Tractor Complements on Iowa Commercial Farms

By Steven C. Griffin, P. Alan Treffeisen, and Earl O. Heady

Miscellaneous Report

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THE CENTER FOR AGRICULTURE AND RURAL DEVELOPMENT IOWA STATE UNIVERSITY, AMES, IOWA 50011



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Center for Agricultural and Rural Development

Iowa State University

Ames, Iowa 50011

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PREFACE

This is the second research report which analyzes the Iowa sample of the USDA-ERS Cost of Production Survey conducted for 1974. The first report [1] analyzed a number of farm operator characteristics of Iowa commercial farms. This report concentrates on an analysis of tractor complements found on the Iowa farms surveyed in the USDA-ERS study.

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Special recognition should be given to Dr. Ronald D. Krenz, Program Leader, Firm Enterprise Data System Project, Commodity Economics Division, USDA, and his staff for providing the survey data tape and documentation.

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SUMMARY

This study summarizes the information obtained on tractor holdings and use from a random sample of Iowa farms operating 100 acres of land or more in 1975. The survey was a subset of a national survey initiated and coordinated by the U.S. Department of Agriculture. The purpose of the survey was to obtain information on production costs, but data on many other farm characteristics also were obtained. Analysis of some of these other farm characteristics is found in a report by Griffin, Treffeisen and Heady [1]. The data which pertain to tractor inventories are analyzed in this report.

The tractor is the most important item of a farm machinery complement, both in terms of the dollar investment it individually represents and by the key role it plays in determining the size and composition of the complement to which it provides locomotion and

power. The tractor's predominance, though dimmed slightly be emerging numbers of self-propelled, primarily harvesting equipment, is based on its role as a shared power source. In general, a shift to larger farm equipment generally must be preceded, if not accompanied, with an increase in tractor power. By the same token under-sized implements when matched with a larger-than-necessary tractor may waste fuel, power, labor, and precious investment capital. Therefore, decisions concerning the tractor or any of its implements, either singularly or as operational groups, invariably affects the operation and economics of the entire system.

The average number of tractors owned on the farms surveyed was 3.3. Forty percent of the farmers owned three tractors, 20 percent had two, 25 percent had four, and less than 3 percent had only one. The number of tractors per farm was positively correlated with farm size. Tractors in the 25-34, 35-49, and 50-64 horsepower ranges were the most common, comprising respectively, 15, 26, and 19 percent of the total number of tractors. Half of the operators owned at least one tractor of 50-64 horsepower, and 40 percent owned at least one of 25-34 horsepower.

The average year of manufacture of the tractors on the farms surveyed was 1960. New tractors predominated in the sample, with 40

percent 10 years old or less at the time of the survey. Almost onethird of the machines were more than 20 years old, but these were mostly small utility tractors. In general, there was an inverse relationship between tractor age and tractor size. This indicates that farmers are replacing their older tractors with larger ones.

Tractor variables seemed to follow roughly a "life cycle" hypothesis: operators accumulating assets (tractor power) during their early farming career and then reducing their holdings during later years as they approach retirement [2, pp. 431-433]. There was a strong positive link between total value of tractors per farm and variables related to farm size. For example, average total land operated went from 218 to 1,026 acres between farms with total tractor value of less than \$5,000 and those with a total book value of \$40,000 or more, while average crop sales rose from \$28,534 to \$447,440 between these two groups. Farms of less than 200 acres had an average of 2.7 tractors with an average of 52 horsepower, a book value of \$3,121, and used an average of 264 hours. Farms of 1,000 acres or more, on the other hand, had an average of 4.1 tractors of 80 horsepower, each valued at \$9,026 and used 557 hours per year.

Correlations among the tractor variables were significant. Farms with more tractors tended to have higher total tractor value, hours of use, and horsepower hours of use.

The age distribution of tractors on farms does not indicate an abrupt increase in demand for tractors in the coming years. Rather,

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farmers will continue to maintain a balance between larger "field" tractors and smaller utility tractors. Most of the new machines will be for field operations, but there will still be a market for utility tractors because it is in this capacity that inventories are quite old.

Generalizations concerning multiple tractor complements were possible when the original 12 tractor size classes were merged into low, medium, and high power groups. This gave a total of 58 different complements, seven of which represented 56 percent and sixteen of which represented 80 percent of the farms in the sample. A look at the most popular complements showed that they consisted of two to four tractors, divided between utility tractors and high powered machines for field operations.

Operators in different age groups had substantially similar tractor complements, the main difference being that complements with large tractors or more than one medium-sized machine were somewhat more common among farmers aged 45 and under than among older ones. It was hypothesized that these differences were due in part to larger farm size among the younger farmers.

As was expected, there were significant differences in tractor complements between farms with different amounts of cropland. Large farms in general had more tractors and more machines of 95 horsepower and above than did their smaller counterparts. In addition, large farms exhibited more diversity in tractor complements than did smaller ones. This was explained by the fact that large farms have more alternatives open to them in terms of number and size of tractors than do smaller operations.

INTRODUCTION

Farm Machinery in Agriculture

The development and adoption of farm machine technology in U.S. agriculture during the past 40 years has had a significant impact on the structure of agriculture and brought on substantial change in the nature of farming. Expanding farm size, increasing capitalization, and growing dependence on nonfarm inputs characterize today's modern farm, which is now so dramatically different from the small, selfsustaining unit of years past.

The changing structure of agriculture

An examination of the shifting economic composition of the farming sector provides insight into the changes taking place in production agriculture. Between the years 1960 and 1977, total farm numbers de-

clined 31.7 percent [9]. During the same interim, however, the number of farms having cash receipts more than \$40,000 (Class I and above) increased 351 percent. These larger "commercial" farms in 1977 represented 18.8 percent of the total number of farms and marketed 78.1 percent of total farm output compared to only 2.9 percent of the farms and 32.8 percent of production in 1960.

At the other end of the economic continuum, farms with less than \$5,000 in sales, representing 62.2 percent of all farms in 1960, declined to 46.5 percent of all farms [8]. This change represents an exit from the farming industry (or, for a few an expansion in size) of 1.3 million farms in only 17 years. Thus, 96 percent of the decline in farm numbers between 1960 and 1977 can be attributed to the demise and dismemberment of these "small" farms.

The obvious mathematical result, and indeed, the economic propellant of such a decline in farm numbers (with only a slight decrease in the land area devoted to farming) is an increase in the average farm size (in terms of acres per unit). The average farm size in the United States has increased from 213 acres in 1950 to 393 acres in 1977.¹ Iowa agriculture has followed approximately the same trend although more slowly. Iowa's average farm size was 206 acres per farm in 1950. It expanded to 247 acres per farm in 1973 [3].

The changing input mix of agricultural

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production

As the structure of the farming industry has evolved from a large number of small farms to a much smaller number of relatively large farms, the combination of inputs used per unit of agricultural output has also changed greatly (Table 1). Machinery has been used extensively by farmers to replace labor in the input mix, allowing farmers

¹Farm size in terms of sales per unit has increased even more dramatically during the same time period. Total cash receipts and other farm income has risen from \$8,882 per farm in 1960 to \$36,752 per farm in 1977. Part of this increase can, however, be attributed to general inflation.

Year	Crop Production Per Acre	Total Input	Farm Labor	Cropland Used For Crops	Mechanical Power and Machinery	Fertilizer, Liming, Materials & Pesticides	Number of Tractors	Total Horsepower of Tractors
				2 2 1	R R R		thousands	millions
				In	dex 1967 = 100	D		
1950	69	104	218	111	84	29	3,394	93
1955	74	105	185	111	97	39	4,345	126
1960	89	101	141	104	97	49	4,688	153
1965	100	98	110	99	94	75	4,787	176
1966	97	98	103	98	96	85	4,783	182
1967	100	100	100	100	100	100	4,786	189
1968	105	100	96	98	101	105	4,766	195
1969	106	99	93	98	101	111	4,712	199
1970	104	100	88	98	100	115	4,619	203
1971	112	100	86	100	102	124	4,584	206
1972	115	100	81	98	101	131	4,549	209
1973	116	101	80	103	105	136	4,518	212
1974	104	100	78	106	109	140	4,493	219
1975	112	100	75	108	113	127	4.469	222
1976	111	102	72	109	115	145	4.434	228
1977	116	103	70	111	116	151	4,402	232
1978	NA	NA	NA	NA	NA	NA	4,370	238

Table 1. Indices of crop production per acre, selected major farm inputs, number of tractors and total horsepower, United States, selected years, 1950-78

SOURCE: U.S. Department of Agriculture, [8].

NA: Not Available.

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to stretch their own labor over more acres and activities. The availability of ever-larger farm machines and the substantial economies of scale involved in their use has both allowed and encouraged many "family" farms to take part in the general increase in farm size.

In 1940 farmers owned \$1.8 billion worth of tractors and other farm equipment and used 20.5 billion hours of labor (Table 2). Thus, machinery assets per hour of labor in that year averaged 9 cents. By 1977, machinery investment per hour of labor averaged \$12.32.²

The capital required for machinery investment continues to be the largest non-real estate use of capital found on the balance sheet of the farming sector [7]. As an annual user of funds, machinery purchases in 1978 accounted for 54 percent of new capital formation

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and 12 percent of the total cash flow on farms [7]. Also,

the proportion of the average farmer's capital assets "tied-up" in machinery has tended to increase, in real terms, since mass farm mechanization swept the agricultural production sector during the post-World War II years. Farmers spent \$7.76 billion in 1977 for tractors

²According to the index of prices paid by farmers (1910-14 = 100), the cost of labor has risen significantly more than machinery prices over time (an index number (March 15, 1978) of 2180 for wages versus 1419 for tractors and 1293 for other machinery prices. Therefore, the dollar value (a nominal definition) to hour (a physical, "real" definition) ratio would tend to exaggerate the shift to machinery in real, physical terms of technical substitution, given neutral productivity increases in both inputs.

Table 2.	Value of tractors and other farm machinery on farms, hours
	of farm work, and machinery investment per hour of labor,
	United States, selected years, 1940-78

Year	Value of Tractors and Other Machinery on Farms	Hours of Farm Work	Machinery Investment Per Hour of Labor	
	(million dollars)	(billion hours)	(dollars)	
1940	1,840	20.5	.09	
1950	8,407	15.1	.56	
1960	15,503	9.8	1.58	
1970	24,753	5.9	4.20	
1971	26,158	5.7	4.59	
1972	27,988	5.4	5.18	
1973	30,008	5.3	5.66	
1974	34,912	5.2	6.71	
1975	44,764	5.0	8.95	
1976	53,171	4.8	11 09	

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1977	57,885	4.7	12.32
1978	62,088	NA	NA

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SOURCE: U.S. Department of Agriculture [8].

NA: Not Available.

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and other farm machinery (excluding trucks and automobiles); pushing the total value on farms to more than 57.8 billion [7]. This represents an average machinery investment of \$21,391 per farm.

The almost constant stream of scientific discoveries, innovations, and technological improvements has presented farmers the opportunity to employ new, more efficient means of increasing their output at lower unit cost. But, many of these technological developments would be of limited value to farmers without the proper equipment to prepare the land, apply the production inputs, and harvest the output in a timely manner. Thus, both directly and indirectly, the input of machinery services is assuming a larger and more important role in the agricultural production process.

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Farm machinery capacity and use over time

The inventory of major farm machines on farms (in number of individual units) has risen rapidly in the past to meet the growing demand. By 1957 there was an average of one tractor per farm in the United States. The estimated number per farm rose to 1.6 by 1970. In recent years, however, the trend toward greater numbers of farm equipment has leveled out as fewer units of larger-sized machines are providing the necessary capacity [8]. The average horsepower of tractors on farms, for instance, has been increasing rapidly (more than 3 percent per year). The average PTO horsepower of farm tractors sold in 1977 was 105, compared with 63 in 1965, only 12 years earlier [8]. Although only 4 percent of the farm tractors sold in 1963 were rated 90 horsepower or more, 44 percent of the tractors sold in 1973 were so rated. In 1977 50 percent of the tractors purchased were 100 horsepower or more. The average amount of tractor-horsepower available per acre nationwide has increased more than 600 percent since 1940 and 150 percent since 1960 (Table 3).

Farm machinery expenses and investment on farms

Machinery-related expenses, such as fuel, hired labor, and repairs, may constitute as much as 35 to 50 percent of an individual farm's operating expenses [5]. Machinery investment varies with the size and type of farm, but it can represent as much as 18 percent of the total assets (including land) on farms [10]. Some commodities are produced with more machinery-intensive methods, however. In recent years, machinery costs have been 18 percent of corn production costs. Comparable estimates for cotton, soybeans and wheat are 21 percent, 24 percent, and 24 percent, respectively [4].

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and time-consuming to conduct and analyze. It is therefore obvious that the maximum use should be made of surveys already conducted.

This report summarizes tractor data obtained from a random sample of Iowa farms conducted by the U.S. Department of Agriculture. The population samples included all farms operating 100 or more acres of cropland in 1975. The emphasis of the survey was on commercial farms.

The overall study was initiated to obtain data related to production costs of major commodities on commercial farms, but the survey also included information on the personal characteristics of farm operators and their land and machinery holdings. Analysis of some of these other farm characteristics is found in an earlier report [1]. Data collected on tractor inventories are analyzed in this report. Information related to the size and nature

of machinery holdings on farms can be of use to research and education programs directed to farmers. This information also can be useful to credit agencies, implement manufacturers and dealers, and other institutions serving agriculture.

The ERS Cost of Production Survey

As part of the Agriculture and Consumer Protection Act of 1973, Congress directed the Secretary of Agriculture to conduct studies of the cost of production for wheat, feed grains, cotton, and dairy products.⁴ As a result of this legislation, the Economic Research Service (ERS) requested additional funding for cost-ofproduction surveys. Such funds were obtained, and in early 1975 the Statistical Reporting Service conducted a comprehensive national survey involving more than 6,500 farm interviews. The survey work was directed by a special ERS cost-of-production task force.

The survey was conducted in 40 production subregions delineated to represent the major crop production areas of the United States and to include areas with similar crops and cropping practices. Name lists of farm operators were compiled from ASCS lists of farmers on record by allotment farm. Multiple "farm" operators were merged into single operations. The lists were then arrayed by county and size (in acres of cropland farmed). The congressional mandate limited the study to those farms of a "size unit that required at least one man to

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farm on a full-time basis." Thus, the farms selected for sampling ranged from a minimum of 50 acres of cropland in the Southeast to a minimum of 400 acres in the Northern Plains and the Pacific Northwest. Also, farms in counties with less than 10 percent of their total land area in cropland were excluded. The minimum amount of cropland required to be included in the Iowa sample was 100 acres [6].

⁴Section 808, Public Law 93-86, 83d Congress, Agriculture and Consumer Protection Act of 1973.

A sample larger than needed to make statistically significant regional cost of production estimates was drawn because of the possibility that the 1973 list of farm operators was not fully representative of the farms in 1974. The sample size in each subregion varied because of the number of crops produced. The total number of farms excluded in the survey totaled 2,385 or 36.6 percent of total farms sampled. The majority of this number was excluded for not meeting the minimum cropland acreage requirement.

Cost of production data from the survey were used by USDA economists to construct Firm Enterprise Data System (FEDS) enterprise budgets. From these FEDS budgets, national estimates of the cost of production of selected major crops were made by the Economic Research Service and reported to Congress [6].

The survey questionnaire data were stored on a computer tape. It was relatively easy to isolate the Iowa sample from this tape for analysis.

FEDS Areas in Iowa

Four subregions were delineated within Iowa's boundaries for the sample survey with two of these FEDS areas further divided into subareas. Within political boundaries (county and state) these areas combine, as much as possible, farming areas with similar enterprises, cropping practices, topography and soil type (Figure 1).



TM TAMA MUSCATINE Source 1977 Iowa Agricultural Statistics, Iowa Crop and Livestock Reporting Board

Figure 1. FEDS areas and principle soil association areas in Iowa.

FEDS Area 100 consists of the majority of the three western tiers of counties in Iowa. Marshal, Monona-Ida-Hamburg, and Galva-Primghar-Sac are the principal soil association areas within this FEDS Area. Notably, the area contains the second, third, and fourth leading counties in Iowa for corn acres harvested for grain in 1976. Five other counties in the area have more than 165,000 acres in corn. FEDS Area 100 also includes the five leading counties in the number of grain-fed cattle marketed.

FEDS Area 200 (subareas 201, 202, and 203) consists of a diagonal slice of counties from north central to southeastern Iowa. This area contains the highly productive Clarion-Nicollet-Webster and other soils. The area includes the five leading counties in soybean acreage and the leading county in corn acreage harvested for grain in 1976.

FEDS Area 300 (subareas 301 and 302) in northeastern Iowa is notable for its high concentration of dairy production. Four of the five leading counties in number of milk cows are in this area. The area also contains the five leading counties in hay acres (all types) harvested and three of the five leading counties in oats acreage.

FEDS Area 400 consists of approximately the southern three tiers of counties in central Iowa. More rolling and with fewer tillable acres, this area has fewer acres in corn and soybeans than the other FEDS areas. Cow-calf enterprises are numerous, however. The area has three of the leading four counties in Iowa in number of beef cows and an additional eight counties with greater than 30,000 head.

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ANALYSIS OF THE SURVEY DATA

Number of Tractors Per Farm

The Iowa farms surveyed had 1,633 tractors, giving an average of 3.25 tractors per farm. Twenty-five percent of the operators owned four tractors, 40 percent owned three, 20 percent owned two, and less than 3 percent owned only one tractor.

There was a significant positive correlation $(R = .39)^5$ between the number of tractors per farm and many variables related to farm size, such as total land operated (R = .39), cropland (R = .41), total value of tractors (R = .50), total hours of use (R = .44), and total horsepower hours of use (R = .40). Farms operating with less than 200 acres total land had an average of 2.7 tractors, while farms with 1,000 acres or more had an average of 4.1 tractors.

There was some difference in the number of tractors by FEDS area,

as shown by the following:

FEDS Area	Region of Iowa	Tractors per Farm
100	West	3.2
200	North Central	3.3
300	Northeast	3.5
400	South	2.9

⁵Note: An R value of .39 or greater gives an R² of .15 or greater, meaning that the independent variable "explains" at least 15 percent of the variance in the dependent variable. An R value of .39 or greater is significantly different from zero at the .0001 level.



Figure 2. Percentage of farms owning given number of tractors.

Tractor Size on Farms

For purposes of the survey, tractors were divided into 12 sizes as shown in Table 4. Tractors in the 25-34, 35-49 and 50-64 horsepower range were the most common, comprising respectively, 15, 26 and 19 percent of the total number of tractors on the farms surveyed. Half of the operators owned at least one tractor of 50-64 horsepower. More than half owned at least one of 35-49 horsepower, and 40 percent owned at least one of 25-34 horsepower. Ten percent of the farmers surveyed owned two or more tractors of 50-64 horsepower, 16 percent owned two or more tractors of 35-49 horsepower, and 19 percent owned two or more of 25-34 horsepower.

Table 4. Number and percentage of tractors by horsepower rating

Horsepower Rating	Horsepower Range	Number of Tractors in Iowa Sample	Percent of Total	Average Year of Manufacture
11	5-16	48	2.9	1952
12	17-24	122	7.5	1948
13	25-34	250	15.3	1953
14	35-49	428	26.2	1958
15	50-64	310	19.0	1962
16	65-79	181	11.1	1967
17	80-94	146	8.9	1969
18	95-109	84	5.1	1971
19	110-124	26	1.6	1971
20	125-154	35	2.1	1971
21	155-204	2	.1	1972
22	205+	1	.1	1973
Total		1,633	100.0 (Ave.) 1960



Horsepower Range

Figure 3. Percentage of farms owning given number of tractors of a specified horsepower range.

Tractor Age

The average year of manufacture of the tractors in the survey was 1960. Newer tractors predominated, as shown in Table 2. Forty percent of the tractors were 10 years old or less at the time of the survey, but almost one-third of the sample was more than 20 years old. The larger tractors tended to be newer while the smaller tractors were the oldest (Table 5).

Year of Manufacture	Number	Percentage of Total
1939 or earlier	21	1.3
1940-1944	61	3.7
1945-1949	140	8.6
1950-1954	293	17.9
1955-1959	202	12.4
1960-1964	252	15.4
1965-1969	337	20.6

Table 5. Number and percentage of tractors by year of manufacture

1970-1974	326	20.0
Total	1,633	99.9

The age distribution of tractors 25-34 horsepower and 35-49 horsepower, relatively smaller machines, was skewed more to the left than the overall distribution (i.e. the distribution is asymetric with the bulk of the observations less than the mean). When tractors of 25-64 horsepower are compared with those of 65 horsepower and more, the larger machines are, on the average, considerably newer than the smaller ones. Figures 4, 5, and 6 display the number of tractors of a given horsepower rating with respect to their individual year of manufacture. The figures demonstrate that the age distribution of smaller tractors tended to be more skewed to the left than the overall distribution, while that of larger tractors was skewed to the right. Machines of 35-64 horsepower had an age distribution somewhat similar to the group of tractors as a whole. The different FEDS areas had similar overall tractor age distributions.

Differences in Farm Characteristics By

Tractor Size and Number

A statistical analysis was conducted to determine possible variations in tractor size and number among farms of different sizes and among operators of different ages. Each tractor (rather than each

farm) counted as one observation, so that farm and operator characteristics were weighted by the number of tractors on a particular farm.

The results of the analysis showed that farms with at least one large tractor tended to have larger-than-average crop sales (Table 6). Crop sales increased from an average of \$69,033 among all farms with at least one tractor of 5-16 horsepower to an average of \$325,638 among those farms with at least one tractor of 125-154 horsepower. Although many farms with small tractors also had large machines and correspondingly, high crop sales, no farm with at least one <u>large</u> tractor had low crop sales.

The tractor variables seemed to follow the farm "life cycle" of operators accumulating assets in their beginning years and



Figure 4. Number of tractors by year of manufacture: all sizes and 25-35 horsepower.



Year of Manufacture

Figure 5. Number of tractors by year of manufacture: all sizes and 35-49 horsepower.



Year of Manufacture

Figure 6. Number of tractors by year of manufacture: all sizes and 50-64 horsepower.

				1		N.	Horsepow	er Range					1122.11
		5-16	17-24	25-34	35-49	50-64	65-79	80-94	95-109	110-124	125-154	155-204	205+
Age of operator ^a	(coded)	3.9	3.8	3.9	3.8	3.8	3.7	3.6	3.5	3.3	3.7	4.0	2.0
Experience of operator	(Years)	23.3	22.1	23.0	23.2	23.1	22.5	21.9	19.9	17.7	22.4	27.5	8.0
Total land operated	(acres)	397	318	369	352	418	412	503	531	596	737	745	1,450
Cropland	(acres)	298	256	298	279	342	322	420	453	515	626	695	1,341
Crop sales	(dollar)	\$69,003	\$60,212	\$72,172	\$70,172	\$94,196	\$94,618	\$109,000	\$176,497	\$257,320	\$325,638	\$79,333	\$191,000
Crop sales as percent of total sales	(percent)	72.5	72.3	73.9	72.7	73.3	73.0	76.1	75.6	74.7	78.3	100.0	72.6
Number of tractors	(no.)	3.7	3.8	3.8	3.5	3.6	3.5	3.6	3.7	3.6	4.0	5.0	4.0
Value of tractors	(dollar)	\$14,566	\$11,845	\$13,561	\$13,634	\$16,275	\$17,560	\$ 20,469	\$ 25,841	\$ 25,509	\$ 29,072	\$32,850	\$ 69,600
Total tractor hours	(hr./yr.)	1,185	1,068	1,233	1,156	1,342	1,359	1,356	1,459	1,416	1,692	1,350	1,900
Total HP hours	(hp-hr/yr.)	57,662	53,757	65,845	67,665	85,288	91,405	99,722	117,716	139,399	161,777	113,050	280,800
Average year of manufacture	(year)	1952	1948	1953	1958	1962	1967	1969	1971	1971	1971	1972	1973
Number of farms worth at least one trac-													
range		48	122	250	428	310	181	146	84	26	35	2	1

Table 6. Means of selected variables for farms having at least one tractor of given H

^aA coded variable with 3.0 equal to 35-44 years and 4.0 equal to 45-54 years.

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2.4					-

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then selling off prior to retirement. This trend can be seen by comparing the tractor numbers, ages, sizes, and use for different operator age groups (Table 7).

Table 7. Means of selected variables for farms grouped by age of operator

		Age	e of Oper	rator (y	ears)	
	< 25	25-34	35-44	45-54	55-64	65+
Number of tractors Total value of	3.0	2.8	3.4	3.4	3.3	3.0
tractors	\$12,758	\$14,401	\$16,259	\$15,742	\$13,158	\$ 9,675
Value per tractor	4,253	5,143	4,782	4,630	3,987	3,225
Total hours of use Hours of use per	1,028	1,045	1,267	1,215	1,155	790
tractor Total horsepower	343	373	373	357	350	263
hours of use Horsepower per	60,333	71,784	83,760	76,665	68,496	41,249
tractor Average year of manufacture of	59	. 69	66	63	59	52

The data on tractor value and use admittedly reflect the subjective views of the operator, but the above data definitely show a trend toward larger investment in and more intensive use of tractors by farmers in the middle age groups, particularly those in the 35-44 age group. Previous analysis indicated that operators in this age group had the largest total land areas and highest crop sales. There were no significant differences in average tractor age between different operator age groups. Table 8 compares selected farm characteristics for farms with different ranges of tractor value. There was little difference in experience between farms with total tractor value in the various ranges, but variables directly related to farm size increased dramatically with increasing tractor value. Total tractor value exhibited a high positive correlation with cropland (R = .72) and total land operated (R = .67). Cropland increased from an average of 161 acres among those farms with total tractor value of less than \$5,000 to an average of 886 acres among those farms with total tractor value of \$40,000 or more. Total land operated increased from 218 to 1,026 acres between these two tractor value groups. Average crop sales increased continuously as tractor value increased, from only \$28,534 among farms

with \$5,000 or less in tractors to \$123,780 on farms with \$20,000-\$39,999 total tractor value, to \$447,440 among those with tractors worth \$40,000 or more.

Average number of tractors per farm increased as total value of tractors per farm increased, although the increase in numbers was proportionately smaller than that in value. The result was that average value of the machines increased with total value. Farms with \$5,000 or less in total tractor value had an average of 2.4 tractors worth an estimated \$1,240 each, while farms with \$40,000 or more total value had an average of 4.6 machines worth \$10,313 each.

			Total	Value of T	ractors on Fa	arm ^a
Farm Characteristic	Unit	\$5,000	\$5,000- \$9,999	\$10,000- \$19,999	\$20,000- \$39,999	\$40,000 or more
Experience of operator	(years)	20.8	23.9	21.0	23.0	20.9
Total land operated	(acres)	218	263	353	547	1,026
Cropland	(acres)	161	201	281	457	886
Crop sales	(dollars)	\$28,534	\$43,827	\$74,053	\$123,780	\$447.440
Number of tractors	(number)	2.4	2.8	3.3	4.0	4.6
Value of tractors	(dollars)	\$ 2,976	\$ 7,275	\$14.056	\$ 25,971	\$ 47 438
Average value of tractors	(dollars)	\$ 1,240	\$ 2,598	\$ 4.259	\$ 6,493	\$ 10 313
Total hours of use	(hours)	657	908	1,119	1 580	3 567
Hours of use per tractor	(hours)	274	324	339	305	5,507
Total horsepower hours				555	202	220
of use per year	(hp hr.)	29,069	46,918	69,943	113,527	216,357
Horsepower hours per tractor per year	(hp hr.)	12,112	16,756	21,195	28,382	47.034
Average horsepower of						
tractors	(hp)	44.2	51.7	62.5	71.9	84.3
Number of observations		51	132	200	104	15

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Table 8. Means of selected farm characteristics for farms by total tractor value

^aOperator's book value.

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The farms with tractors worth less than \$5,000 averaged total use of 657 hours and tractor use of 274 hours. The farms with \$40,000 or more total tractor value averaged total use of 2,567 hours, equivalent to 558 hours per tractor. Total horsepower hours increased from 29,069 to 216,357 between the two tractor value groups, while horsepower hours per tractor went from 12,112 to 47,034 and average horsepower tractor from 44.2 to 84.3.

There were some differences in total tractor value and average value per tractor between FEDS areas (Table 9). Southern Iowa farms had considerably lower total and average tractor values than the other FEDS areas.

Table 9. Total value of tractors per farm and average book value per tractor by region

FEDS Area	Region of Iowa	Total Value of Tractors per Farm	Average Book Value per Tractor
100	Western	\$15,303	\$4,559
200	North Central	14,753	4,498
300	Northeastern	15,818	4,559
400	Southern	11,143	3,829

Significant Correlations Between Tractor

Variables and Other Farm Characteristics

There was a strong positive correlation between tractor variables and variables related to farm size (Table 10, Table 11). Total land operated was significantly correlated with number of tractors per farm

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			Total La	nd Area Pe	r Farm (Ac	res)		
Farm Characteristics	200	200-299	300-399	400-499	500-749	750-999	1000+	-
Number of tractors	2.7	3.1	3.3	3.5	3.8	4.2	4.1	
Total value of tractors per farm	\$8,426	\$10,427	\$14,088	\$17,623	\$22,022	\$25,880	\$37,008	
Average value per tractor	\$3,121	\$3,364	\$4,269	\$5,035	\$5,790	\$6,162	\$9,026	
Total hours of use per year	714	1,014	1,158	1,260	1,543	1,947	2,285	
Hours of use per tractor per year	264	327	351	360	406	464	557	
Total horsepower hours per year	36,774	56,683	69,825	85,555	112,215	126,339	182,563	
Average horsepower per tractor	52	56	60	68	73	70	80	

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nd area per farm

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Table 11. Tractor numbers, value, and use on farms by total crop sales per farm

	Total Crop Sales Per Farm							
	\$20,000	\$20,000- \$39,000	\$40,000- \$69,999	\$70,000- \$99,999	\$100,000- \$199,000	\$150,000 or more		
Number of tractors	3.0	2.9	3.3	3.3	3.8	3.9		
Total value of tractors per farm	\$6,717	\$8,904	\$13,773	\$16,276	\$20,859	\$27,940		
Average value per tractor	\$2,239	\$3,070	\$4,174	\$4,932	\$5,489	\$7,164		
Total hours of use per year	733	892	1,130	1,145	1,445	1,968		
Hours of use per tractor per year	244	308	342	347	380	505		
Total horsepower hours of use per year	34,835	48,455	69,172	74,108	96,594	150,558		
Average horsepower per tractor	48	54	61	65	67	77		

(R = .39), total value of tractors (R = .67), total hours of use (R = .49), and total horsepower hours (R = .60). These positive relation-ships are shown in Table 12.

The positive correlations between tractor variables and cropland were similar in magnitude to those between tractor variables and total land. Cropland was significantly correlated with number of tractors (R = .41), value of tractors (R = .72), total hours of use (R = .50), and total horsepower hours of use (R = .63).

The positive relationship between crop sales and tractor variables such as total value (R = .44) and total horsepower hours of use (R = .43) can be seen in Table 12.

Farms with high crop sales had larger, more valuable tractors and used them more intensively than farms with low crop sales. Farms in the less than \$20,000 crop sales category had tractors of an average size of 48 horsepower worth \$2,239 each and used an average of 244

hours. Farms with crop sales of \$150,000 or more, on the other hand, had tractors of 77 horsepower worth \$7,164 each and used 505 hours each. Not surprisingly, correlations among tractor variables were significant, as shown in Table 12. Farms with more tractors tended to have higher total tractor value, hours of use, and horsepower hours of use.

Tractor Complements on Iowa Farms

The machinery data from the cost of production survey were analyzed to determine patterns of multiple tractor complements on Iowa farms. With 12 different tractor sizes, the 502 farms surveyed

Table 12. Correlation between tracto	or variables and other
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	Age of Operator	Schooling of Operator	Experience of Operator	Off-farm work of Operator	Total Land Operated	Cropland	Land Owned by Operator
Number of tractors	.08	04	.11	17	.39a	.41a	.30
Value of tractors (\$)	09	.07	.00	17	.67ª	.72 ^a	.40a
Total hours of use Total horsepower hours	02	02	.07	23	.49 ^a	.50 ^a	.35
of use	08	.02	.00	22	.60 ^a	.63 ^a	.37
	Land	Land	Land	Crop	Livestock	Feeder	Total
	Rented	Rented	Managed	Sales	Sales	Cattle	Labor
	From	to	for			Sales	Hours
	Others	Others	Others				
Number of tractors	.19	.14	.08	.22	.17	.18	.26
Value of tractors (\$)	.41 ^a	.11	.08	.44ª	.33	.32	.36
Total hours of use Total horsepower hours	. 25	.13	.09	.33	.29	.42 ^a	.22
of use	.36	.12	.07	.43 ^a	.36	.44 ^a	.28
	Total	Grain	Fuel	Number	Value	Total	Total
	Wages	Storage	Tank	of	of	Hours	Horsepower
	Paid		Storage	Tractors	Tractors	of	Hours of
	Out		3			Use	Use
Number of tractors	.02	.32	.28	(1.00)	. 50 ^a	.44 ^a	40a
Value of tractors	.01	.52a	.60a	.50ª	(1.00)	.48 ^a	.64 ^a
Total hours of use	.00	.31	.27	.44 ^a	.48	(1.00)	.89 ^a
of use	.01	.39 ^a	.41 ^a	.40 ^a	.64 ^a	.89 ^a	(1.00)

^aDenotes R values giving an R^2 which "explains" at least 15 percent of the variance in the tractor variable.

farm characteristics

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had 257 different tractor complements. Twenty-five of these complements were common to five or more farms (i.e., 1 percent of the sample or more), and together represented 34 percent of the sample.

In an effort to better summarize the sample data, the 12 tractor sizes were merged into three power levels -- low (5-49 horsepower), medium (50-94 horsepower), and high (95-205+ horsepower). This consolidation of machinery sizes produced a dramatic reduction in the number of different tractor complements represented in the sample, from 257 to 58. Sixteen of these complements were found on 10 or more farms (ie., 2 percent of the sample or more), and in total they represented 80 percent of the farms in the sample. There were seven tractor complements which were shared by a least 5 percent of the sample. These groupings covered 282 farms, or 56 percent of the total, as shown in Table 13.

Number of tractors of various horsepower in complement			Number of farms farms	Percentage	
95-205+ horsepower	50-94 horsepower	5-49 horsepower	sample having the specified complements	of 502 farm sample	
0	1	2	76	15	
0	2	1	50	10	
0	1	1	38	8	
0	0	2	33	7	
0	1	3	33	7	
0	0	3	28	6	
0	2	2	24	5	
			282	56	

Table 13. Number and percentage of farms having most common tractor complement configurations

Clearly, the most popular tractor complements are those with two to four machines divided between utility tractors and machines for field operations. Only one of the complements listed contained more medium-powered than low-powered machines.

Tractor Complements for Different Operator

Age Groups and by Amount of Cropland

A comparison was made of tractor complements for farmers in different age brackets and with different amounts of cropland. Earlier in this publication, it was hypothesized that farmers accumulate assets as they become established and then sell these assets off as they approach retirement. It was mentioned that while the average number of tractors per farm increased and then decreased with operator age, operators probably maintained a balance between smaller utility tractors and

larger machines for field operations.

The results of the survey revealed that operators of different ages use substantially similar machinery complements. These similarities are summarized in a listing of the five most common tractor complements for operators in different age groups (Table 14). Complements with large tractors or more than one medium-sized machine were slightly more common among younger farmers than among those 45 years of age or older. At least some of the differences can be attributed to variations in farm size among operators of different ages. An

Table 14.	Comparison of most common tractor complements for opera-	
	tors indifferent age groups	

Number of tractors of various horsepower ranges in complement		Number of operators in different age groups with given tractor complement					
95-205+ HP	50-94 HP	5-49 HP	25-34 yrs.	35-44 yrs.	45-54 yrs.	55-64 yrs.	65 yrs. and over
0	0	2	7	4	9	9	4
0	0	3	2	6	8	9	3
0	1	1	8	6	10	10	3
0	1	2	13	13	26	19	5
0	1	3	3	6	13	7	2
0	2	1	8	16	13	10	1
0	2	2	2	9	8	4	1
1	1	1	6	6	4	2	0

Table 15. Comparison of most common tractor complements for farms with cropland in different ranges

Number of tractors of various horsepower ranges in complement

Number of farms in different cropland ranges with given tractor complement

				and the second se		
95-205+ HP	50-94 HP	5-49 HP	100-199 acres	200-299 acres	300-499 acres	500 acres or more
0	0	2	28	3	2	0
0	0	3	16	12	0	0
0	1	1	21	9	8	0
0	1	2	33	26	17	0
0	1	3	11	12	9	1
0	2	1	15	16	14	5
0	2	2	7	6	9	2
0	3	1	2	0	7	4
1	1	0	0	3	3	5
1	1	1	4	3	11	1
1	1	2	0	2	5	6

earlier study showed farmers aged 35-44 as having the largest operations. It is likely that farmers younger than this were still expanding, while older operators were in the process of reducing their holdings.

One would expect to find significant differences in tractor complements for farms with different amounts of cropland. Complements containing large-sized tractors (95 HP and above) should become more common as cropland per farm increases.

A breakdown of farms by area in cropland showed that this was indeed the case (Table 15). Machines rated at 95 horsepower and above figured prominently in the tractor complements of farms with 500 or more acres of cropland, but were not common on smaller operations. Only

8 percent of the smallest farms in the sample, those with 100-199 acres of cropland, had one or more tractors in the 95 horsepower or greater range. This number increased to 18 percent among farms with 200-299 acres cropland and 29 percent among those 300-499 acres. Finally, 62 percent of the largest farms, those with 500 acres or more of cropland, had at least one tractor rated at 95 horsepower or above. There was slightly more homogeneity in tractor complements among smaller farms than among larger ones (Table 16). The group of 179 farms with cropland between 100 and 199 acres had only 26 different tractor complements, while the 65 farms 500 acres or more in

size had between them 35 complements. Small operations generally

Table 16.	Number of farms and different tractor complements by	
	the amount of cropland farmed per farm	

Amount of Cropland per Farm	Number of Farms	Number of different Tractor Complements
100-199 acres	179	26
200-299 acres	128	31
300-499 acres	130	35
500 acres or more	65	34
Total	502	58 ^a

^aThe total number of different complements for the entire sample was 58.

have less choice in machinery selection than their larger counterparts. Farms with between 100 and 199 acres of cropland are unlikely to have tractors in the 95 horsepower or greater range. To take an extreme case, suppose that the farmer can form a complement

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of one, two, or three tractors from among the small and medium-sized groups. He then will have a choice of only nine different complements. In contrast, a large farm with three, four, or five tractors chosen from among all three sizes has a choice of 46 different complements.

CONCLUSIONS

The average year of manufacture of the tractors in the survey was 1960, giving an average age of 14 years for the machines. Thus, it would seem natural to speculate on the possible need for replacement tractors.

Almost one-third of the tractors in the survey were manufactured before 1955, but these were mostly small utility tractors. Forty percent of the tractors were manufactured after 1964, making them 10 years old or less at the time of the survey. Undoubtedly, it was these newer, larger tractors that were performing most of the heavy work on the farms surveyed. It would appear safe to assume that there will not be an abrupt increase in the demand for new replacement

tractors but that demand will continue at a fairly steady pace.

The results of the survey showed clearly that tractor holdings follow the farm "life cycle" hypothesis. Investment in tractors increases together with farm size as the operator becomes better established and then decreases as the farmer approaches retirement. The survey indicated no major differences in the average age of tractors of different operator age groups, the implication being that operators in different stages of the "life cycle" maintain a balance between smaller, older utility tractors and larger, newer machines.

By merging the original 12 tractor size classes into low, medium, and high power groups, 56 percent of the 502 farms in the survey were represented by only seven different multiple tractor complements. All of these complements consisted of one, two, or three low-power tractors (5-49 horsepower) and in every case except one, the same number or fewer medium-sized tractors (50-94 horsepower).6

There has been much talk of trends toward increased farm size. To the extent that these trends hold, there should be a move toward the purchase of new, large tractors. High-power tractors were found mostly on farms with the largest land areas. For example, the average land area of farms with tractors rated between 95 and 109 horsepower was 531 acres. There should also be a continued market for new utility tractors, however. At the time of the survey, fully 25 percent of the tractors of size 35-49 horsepower were less than 10 years old,

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indicating that farmers are still interested in purchasing new machines of this size.

⁶One of the seven complements consisted of two medium-sized tractors and one small tractor.





