same procedure of sorting was followed as in the preceding section on machinery investments. The 285 farms were first ranked in order of size based on the number of tillable acres. Then the three largest farms were separated and ranked according to size of total machinery operating expense per farm. The next three farms were divided into the same groups, and this process was continued until all farms were arranged into either low, medium or high machinery expense groups.

The results of the tabulations are shown in Table 2. The size of farm as measured by number of tillable acres was held constant for the three groups within a range of two acres. The number of farms was the same in all three groups so direct comparisons may be made.

Machinery expense per farm was more than twice as high on the high-expense group of farms as those with the least expense. Machinery expense is usually the second highest expense item on farms, second only to labor costs. On these farms, the low group had a machinery expense only one-third that of the total man labor charge, but for the high machinery expense group it was 60 percent as much as the total labor charge. It would seem reasonable to assume that if machinery supplants labor, then those farms that spend most on

Table 2 - Relationship of Machinery Expenses to Other Factors with Tillable Acres Held Constant on 285 Farms in Southern Michigan, 1946.

Item	Machinery expense per tillable acre		
	Low 1/3	Medium 1/3	High 1/3
Number of farms	95	95	95
Tillable acres	160	159	161
Machinery expense	$653	$942	$1,431
Machinery expense per tillable acre	$4.09	$5.92	$8.87
Machinery investment . .	$2,873	$3,071	$3,335
Number of tractors per farm	1.2	1.2	1.3
Tractor operating expense per tractor	$236	$279	$298
Tractor operating expense per farm	$282	$331	$385
Number of horses per farm	1.1	1.0	1.0
Number of farms without horses	42	49	40
Number of men	1.6	1.7	1.9
Total man labor charge .	$1,944	$2,084	$2,458
Total productive man work units	516	565	570
P.M.W.U. per man	320	330	300
Crop acres per man . . .	96	78	71
Crop P.M.W.U.	213	205	206
Livestock P.M.W.U. . . .	274	344	347
Labor income	$3,471	$3,947	$3,648

machinery should have lower total labor charges, but this was not the case. Of course, some allowance must be made for the 10 percent more total productive man work units on the high expense farms.

Machinery expense per tillable acre was $8.87 on the high group compared to only $4.09 for those farms with the lowest expense. Machinery investment was $462 higher on the farms with highest machinery expense. This shows those farms with highest machinery expenses had more machinery. Interest on investment cost was not included in machinery expense.

Tractors per farm were 8 percent more numerous on the high expense group than the low group, but this would have helped to increase the operating expense of those farms. Tractor operating expense was higher on the high expense group which also had the most tractors. Tractor operating expense per tractor was also higher on this group of farms, indicating those tractors were used more hours per year or were of larger capacity.

Number of horses per farm was slightly higher, about 5 percent, on those farms with the lowest machinery expense. The middle group had the most farms without horses and the high machinery expense group the least, but this difference was too small to be significant. As these farms average only about one horse per farm, it can reasonably be concluded that horses have ceased to have much effect on the farm operations.

Number of men was higher on the farms with highest machinery expenses. Total man labor charge was $514, or 26 percent, higher on the farms with highest machinery expense. This compares with about 19 percent more men on those farms. The total labor charge on the high expense farms shows no reduction from the use of more machinery.

Total productive man work units were slightly higher on the high machinery expense group than on those farms with medium machinery expenses, and were materially greater than the low machinery expense group. Productive man work units per man were lowest of all on the farms that spent the most on machinery. This was because they had 19 percent more men to do only 10 percent more work than on the low expense group of farms. There were 300 productive man work units per man on the high expense group, 320 on the low expense group, and 330 per man in the group with medium expenses for farm machinery.

Crop acres per man were also lowest on the farms with the greatest machinery expense, 71 crop acres for the high expense group compared to 96 crop acres per man on farms with the lowest machinery expenses. Most farm machinery is used in crop production and this indicates that those farms which spent most on machinery were actually the least efficient in use of labor in so far as crop acres per man are a measure. Crop productive man work units were only slightly greater on the low machinery expense group which indicates those farms raised less intensive crops.

Livestock productive man work units were considerably higher on the medium and high machinery expense groups than on the low expense group, 27 percent more on the high machinery expense group than on the low group of farms. This was likely the greatest factor influencing labor incomes.

Labor income was highest, $3,947, on the medium machinery expense group of farms, $3648 on the high expense group, and $3471 on those farms with lowest machinery expenses. If other factors had been constant and this difference in labor incomes was associated with machinery expenses, then the expenditure of a moderate amount on machinery, as shown in the medium expense group would seem to result in the greatest farm earnings. However, other factors do not remain constant and these other factors, especially amount or intensity of livestock enterprises, apparently had a greater influence on farm earnings than the amount spent on machinery operating expenses.

RELATIONSHIP OF LABOR-SAVING MACHINERY TO LABOR EFFICIENCY

An attempt is made in this section to establish an index of mechanization to rate farms according to the labor-saving efficiency of their machinery investment. It is assumed that the amount or quantity of machinery may not necessarily be the best measure of quality or efficient kinds and types of machines that will save the most labor.

In so far as a review of literature revealed, and through discussions with agricultural engineers, there has never been an attempt to rate the different kinds and types of farm machinery according to its degree of labor-saving efficiency. This may not be feasible. It most certainly is difficult to devise a reliable rating scale.

Perhaps the best method would be to determine the number of hours required to perform an operation by hand methods, then compute the number of hours required by the use of the machine and rate machines on a percentage basis of time saved. Such an undertaking is beyond the scope of this study. It would also be handicapped by the necessity of evaluating the effectiveness of the operations, quality of work, and so forth.

The rating scale used here is based on the number of certain major labor-saving machines listed on the beginning of the year inventories of these farms. Because of the lack of any previous study concerning efficiency ratings an arbitrary device was constructed to rate the labor-saving effic-

iency of the machinery on a farm. Partially because of the nature of the data available for this study only major machines were considered. It was desired to choose machines that would not ordinarily be found on every farm, such as a manure spreader, so there could be gradations in the ratings.

Farming enterprises were divided into four groups and those machines most typically labor-saving, as revealed in the review of literature, in each group were selected as standards. In addition, a group of service tools were added, and weight was given for those farms having more than one tractor. The six points in the index of mechanization with the kind of enterprise the machine is used in are as follows:

1. Combine - - - - - - - - - - - - - - small grains
2. Corn picker - - - - - - - - - - - - corn
3. Pick-up baler, forage chopper, or a buck rake - - - - - - - - hay
4. Milking machine - - - - - - - - - dairy
5. Manure loader or a gutter cleaner - service tools
6. Two or more tractors - - a measure of power available

The combine and cornpicker are undoubtedly the greatest labor savers in harvesting small grains. Hay making methods are at present in an evolutionary state of flux. Agricultural engineers are by no means agreed as to which method will eventually emerge as most popular. Some studies have indicated that there is more variation in labor requirements and time saved within a method of hay-making than be-

tween different methods [21] . The hay loader has not been included as it is too common and probably saves less labor than the other three machines. Many tools such as litter carriers and feed carts are not included with service tools because they are but minor investments.

Although two small tractors may require more labor to do the same amount of work as one large tractor, and number of tractors will be largely proportional to size of farm, it was deemed advisable to include the sixth point in the rating scale to show the amount of power available to operate other labor-saving machines. An abundance of power is required to most effectively utilize labor-saving machines. One of the greatest labor-saving devices, an adequate automatic water system, is not included as it is usually listed under the improvement inventory in farm accounts rather than as machinery and equipment.

The 285 farms in this study were first divided into three groups according to size as measured by number of tillable acres. There were 94 small farms, 29-119 tillable acres; 91 medium-sized farms, 120-169 tillable acres; and 100 large farms, 170-666 tillable acres. The grouping by numbers of farms according to the number of major labor-saving machines per farm is shown in Table 3. This shows the logical trend toward more labor-saving machines on the larger farms. The farms in each size class were then divided

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21/ B. R. Bookhout, Haymaking Job Analysis, Journal of Farm Economics, 29 (3): 761-67, 1947.

into four groups to tabulate the data.

Table 3 - Number of Farms with Different Amounts of Major Labor-saving Machinery, 285 Farms in Southern Michigan, 1946

Size of farm	Number of farms	Number of major labor-saving machines per farm						
		0	1	2	3	4	5	6
		Number of farms						
Small	94	12	50	22	8	2	-	-
Medium	91	10	33	34	10	2	2	-
Large	100	4	20	16	31	19	6	4

Small Farms

A tabulation was made of each size group to show the effect of the number of labor-saving machines per farm on labor income and other factors. Table 4 is a record of these data on small farms. Only two farms in this size group had more than three major labor-saving machines. Those having only one machine were the largest group and this was in most cases a milking machine. There was a range of 11 acres or only 14 percent in the size of farms among the four groups.

Labor income was highest on those farms having the most machines with $3,103, but was lowest on the second group with only $2,299. Total productive man work units were one-third higher on the farms having most labor-saving equipment and this would account for most of the increase

Table 4 - Effect of Labor-saving Machines on Labor Income and Other Factors on 94 Small Farms in Southern Michigan, 1946

Item	Small farms (29-119 tillable acres) Number of major labor-saving machines per farm			
	0	1	2	3-4
Number of farms . . .	12	50	22	10
Tillable acres . . .	80	84	89	91
Labor income	$2,530	$2,299	$2,854	$3,103
Labor income per tillable acre	$31.82	$27.43	$32.05	$34.25
Total productive man work units	318	356	403	425
Number of men	1.0	1.3	1.4	1.5
P.M.W.U. per man . .	318	278	287	279
Livestock P.M.W.U. .	184	227	261	252
Crop P.M.W.U. . . .	122	113	123	126
Productive animal units	22	22	26	26
Total man labor charge	$1,390	$1,547	$1,730	$1,930
Machinery investment	$1,437	$1,916	$2,835	$3,767
Machinery investment per tillable acre	$18.08	$22.86	$31.84	$41.58
Machinery expense . .	$528	$593	$874	$594
Machinery expense per tillable acre . .	$6.64	$7.07	$9.81	$6.55

labor income.

Number of men was 50 percent greater for the group with most machines than for the least. This resulted in the lowest rated machinery group having the most productive man work units per man, 318. The group with two labor-saving machines per farm had the most livestock productive man work units but had the same number of productive animal units, 26, as the high group. Total man labor charge was in proportion to the number of men and was highest on the group having most machinery.

Machinery investment was considerably higher in the group having most labor-saving machinery, over 2½ times as much as the group with none. Investment per tillable acre was in similar ratio. Machinery operating expense shows quite different results. The high-rated group had only slightly higher total machinery expense than the low group and was actually lower in expense per tillable acre. The reason the high machinery group had such low expense was possibly because those farmers performed more custom work. This added income would counter-balance the extra cost of the larger investment in equipment.

In summary it may be said those farms with the most labor-saving machines had the highest incomes but also had a la rger volume of business as shown in total productive man work units. The farms with most machines had a larger number of men per farm resulting in no gain in labor efficiency per man.

Medium-sized Farms

This size class shows the most pronounced results of all from the use of labor-saving machines. There was little difference in size among the four groups, ranging from 138 to 146 tillable acres. The labor income on those farms with most labor-saving machinery was nearly twice as great, $5,165 compared to $2,674 for those farms without any. It is remarkable that merely sorting on the basis of labor-saving machines per farm should result in such decided differences in earnings.

One of the associated causes of the increased earnings is a 44 percent greater total productive man work units, 416 on farms without labor-saving machines to 599 on farms with most machines. There were 25 percent more animal units on the high-machinery group of farms than on the low group. These must have been more intensive types of livestock as there were about 50 percent more livestock productive man work units on the farms with most machinery. The group with no labor-saving machines had 260 productive man work units per man which was noticeably less than the other groups.

Machinery investment was about two and one-third times as great for the high machinery group as on the low group. The machinery expense was nearly twice as large, $8.31 per tillable acre compared to only $4.66 on the low group.

In this size of farm class there was a large increase in farm earnings on those farms with most labor-saving machines. This increase was far greater than could be accounted for by the larger volume of business on those farms.

Table 5 - Effect of Labor-saving Machines on Labor Income and Other Factors on 91 Medium-sized Farms in Southern Michigan, 1946.
(29-119 tillable acres)

Item	Number of major labor-saving machines per farm			
	0	1	2	3-4
Number of farms . . .	10	33	34	14
Tillable acres . . .	141	138	146	146
Labor income	$2,674	$2,956	$3,617	$5,165
Labor income per tillable acre	$18.95	$21.37	$24.81	$35.38
Total productive man work units	416	465	521	599
Number of men	1.6	1.4	1.6	1.8
P.M.W.U. per man . .	260	323	357	332
Livestock P.M.W.U. .	250	267	314	366
Crop P.M.W.U. . . .	155	184	192	214
Productive animal units	27	28	34	34
Total man labor charge	$1,923	$1,715	$1,826	$2,517
Machinery investment	$1,722	$2,182	$2,910	$4,055
Machinery investment per tillable acre	$12.20	$15.77	$19.97	$27.77
Machinery expense	$658	$778	$925	$1,214
Machinery expense per tillable acre . .	$4.66	$5.62	$6.34	$8.31

Large farms

As farms increase in size there is a natural trend toward the use of more labor-saving machines and a higher machinery investment. There were only four out of the 100 farms with no major labor-saving machines, and there were also four that met the requirements of all six points in the rating scale. There was considerable difference in the size of farms in this class, 212 tillable acres for the group with least machinery to 321 tillable acres for the well equipped group. This variation in size makes comparisons less valid.

Labor income was nearly twice as great for the farms with most labor-saving machinery, $6,863 compared to $3,779 on the low rated farms. Labor income per tillable acre was more nearly uniform reflecting the difference in size of farms.

Total productive man work units of 1,108 on the high rated farms compared to 592 on the farms with one or no machines show that the well equipped farms also had a much larger volume of business. The productive man work units per man were high on all four of these groups but was exceptionally high on those farms with 5 or 6 major labor-saving machines which had an average of 406 per man. This evidences an association between use of labor-saving machinery and labor efficiency.

Crop productive man work units ranged from 380 for the high rated farms down to 270 on those with least machinery but this was in line with the smaller size of farms. The high machinery group of farms had 65 percent more productive animal units and more than twice as many livestock produc-

Table 6 - Effect of Labor-saving Machines on Labor Income and Other Factors on 100 Large Farms in Southern Michigan, 1946.
(170-666 tillable acres)

Item	Number of major labor-saving machines per farm			
	0-1	2-3	4	5-6
Number of farms	24	47	19	10
Tillable acres	212	240	244	321
Labor income	$3,779	$4,826	$5,709	$6,863
Labor income per tillable acre	$17.82	$20.06	$23.35	$21.38
Total productive man work units	592	751	840	1108
Number of men	1.8	2.3	2.3	2.7
P.M.W.U. per man . . .	315	319	368	406
Livestock P.M.W.U. ...	315	435	450	646
Crop P.M.W.U.	270	300	353	380
Productive animal units	40	51	55	66
Total man labor charge	$2,253	$3,143	$2,977	$3,571
Machinery investment .	$2,874	$4,163	$4,672	$7,049
Machinery investment per tillable acre . . .	$13.55	$17.30	$19.11	$21.95
Machinery expense . . .	$1,032	$1,647	$1,444	$1,597
Machinery expense per tillable acre . . .	$ 4.86	$6.84	$5.91	$4.96

tive man work units, 646 compared to 315 for the low group.

Machinery investment was exceptionally high with $7,049 on farms with most labor-saving machines compared to only $2,874 on the low group. Investment per tillable acre ranged from $13.55 to $21.95 on farms with most machines. Machinery expense per tillable acre was nearly as low with $4.96 on farms with most machines as the $4.86 on farms with least machines. This would indicate that a farm can justify a large machinery investment if there is a large volume of business to utilize the machines.

It can reasonably be concluded that most of the increased earnings on the farms with most labor-saving machinery were due to having a larger volume of business on those farms rather than to the use of more labor-saving machinery.

Summary on Effects of Using Labor-saving Machines

Some of the more important factors in the use of labor-saving machinery on all three sizes of farms have been brought together here for further comparative studies.

Figure 5 shows the close relationship between numbers of labor-saving machines per farm and the size of machinery investment. It also shows that machinery investment per tillable acre is much higher on small farms than on large farms, and this differential increases as more machinery is added. If machinery costs per tillable acre are to be kept

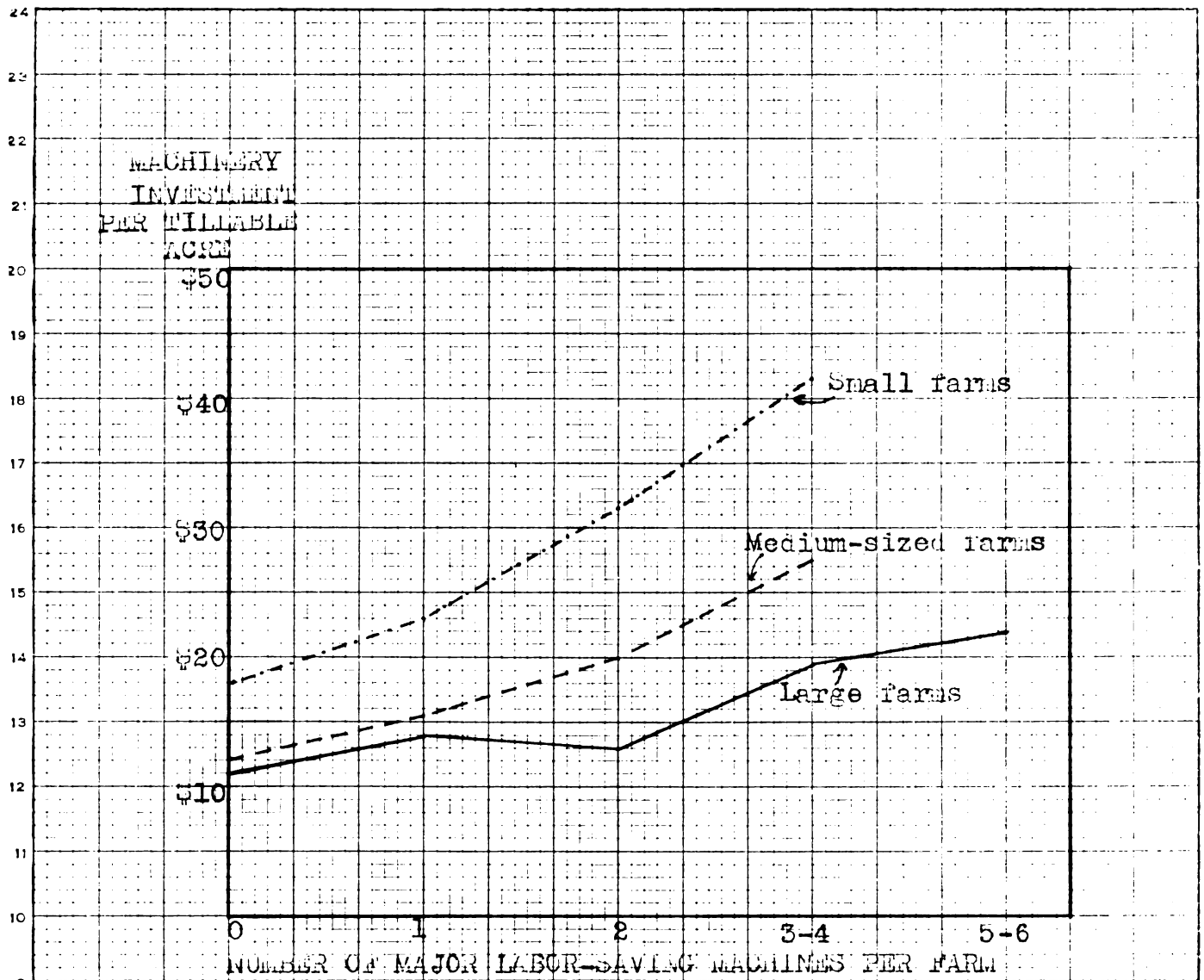

Figure 5 - Relation of amount of labor-saving machinery to machinery investment on 285 farms in Southern Michigan, 1946.

low a large investment in machinery must be accompanied by a large volume of business.

Table 7 - Relationship of Labor-saving Machinery to Labor Efficiency on 285 Farms in Southern Michigan, 1946.

Size of farm	Range in tillable acres	Number of farms	Number of major labor-saving machines per farm					
			0	1	2	3-4	5	6
			Productive man work units per man					
Small	(29-119)	94	318	278	287	279	-	-
Medium	(120-169)	91	260	323	357	332	-	-
Large	(170-666)	100	325	314	355	333	432	373
Weighted average of all farms		285	297	299	331	324	432	373

The relationship of the use of labor-saving machinery to labor efficiency is shown in Table 7. There was a range from an average of 297 productive man work units per man on those farms with the least number of major labor-saving machines to 432 on those farms with 5 labor-saving machines per farm. There were only six farms in group 5 and four farms in group 6 so the results in those columns may not be reliable. It must not be deduced from this table that the greater labor efficiency on farms with most machinery is due only to the use of the labor-saving machinery. The improved efficiency was also influenced by the larger volume of business on those farms as shown in Tables 4 - 6.

The relation of size of business and use of labor-saving machines on farm earnings is shown in the scatter diagram, Figure 6 on page 48. As the total number of productive man work units increases there is an increase in labor incomes. For each size of farm it will be noted that as labor incomes increase, there is an accompanying increase in numbers of major labor-saving machines per farm. This does not show whether the increased numbers of machines on the high income farms were a cause of the increased earnings, or merely an accompanying effect. The greater use of machinery may have helped increase the volume of business by increasing labor output per worker and thus, indirectly, contributing to the increased farm earnings. That the greater use of machinery does not increase labor efficiency is shown in the study on machinery investment with size of farm held constant, on page 24 of this report. The results shown in Table 7, page 46, are considered inconclusive as the size of farm was not held constant.

Table A in the appendix presents an account of the numbers of the different kinds of labor-saving machines used in setting up the rating scale, which were found on these 285 farms. This same material is shown graphically in Figures 7-12 on a percentage basis. These graphs were presented to show a comparison of the amounts of the different kinds of machines on small, medium and large sized farms.

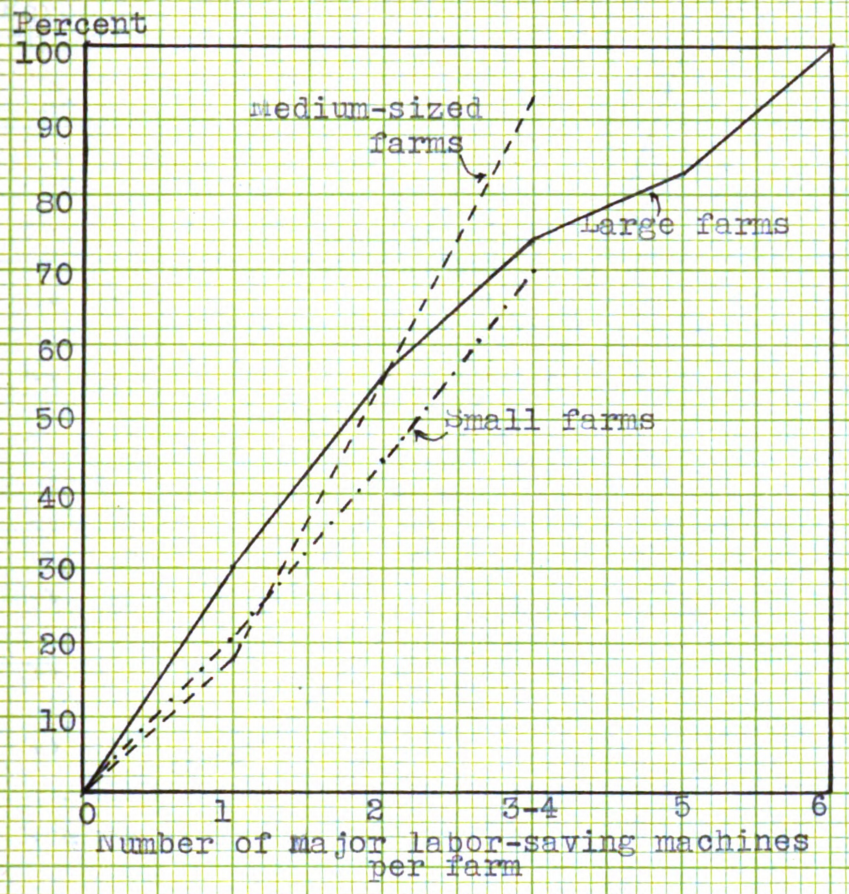

Figure 7 - Percent of 285 farms in Southern Michigan, with Combines, 1946.

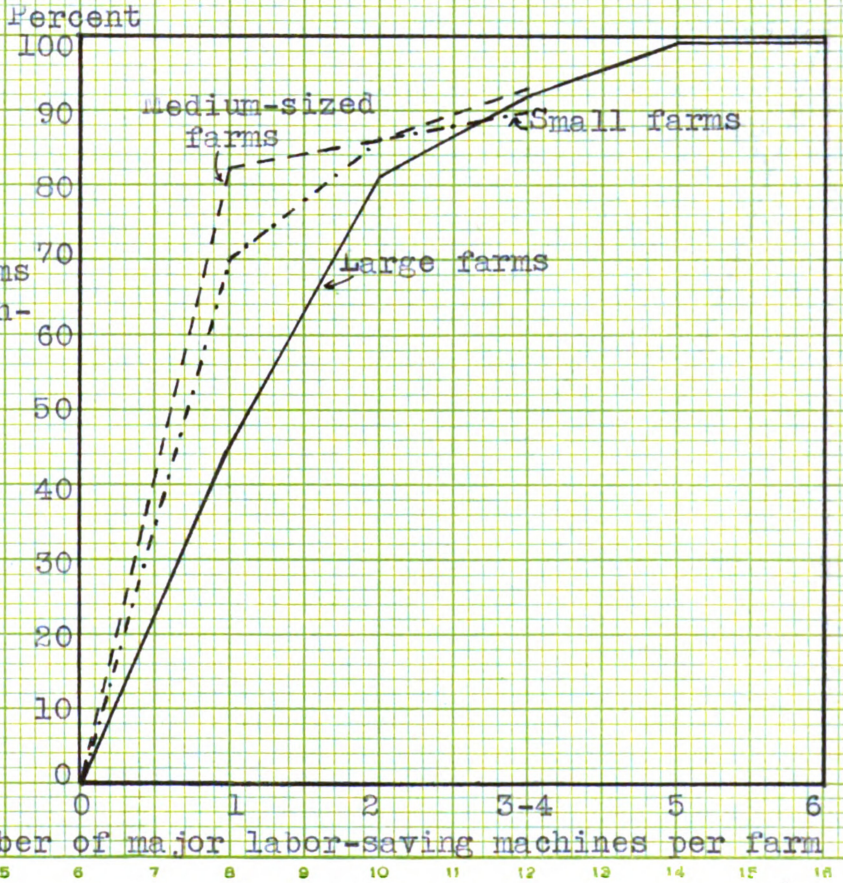

Figure 8 - Percent of 285 farms in Southern Michigan with Milking machines, 1946.

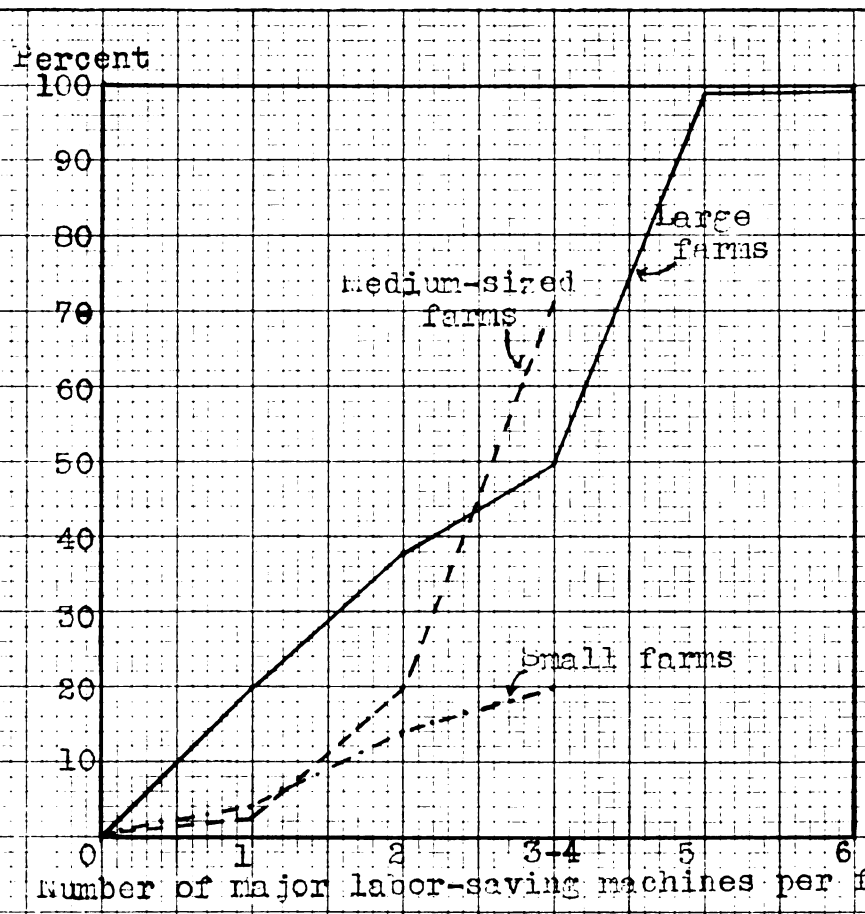

Fig. 9 - Percent of 285 farms in Southern Michigan with corn pickers, 1946.

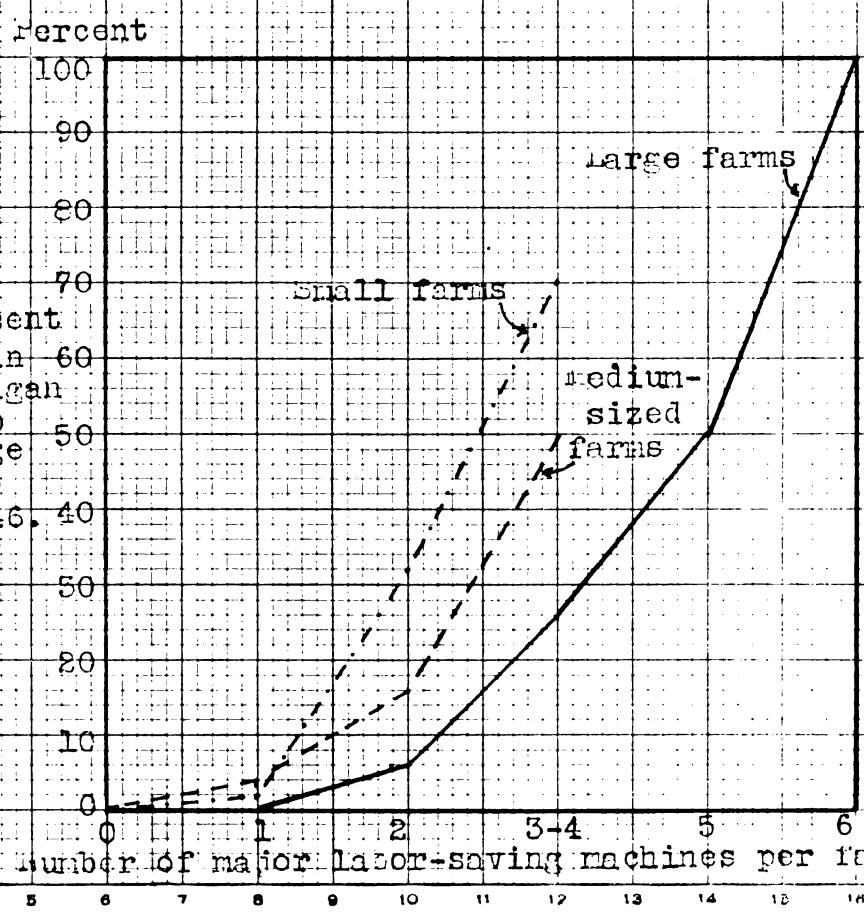

Fig. 10 - Percent of 285 farms in Southern Michigan with a pick-up baler, a forage chopper, or a Buck rake, 1946.

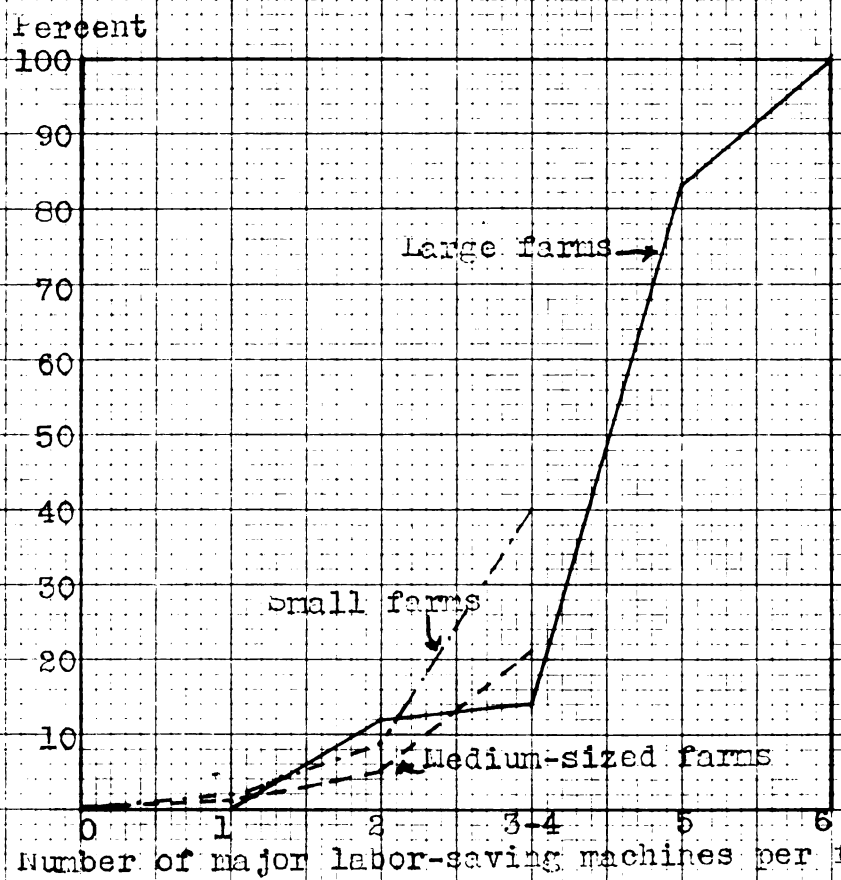

Fig. 11 - Percent of 285 farms in Southern Michigan with a manure loader or a gutter cleaner.

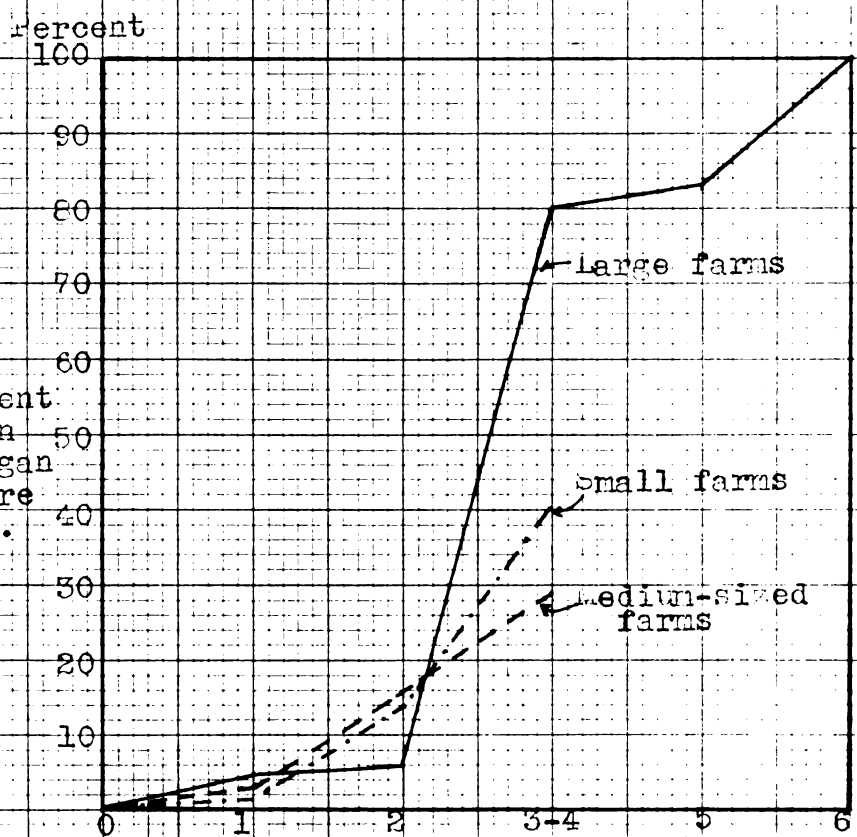

Fig. 12 - Percent of 285 farms in Southern Michigan with two or more tractors, 1946.

REPORT ON MACHINERY PURCHASES IN 1946

This section is a study concerning the kinds and amount of machinery farmers in Southern Michigan were buying in 1946. The farms were divided into three groups according to the number of tillable acres per farm. The numbers of principal machines purchased in 1946, and the cost of the machines to the farmers are shown in Table B in the appendix of this report. Both new and used machines are included in this report so an average price would not have much meaning with relation to the price of new machines. Major repairs which would affect the life of the machine and could not be charged to annual operating expense are included in these costs. These repairs were mostly on the power and transportation machines. It was not always possible to determine from the records whether an item was a major repair or the full cost price of a used machine so the numbers of machines may not be accurate. It is not believed that the inadequacy of the data in this respect would greatly affect the accuracy of derived comparisons.

The machines were grouped according to type of use made of the machine. Livestock equipment includes not only feeders, brooder houses, milking machines and other miscellaneous livestock equipment, but also feed grinders and manure spreaders. Miscellaneous machinery has everything in it that could not be fitted into one of the other groupings.

Table 8 shows the percent of the total purchase cost

spent for the different kinds of farm machines. The most money was spent for the purchase of power and transportation machines, although on small farms a little more was spent for harvesting machinery. The farmers on large farms spent one-third of the total amount of their new machinery purchases to buy tractors. The source of the data for this study does not show the size of all the tractors but many of these were larger capacity, three-plow types with greater output per unit of labor. Automobiles and trucks were in short supply in 1946 and the major portion of the expenditures shown were for used machines and major repairs on those already owned.

Harvesting machinery was the other group which accounted for a large share of purchases. Two-thirds of the amount spent for machinery purchases was spent for these two groups of machines. Farmers on small farms spent 36 percent of all machinery purchases for harvesting machines but those on large farms spent only 20 percent on these machines. Combines accounted for 16 percent of all purchases on small farms, but only 5 percent on large farms. The large farms possibly were already well equipped with combines, but they were just being introduced on many of the smaller farms. Further studies should be made to determine if these combines on small farms are bantam-sized machines, or if they were purchased to do custom work to increase the volume of business on limited acreages. Only two pick-up balers were bought in each size grouping in 1946.

Table 8 - Percent of Total Machinery Purchase Costs For Different Kinds of Machines on 285 Farms in Southern Michigan, 1946

Kind of machinery	Size of farm		
	Small (29-119) tillable acres	Medium (120-169) tillable acres	Large (170-666) tillable acres
	Percent of total machinery purchase cost		
Number of farms	94	91	100
Power and transportation:			
Tractors	18	20	33
Automobiles (farm share)	9	5	5
Trucks	7	6	6
Total	33	31	44
Harvesting machinery:			
Combines	16	14	5
Pick-up balers	6	4	3
Corn pickers	5	6	5
Other harvesting machines	9	6	7
Total	36	30	20
Livestock equipment:			
Milking machines	3	4	2
Milk coolers	2	1	2
Other livestock equipment	6	10	9
Total	11	15	13
Drills and planters	1	2	3
Tillage machinery	6	8	6
Wagons and trailers	5	5	5
Miscellaneous machinery	8	9	9
TOTALS	100	100	100

Purchases of drills and planters was a small item, ranging from 1 to 3 percent of purchases. Tillage tools accounted for 6 to 8 percent of machinery purchase costs. Many rubber-tired wagons were bought and this pushed the purchases for wagons and trailers up to 5 percent of the total. Livestock equipment expenditures were mostly for milking machines and manure handling machinery.

No complete data were available for other years on these farms so a study of trends in machinery purchases could not be made. Two-thirds of the machinery purchases in 1946 were for power or transportation machines and harvesting machinery. Farmers on small farms spent three times as high a percentage of their total purchases on combines as those on large farms. Farmers on the large farms spent relatively more on tractors.

SUMMARY AND CONCLUSIONS

Michigan farmers are facing the problem of deciding how much machinery it is practical for them to have on their farms. It was thought that a study of farm accounting records on farms of Southern Michigan would provide information to answer some general problems of how much machinery a farmer can afford. The purpose of this study was to determine the effects of the use of farm machinery on labor efficiency and farm earnings.

The data were taken from farm accounting records on 285 farms in south central Michigan for the year 1946, which were kept in connection with the farm accounting project of the Farm Management Department of Michigan State College. These farms averaged 160 tillable acres so they were more than twice as large as the average size of farm in this area.

Machinery investments -- The first section of this study is on the relationship of machinery investments to labor efficiency and farm earnings. Machinery investments per farm on the one-third of the farms with the most machinery were $4,170, or nearly twice the investment on those farms with the least machinery, $2,098.

The farms with most machinery had 20 percent more total productive man work units and 25 percent more men per farm than those with the least machinery. This resulted in 316 productive man work units per man on farms with the smallest machinery investment, 338 units on the medium

one-third, and only 306 on farms with the largest investment. This shows no gain in labor efficiency from the use of more than the normal minimum needs of machinery.

Labor income was $4,054 on the farms with most machinery compared to $3,411 on the third with the smallest machinery investment. A comparative study of Type of Farming Area reports on these farms shows this difference was due to the larger volume of business, therefore, no increase in labor incomes could be attributed to the larger amounts of machinery.

Machinery Expenses -- The section on the relationship of machinery expenses to labor efficiency and farm earnings gave results similar to those in the study of machinery investments. Labor incomes averaged $3,947 on the farms with medium expense per tillable acre, decreased to $3,648 on the farms with highest machinery expense, and were lowest on farms with the least expense, $3,471.

Total productive man work units were lowest on the farms with the lowest machinery expenses and labor incomes. Total productive man work units were about the same on the medium and high investment groups, but the higher man labor charge on the farms with highest machinery expense decreased the labor income a like amount. Productive man work units per man were 300 on farms with highest machinery expense compared to 320 on farms with lowest expense.

Labor-saving machines -- An attempt was made to rate farms on the degree of labor-saving effectiveness of the machinery investment. No claim is made as to the validity

of the rating scale used. The results from this study showed no effect on labor incomes or labor efficiency that was not proportional to the volume of business on the small and large size groups of farms. On the medium-size farms there was a large increase in labor income from $2,674 on the farms with the least, to $5,165 on farms with the most labor-saving machinery. This increase was accompanied by a 44 percent larger total productive man work units. The greater labor income on farms with most labor-saving machinery was far greater than could be accounted for by the larger volume of business on those farms.

Machinery Purchases -- From the report on farm machinery purchases for 1946 it was ascertained that two-thirds of the cost of purchases were for power or transportation machines and harvesting machinery. Farmers on small farms spent 16 percent or three times as high a percentage of their total purchases for combines as those on large farms. Farmers on the large farms spent 33 percent of their machinery purchase costs for tractors.

Conclusions -- In general, it can be said that the results from this study of 285 Southern Michigan farms show no increase in labor efficiency or farm earnings that can be attributed to a machinery investment above the normal, minimum needs. Neither do these results show a decrease in labor earnings from investments in above normal amounts of machinery as might be expected in more normal price periods.

Farms with the most machinery usually had larger

labor incomes, but at the same time also had a larger volume of business. This does not indicate whether a large machinery investment was a cause of the increased farm earnings, or merely an accompanying effect. If the greater use of machinery helped to increase the volume of business by increasing output per worker it would, indirectly, increase farm earnings. However, the results from this study show no increase in labor efficiency from the use of more than the normal minimum amounts of machinery.

These results indicate that investments in farm machinery above the normal, minimum needs are not justified purely from the standpoint of increasing economic returns. Apparently, the desire to shorten the number of hours of work per day, reduce drudgery, and make farm life more enjoyable are just as important considerations by farmers in the purchase of additional machinery as is the economic motive. Unless we recognize these intangible values we are ignoring one of the principal reasons why farmers buy machinery.

It must not be construed from these conclusions that farm machinery does not save labor. Innumerable surveys have shown a great reduction in man-hour requirements over the past century in raising various crops, which were due in large measure to the increase in mechanization. The farms in this study with the lowest machinery investment probably had enough machinery for their normal minimum needs, and in addition may have hired additional machinery on a

custom basis. They would thereby have received benefits from the use of machinery which did not increase their machinery investment.

It can be concluded, therefore, that results from this study show no positive relationship between the size of machinery investment on these farms in Southern Michigan and labor efficiency or farm earnings. Limitations of the data must be considered but results indicate that large investments in machinery on typical Southern Michigan farms do not result in proportional economic returns. The implications from this study show the need for more research on farm machinery investments.

APPENDIX

Table A - Numbers of the Different Kinds of Major Labor-saving Machines on 285 Farms in Southern Michigan, 1946.

Number of labor-saving machines per farm	Number of farms	Kind of major labor-saving machines					
		Combine	Corn-picker	Pick-up baler*	Milking machine	Manure loader, Gutter cleaner	Two or more tractors
		Number of farms with the machines					
Small farms (29-119) tillable acres (127 machines)							
0	12	-	-	-	-	-	-
1	50	10	2	1	35	1	1
2	22	10	3	7	19	2	3
3-4	10	7	2	7	9	4	4
Total	94	27	7	15	63	7	8
Medium-sized farms (120-169 tillable acres) (151 machines)							
0	10	-	-	-	-	-	-
1	33	3	1	1	27	-	1
2	34	19	7	6	29	2	5
3-4	14	13	10	7	13	3	4
Total	91	35	18	14	69	5	10
Large farms (170-666 tillable acres) (275 machines)							
0	4	-	-	-	-	-	-
1	20	6	4	-	9	-	1
2	16	9	6	1	13	2	1
3-4	50	37	25	13	46	7	41
5	6	5	6	3	6	5	5
6	4	4	4	4	4	4	4
Total	100	61	45	21	78	18	52
Total all farms	285	123	70	50	210	30	70

* Pick-up baler, a forage chopper, or a buck rake (one only).

Table B - Numbers and cost of different kinds of new and used machines purchased in 1946 on 285 farms in Southern Michigan

	Small farms (29-119 tillable acres)		Medium-sized (120-169 tillable acres)		Large farms (170-666 tillable acres)	
	No.	Cost	No.	Cost	No.	Cost
Harvesting machinery:						
Combines	8	$10,464	9	$10,420	6	$5,482
Corn pickers . . .	5	3,280	8	4,560	10	6,370
Pick-up balers . .	2	3,349	2	3,251	2½	3,617
Other harvesting machinery	30	5,927	27	4,195	36	8,927
Total harvesting machinery costs	45	23,020	46	22,426	55	24,396
Drills and planters .	8	898	11	1,360	19	3,287
Power and Transport:						
Tractors	9	10,278	13	14,197	30	35,151
Major repairs .	-	1,236	-	1,340	-	3,831
Total cost . .		11,514		15,537		38,981
Autos (farm share)	7	4,411	3	2,357	4	3,325
Major repairs .	-	1,0200	-	852	-	1,533
Tota l cost . .		5,731		3,109		4,858
Trucks	5	4,288	3	4,570	7	7,175
Major repairs .	-	70	-	551	-	1,166
Total cost . .		4,358		5,121		8,341
Tillage machines . .	39	3,503	55	6,202	66	6,619
Livestock equipment:						
Milking machines .	7	1,798	13	3,355	10	2,397
Milk coolers . .	6	1,516	2	660	8	2,844
Other livestock equipment . . .	-	3,959	-	7,581	-	10,166
Total cost	-	7,273	-	11,596	-	15,407
Wagons and trailers .	29	3,345	26	3,954	43	6,531
Miscellaneous machinery	-	5,077	-	6,587	-	11,401
Total of all machinery	-	64,718	-	75,892	-	119,821

Name _____ Address _____ No. _____

County _____

Line	Machine	yr. acquired	Cost	Est. life	Beginning yr. No.	Beginning yr. Value	End of yr. No.	End of yr. Value	Sales
1.	Wagons								
2.*	Extra beds, sacks, etc.								
3.*	Trailer								
4.	Truck								
5.									
6.	Auto farm share								
7.	Tractor size								
8.									
9.	Gas engines								
10.	Electric motors								
11.									
12.*	Sulky plow								
13.	Tractor plow								
14.	Tractor disc								
15.	Tractor cultivator								
16.	Disc harrow								
17.	Spring tooth harrow								
18.	Spike tooth harrow								
19.	Cultipacker or roller								
20.	Field cultivator								
21.	Rotary hoe or cultihoe								
22.									
23.	Corn planter								
24.	Corn binder								
25.	Ensilage cutter								
26.	Corn picker								
27.									
28.	Feeding mill								
29.	Grain drill								
30.*	Grain binder								
31.	Combine								
32.	Grain blower or elevator								
33.	Bean puller or beet lifter								

Footnotes:

No. _____

Line	Machine	Yr. acquired	Cost	Est. Life	Beginning yr. No.	Beginning yr. Value	End of year No.	End of year Value	Sales
1.	Mower [illegible]								
2.	*Pump rake								
3.	Side-delivery rake								
4.	[illegible] rake								
5.	[illegible] baler								
6.	[illegible] baler								
7.	[illegible] buildings								
8.									
9.	Potato planter								
10.	Potato [illegible]er								
11.	Potato di[illegible]er								
12.	Grain [illegible] sacks								
13.									
14.	[illegible]								
15.	[illegible]								
16.	[illegible]								
17.	[illegible]								
18.	[illegible]								
19.									
20.	[illegible]								
21.	[illegible] use, [illegible]								
22.	[illegible]								
23.	[illegible]								
24.									
25.	[illegible]								
26.	[illegible]								
27.	[illegible]								
28.	[illegible]								
29.	[illegible]								
30.	[illegible]								
31.	[illegible]								
32.	[illegible]								
33.	[illegible]								
34.	[illegible]								
35.	[illegible]								
36.	[illegible]								
37.									
38.	Total								

Explain:

Operator _____ Cattle _____ Field No. _____

Livestock . . . . _____ Crop A.U.M. _____

Total Crop Acres _____ Total Investment (Farm) _____

Receipts and Net Increase (Dec.):

1. Potato _____ 9. Poultry _____

2. Horses _____ 8. Hog sales _____

3. Beef cattle _____ 10. Crop sales & inventory balance _____

4. Dairy cattle _____ 11. Labor off farm _____

5. Dairy sales _____ 12. Wood products _____

6. Hogs _____ 13. Miscellaneous _____

7. Wool and wool _____ 14. Machinery and farm improvements _____

15. Total receipt _____

Man Hours expense per tillable acre _____ Total farm _____

Auto operating _____ Tractor operating _____

All machinery and equipment (operating) _____

Efficiency Factors:

1. Total acres _____ 9. Crop acres per man _____

2. Tillable acres _____ 10. Tractor: No. _____ Hp _____

3. Productive animal units _____ 11. No. of horses _____

4. Total A.U.M. _____ 12. Total man labor charge _____

5. Labor income _____ 13. Man labor charge per tillable A. _____

6. Total expense _____ 14. Regular family labor:

7. No. of men _____ Hours _____ Value _____

8. A.U.M. per man _____

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