Costs of STORING Reserve Stocks of WHEAT AT COUNTRY ELEVATORS AND ON FARMS IN KANSAS

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Country Elevators

1. With full utilization of space, average annual costs of storing reserve stocks of wheat in the hard red winter wheat area of Kansas decline from 10.21 cents a bushel for the 100,000-bushel elevator to 7.33 cents a bushel for the 700,000-bushel elevator; more than two-thirds of the total decline occurs between the 100,000- and 300,000-bushel size. (Reserve stocks are considered to be stocks stored for 1 or more years under provisions of the Federal price-support program.)

2. The cost per bushel of storage in a 100,000-bushel elevator used to capacity is 19.3 cents less than when the same elevator is used at one-fourth of capacity. Approximately 67 percent of the decrease in costs occurs by increasing utilization from 25 to 50 percent; 22 percent decrease occurs between 50 and 75 percent; and 11 percent decrease occurs between 75 and 100 percent. Proportionate decreases apply to costs for larger elevators also.

3. In contrast to the savings from using an elevator at full capacity as shown in point 2, costs are reduced 2.4 cents a bushel when storage volume is increased from 100,000 to 400,000 bushels with space fully utilized.

Farm Bins

4. In general, the annual cost per bushel of wheat stored in round steel storage units approaches a point of constancy at about 10,000 bushels after declining, at a decreasing rate, with the increase in size of storage units.

5. Costs per bushel of wheat stored in farm storage units are generally at least 50 percent higher if space is only half utilized than if it is all used; for example, the annual cost per bushel of storage for a 1,000-bushel bin used at full capacity is 8 cents, but the cost increases to about 12 cents at 50-percent utilization.

6. At 100-percent utilization, costs decrease from about 10 cents a bushel for the 2,200-bushel bin to 6.87 cents for the 13,104-bushel unit, or a cost advantage of about 3 cents a bushel for wheat stored in the large unit.

7. Costs of wheat storage are slightly higher (about one-half cent a bushel at 100-percent utilization) for the 25,000-bushel flat quonset-type storage building than for round steel bins combined to provide the same volume of storage. Many flat buildings, however, are used for purposes other than grain storage, and these benefits may outweigh the disadvantages when only costs for storing wheat are considered.

8. The unit costs of storing wheat in a 2,200-bushel farm bin, at all degrees of utilization, are higher than for any other size of bin or combination of bins. While mechanical aeration was not considered necessary for the 1,000-bushel bin, the 2,200- and the 3,276-bushel bins require aeration equipment. At full utilization of space, costs per bushel of wheat stored are 8.01 cents in a 1,000-bushel bin and 8.35 cents in a 3,276-bushel bin, but are 9.80 cents for a 2,200-bushel bin.

COSTS OF STORING RESERVE STOCKS OF WHEAT AT COUNTRY ELEVATORS AND ON FARMS IN KANSAS

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BACKGROUND OF THE STUDY

Scope of Study

This study was undertaken to make available a summary of costs incurred in storing reserve stocks[1] of wheat in several types and sizes of storage units, and to determine the economic effects of holding stocks at various positions in production areas. Its primary purpose was to aid in making decisions regarding the handling of reserve stocks over extended storage periods, taking into consideration the possibility that additional storage space may need to be built to care for large stocks of wheat.

At the time the study began, the quantity of wheat owned by the Government in connection with the price-support program was not large enough to require extensive bin-site storage.[2] For this reason records were not available on costs of storing wheat at bin sites. This report, therefore, provides information regarding costs, and factors which affect those costs, for wheat stored at two positions--country elevators and farms. Only costs of storing wheat in buildings of recent construction located in important wheat-producing areas were considered relevant to the purpose of the study.

Kansas, as one of the leading food-grain producing States, was selected for study of wheat storage costs. The project was carried out by personnel of the Kansas Agricultural Experiment Station, Manhattan, Kans.,[3] under contract with the United States Department of Agriculture, during the fiscal year July 1952 through June 1953. The Iowa Agricultural Experiment Station made a similar study on costs of storing corn during the same period (4).[4]

Inasmuch as this study was concerned with costs of storing reserve stocks of wheat, it was assumed that applicable storage conditions would be those encountered from the date in any given year at which wheat would be placed in reserve storage. This would be approximately at the end of the first storage year.

Costs and details of storage management were obtained from elevators for the last full accounting year prior to the study on storing wheat. For most elevators, the 1952 fiscal year was the year for which the information was obtained. Farm storage costs were based on estimates of constructing and equipping farm bins in 1952.

It was not practicable at the time the study began to analyze weights and grades of wheat moved in and out of storage at the elevators included in the sample; therefore, no attempt was made to measure the value of losses which might be attributed to quality deterioration and shrinkage of wheat stored in elevators. Neither is provision made in itemizing costs of farm storage for a direct study of quality deterioration. Insofar as there may be differences among the several storage facilities in extent of quality deterioration and shrinkage of stored wheat, this study does not present a complete picture of storage costs. A supplementary study dealing with quality deterioration and shrinkage is under way and will provide additional data on costs.

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[1] In this study reserve stocks refer to wheat acquired by the Commodity Credit Corporation and stored for 1 or more years under provisions of the price-support program.

[2] A bin site consists of a group of storage bins erected on sites located in areas of surplus-grain production. Usually, bin sites refer to groups of bins which are the property of the Federal Government.

[3] Contribution No. 237, Department of Agricultural Economics, Kansas Agricultural Experiment Station, Manhattan.

[4] Underlined figures in parentheses refer to Literature Cited, p. 24.

Production and Storage of Grain by Districts

Wheat considered for storage in this study was harvested in 1951, a year when production in Kansas was lower than average. Abandonment of winter wheat acreage was excessive because of an extended drought during the early growing season, as well as heavy losses resulting from particularly severe rains and floods at harvesttime. Much of the wheat land which was abandoned or flooded was later planted to grain sorghums, and a record crop was obtained from this planting.

The relative importance of wheat compared with other grains produced in Kansas, and the proportion of each grain sold as a cash crop, are shown in table 1. As indicated in the last column, it has been customary for producers to sell practically the entire wheat crop in the year of harvest.

Table 1.--Production and off-farm sales of grain, Kansas, 1951[1]

Grain	Production		Sales	
	Quantity	Percentage of total[2]	Quantity	Percentage of production
	1,000 bushels	*Percent*	*1,000 bushels*	*Percent*
Wheat	126,113	52	113,152	90
Corn	58,296	22	18,371	32
Grain sorghums	57,310	22	40,117	70
Other[3]	16,178	4	3,330	21
Total	-	100	-	-

[1] Farm Production, Farm Disposition, and Value of Principal Crops, 1951-52. (9).
[2] Production figures were converted from bushels to pounds before percentage of total was computed.
[3] Oats, barley, and rye.

The importance of the three leading grains (wheat, grain sorghums, and corn) is shown in table 2 and figure 1 for nine areas of the State for the crop year 1951. It is evident that most of the wheat crop is produced in the western and central sections, and grain sorghums in the southwestern area. Corn is of greater importance than the other two grains along the eastern border of the State--particularly in the northeastern counties where relatively little wheat is produced.

Table 2.--Production of three leading grain crops in Kansas, by crop reporting districts, 1946-50 average, annual 1951 and 1952

Crop of--	Crop reporting district									State
	1	2	3	4	5	6	7	8	9	
	Wheat									
	1,000 bu.	*1,000 bu.*	*1,000 bu.*	*1,000 bu.*	*1,000 bu.*	*1,000 bu.*	*1,000 bu.*	*1,000 bu.*	*1,000 bu.*	*1,000 bu.*
1946-50 av.	25,109	22,746	8,788	21,589	33,481	9,370	38,290	43,395	10,464	213,232
1951[1]	11,639	18,845	5,447	4,513	28,251	4,193	12,586	33,786	6,854	126,114
1952	34,274	29,498	7,343	37,363	49,431	9,300	53,581	72,274	14,565	307,629
	Corn, all purposes									
1946-50 av.	1,696	12,031	22,748	107	3,163	15,635	46	2,080	9,910	67,416
1951	3,525	13,189	13,599	500	3,751	10,454	191	3,382	9,704	58,295
1952	2,409	10,973	21,665	222	1,924	13,217	71	1,401	7,958	59,840
	Grain sorghums									
1946-50 av.	1,172	2,165	541	2,557	2,426	1,932	7,015	3,507	2,284	23,499
1951	3,724	2,211	191	12,803	4,347	825	23,711	7,534	1,964	57,310
1952	1,290	2,354	512	1,411	2,491	1,745	4,051	3,084	1,597	18,535

[1] Excessive abandonment of the wheat crop occurred in 1951 because of drought during the growing season and floods during harvesttime. Much of the abandoned wheat land was planted to grain sorghums.

Facilities for handling and storing grain in Kansas reflect the production pattern shown in figure 1. Country elevators are concentrated largely in areas where it is the practice for farmers to haul wheat directly from farm to elevator at harvesttime, a period of several weeks. Storage has been a relatively minor part of country elevator business as most elevators act as receiving houses for wheat and ship it to terminal elevators or mills where it may be held in storage until needed. It has been reported that only 6 percent of the gross income of 48 farmers' elevators in Kansas is derived from storage operations (1). It has not been customary to provide off-farm storage

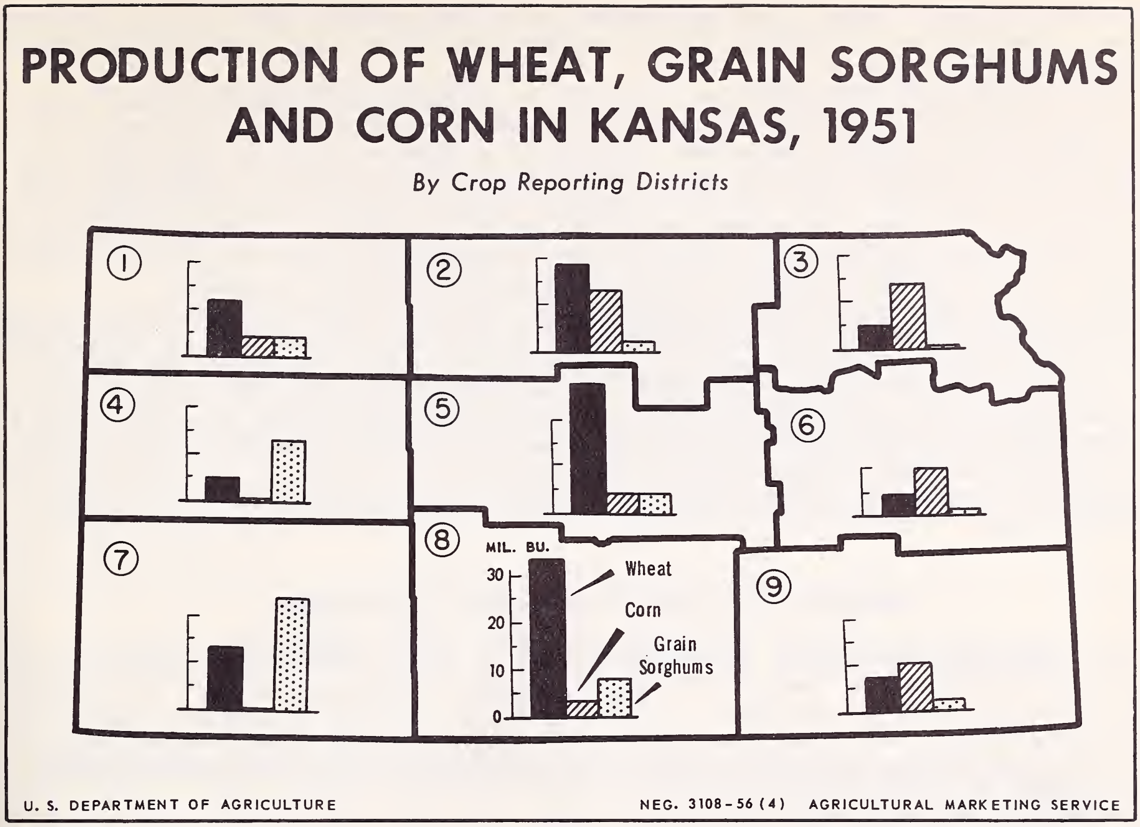

Figure 1

space for corn or grain sorghums as most of these grains are fed to livestock on farms. However, in the period studied, stocks of corn and grain sorghums were larger than usual, and Government storage bins were erected in surplus production areas to hold stocks of these grains acquired under the price-support program.

Price-Support Program

The Federal Government owned very small quantities of wheat at the time this study was made, but it has acquired sizable stocks since 1952 under a program designed to support farm prices. As this study is concerned primarily with costs of storing reserve stocks of wheat, a brief review is given of conditions under which the Government acquires wheat for storage.

Prices are supported by the Commodity Credit Corporation through nonrecourse loans to producers on wheat stored on farms or in warehouses and through the purchase of wheat delivered by farmers under purchase agreements. In years when the market price fails to rise above the support price, a considerable part of the crop may be included in the support program.[5] Loans and purchase agreements are available to producers from harvesttime through January 31 of the year following harvest. The maturity date for loans in Kansas usually is March 31.

If the producer chooses to deliver his wheat or turn over his purchase contract rather than repay the loan at maturity, the Government takes title to the grain. The quantity acquired depends upon the market price--if it is lower than the guaranteed loan price, the producer will usually turn the wheat over to CCC at the maturity date and

[5] Twenty-two percent of the 1951 crop of wheat was placed under the support program, 35 percent of the 1952 crop, 48 percent of the 1953 crop and 44 percent of the 1954 crop (10).

keep the amount of the loan. If the market price is above the loan value at any time during the period the loan is in effect, he may choose to sell his wheat at the higher market price and repay the loan.

Wheat acquired by CCC is stored in elevators insofar as space is available. If the quantity of wheat held by the Government exceeds the amount of commercial space which can be obtained for storage, there are two methods used to care for the excess. First, the Government may erect storage bins on sites leased from property owners and keep the wheat in storage until such time as it appears that its sale by CCC will not depress market prices. Capacities of the bin sites vary greatly. In Kansas in 1951, there were from 2 to 170 bins at a site with capacity of bins ranging from 3,250 bushels to 40,000 bushels. (The bin most commonly erected has a capacity of 3,250 bushels.)

The second method provides for extending the loan and "resealing" the grain in farm bins, and thus the grain is held on the producer's farm for a second year or more. The Government makes a storage payment for grains held on a farm under the reseal program, and the farmer assumes the risk of any loss in quality during the storage period.

Grain placed in elevators by CCC is under the management of the elevator. Grain stored at bin sites is under the direct supervision of the Agricultural Stabilization and Conservation Committee of the county in which the bin site is located; bins and grain are subject to periodic inspection, and any damage to the commodity becomes a loss to the Government.

COST OF STORAGE IN COUNTRY ELEVATORS

The long-term aspects of a study dealing with the storage of reserve stocks of wheat led to a decision to confine analysis of costs of storage to country elevators of concrete construction. Data are not available on country elevator storage capacity in Kansas by type of construction, but, from observation, it is estimated that 70 percent was of reinforced concrete at the time of this study. Recent grain elevator construction has been predominantly of reinforced concrete.

Practically no new elevators in western Kansas are of wood, but during an earlier period numerous small wooden elevators were constructed in the area. Many of these old structures remain and will be used as receiving houses as long as serviceable, but they are impractical in a long-term storage program, because of their small storage space. Also, it is difficult to control rodents and insects in wooden structures.

A few upright steel and concrete-stave elevators are in the area. Future expansion in these types of construction cannot be ruled out, but at the time of this study such elevators were few and relatively small. Current trends in construction indicate that they will continue to comprise a negligible proportion of commercial storage capacity. In a reserve storage program it is apparent that reliance would be primarily on reinforced concrete structures.

In general, a uniform pattern of plant layout, equipment, and work processes is used for concrete elevators. Except for increases in size and speed of operation, elevator equipment for handling grain has not been changed appreciably in recent years. In one important respect, this characteristic of country elevators tends to simplify cost analysis as it reduces the necessity of considering the influence of these factors on cost. It may be considered that technology is uniform among elevators, especially in a study confined to recent years.

The Sample

The area under study was limited to the section of Kansas producing hard red winter wheat, or approximately the western two-thirds of the State. There were 1,070 country elevators in the area in 1951. Of these, 884 had a capacity of less than 95,000 bushels each. This group was eliminated from the study because they were relatively old wooden structures or were too small for consideration in a long-range storage program. Thus, 186 elevators qualified from the standpoint of capacity and type of construction. Of these, 98 had suitable records and had constructed major storage facilities during 1942-51.

This group of 98 elevators was stratified into four broad size groups, and a sample consisting of 22 elevators was selected at random from the four strata, as follows:

Capacity (Thousand bushels)	Number of elevators
95-174	5
175-274	6
275-499	6
500 and over	5
Total	22

The number selected in each stratum was proportional to the total number of elevators in the stratum (3).

The sample comprised approximately 25 percent of the elevators that qualified in type of construction, capacity, time of construction, and availability of records, or 12 percent of all elevators in the area that were deemed to be large enough for a long-range storage program.

Figure 2 shows the geographical distribution of the sample elevators. Their location corresponds roughly to the area of Kansas with the heaviest production of hard red winter wheat. (See figure 1.)

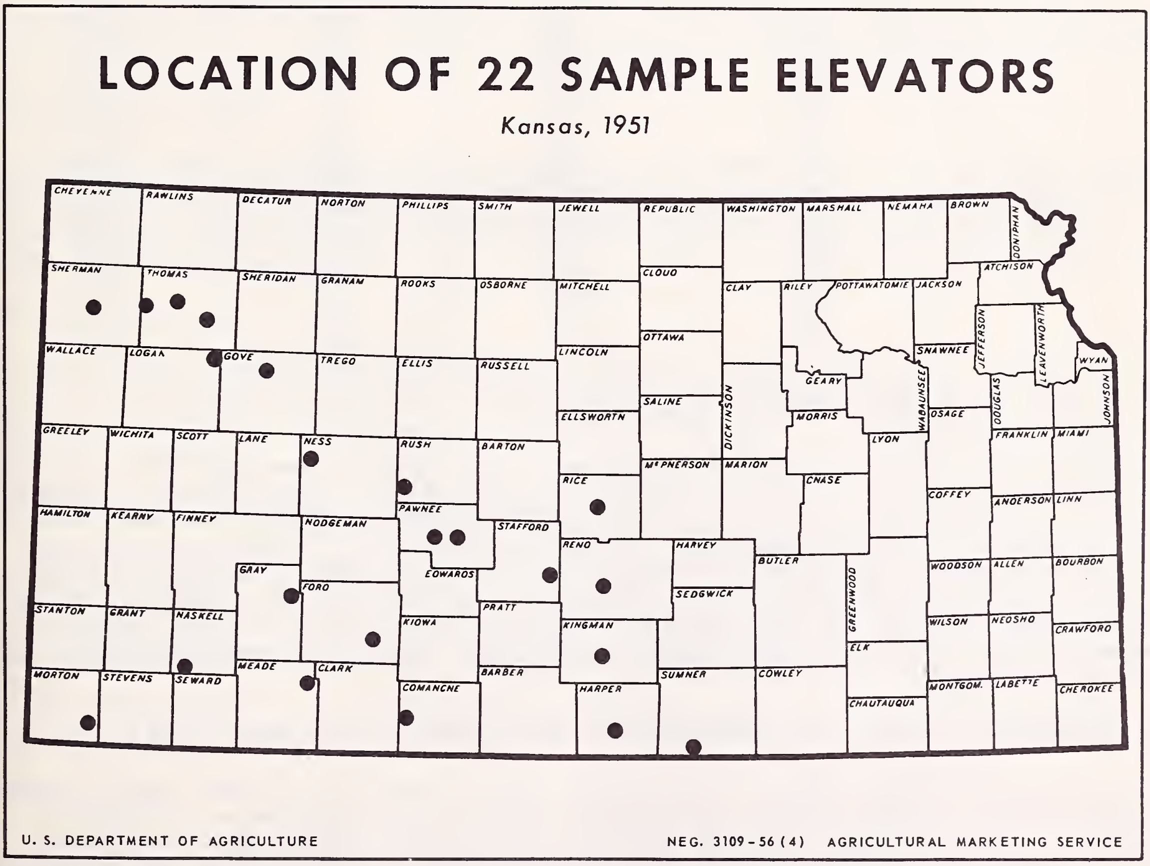

Figure 2

Source of Data

Information on volume and costs was obtained by personal interview and inspection of office records. The primary source of cost data was the annual audit. Data on volume of grain handled and stored were obtained from inventory records of cash purchases, receipts for storage, purchases from storage, shipments for storage and sale, and local sales. Records were obtained from each elevator for the fiscal year which included the harvesting of the 1951 wheat crop.

Allocation of Costs

All elevators in the sample stored grain. In addition, all of the elevators merchandised grain, and all except three supplied customers with sideline commodities. Grain merchandising consisted of buying grain from producers and selling it on either central or local markets. Sideline operations consisted of selling such commodities as feed, coal, hardware, and petroleum products to local customers.

In this study, it was necessary to allocate costs, so as to attribute to storage only those costs associated with this particular function. Table 3 shows total costs obtained from records of the 22 sample elevators, and amounts allocated to each of the three functions according to methods explained below.

Table 3.--Total observed costs and allocation by function, 22 country elevators, Kansas, 1951[1]

Elevator	Costs by function[2]			Total costs[2]
	Storage	Grain merchandising	Sidelines	
	Dollars	*Dollars*	*Dollars*	*Dollars*
1.	5,100	4,600	11,500	21,200
2.	4,800	2,800	2,600	10,300
3.	4,400	3,100	2,900	10,400
4.	6,800	6,800	10,800	24,400
5.	11,700	7,500	32,700	51,900
6.	9,600	12,600	([3])	22,200
7.	8,700	7,800	([3])	16,500
8.	6,900	7,800	3,000	17,700
9.	8,700	7,100	9,300	25,100
10.	12,300	9,100	5,000	26,300
11.	10,800	5,100	4,000	19,900
12.	19,700	4,100	([3])	23,800
13.	16,600	6,400	30,100	53,200
14.	15,000	5,700	11,900	32,600
15.	15,300	8,800	2,400	26,500
16.	19,300	8,600	110,400	138,200
17.	15,900	18,800	15,700	50,400
18.	33,200	12,100	8,400	53,600
19.	22,000	9,700	53,700	85,500
20.	31,600	12,600	51,100	95,400
21.	25,400	5,400	14,500	45,300
22.	27,800	13,100	17,300	58,200

[1] Does not include allowance for interest on investment.
[2] Costs have been rounded to nearest $100, and individual items may not add to total.
[3] These elevators did no sideline business.

Primary information for allocation purposes was obtained by personal interview and by examination of elevator records. Allocation to sidelines was made with the assistance of elevator managers during the interviews. The remaining costs were distributed between storage and grain merchandising. In most elevators, costs of storage and grain merchandising were of a joint nature. The primary criterion used in this allocation was the proportional use made of equipment, buildings, and labor in performing each of the functions. Data for such determinations were obtained from records of grain merchandised and stored, utilization of buildings and equipment, records of labor utilization, and managers' estimates.

DEPRECIATION, TAXES, AND INSURANCE ON BUILDINGS AND EQUIPMENT

Relative similarity in type of construction, time of construction, and in plant layout and organization tended to produce uniformity in investment in building and equipment. Therefore, costs associated with investments, such as depreciation, taxes, and insurance on buildings and equipment, were taken directly from plant records without adjustment. Allocation to storage was based on the proportional use of buildings and equipment for storage operations.

INTEREST ON INVESTMENT

Interest on investment was calculated and allowed as a cost. Basis for this calculation was average depreciated value at a rate of 5 percent. Average depreciated value over the life of an investment was taken to be one-half of original cost. The proportion allocated was based on proportional use of buildings and equipment for storage purposes.

WAGES AND SALARIES

Amounts paid for wages and salaries were obtained from payroll records. Estimates also were obtained of labor utilization in various functions. Wages and salaries were allocated between storage and merchandising on the basis of proportional use of labor for these functions.

ELECTRICITY

Cost of electricity was allocated between storage and grain merchandising on the basis of proportional use of electrically driven equipment for the two functions.

MAINTENANCE AND REPAIR

Costs of maintenance and repairs were obtained from records and were allocated between storage and grain merchandising in accordance with proportional use of buildings and equipment.

INSURANCE ON GRAIN

Recorded amounts paid for grain insurance were found to give an erroneous cost for quantities stored in some elevators because various systems of prepayment and subsequent refund or credit did not always allow reconciliation within a given accounting period. To adjust for this error actual insurance rates were applied to the average monthly inventory of storage stock.

INSECT CONTROL

Only about one-half of the sample elevators recorded separately their costs of insect control. Investigation revealed that, during the time observations were made, insect control was confined to storage stocks. Therefore, the entire recorded amount was allocated to storage.

SHRINKAGE AND DETERIORATION IN QUALITY

Because of the inadequacy of data on actual shrinkage and costs associated with deterioration in quality, these items were not included in this analysis. Elevator records contained no allowance for losses from deterioration in quality. It is known that from time to time some such losses have occurred, but the extent and frequency are not known.

In some instances, an estimated shrinkage allowance was made by elevators, but this was made primarily for tax accounting purposes. Although the allowance may have been based somewhat on previous experience, it was not presented as an accurate measure of actual shrinkage.

OTHER COSTS

Such items as fees, bonds, and licenses were classified as fixed costs and allocated between storage and grain merchandising on the same proportional basis as building utilization.

Items such as office and elevator supplies, travel, telephone, and telegraph expense were classified as variable costs and arbitrarily allocated between storage and grain merchandising on the same basis as labor utilization and cost of electricity.

Relationships Between Storage Costs and Factors Which Affect Such Costs

In order that information obtained from sample elevators might be used to estimate storage costs for other elevators and for periods other than the one covered by the study, it was necessary to isolate factors causing variations in storage cost and to determine the degree to which total costs were affected by such factors. Multiple regression analysis was used for this purpose. (See appendix A.)

The dependent variable in the regression formula was total annual storage cost or that value for which an estimate was desired so that costs might be compared in various types of facilities. The independent variables, or those factors which determine storage costs, were selected on the basis of theoretical considerations and observations made during the study. Type of material used for construction purposes, which ordinarily would have an influence on storage costs, was eliminated as a factor by restricting the sample to elevators of concrete construction. Two other variables expected to influence costs were size of elevator and degree of utilization of capacity.

Observations indicated the possibility of cost variations arising among sample elevators from rotation, or turnover, of storage stocks. Since rotation of stocks involves physical handling of the grain, it was presumed that some cost variation among sample plants might arise from this factor. Therefore, the quantity put in storage and the quantity taken out of storage during the period of observation were taken as additional independent variables. Thus, four measurements of volume were considered as independent variables in determining the multiple regression equation: (1) Size of elevator, i.e. technical capacity in bushels, (2) degree of utilization (which can be measured either in number of bushels stored, or in bushel space of unused capacity), (3) number of bushels put in storage, and (4) number of bushels taken out of storage. Values of these four variables for the sample elevators are shown in table 4.

Table 4.--Total annual costs of storage, size of elevator, unused capacity, quantity put in storage, and quantity taken out of storage, 22 country elevators, Kansas, 1951

Elevator	Total annual storage cost[1]	Size of elevator	Unused capacity	Quantity put in storage	Quantity taken out of storage
	Dollars	*Bushels*	*Bushels*	*Bushels*	*Bushels*
1	6,100	96,000	52,000	105,000	126,100
2	5,800	114,000	49,400	64,000	111,400
3	5,400	150,000	114,600	43,700	40,600
4	8,000	150,000	67,400	173,900	118,700
5	13,300	150,000	70,700	100,900	165,000
6	11,000	200,000	125,000	223,000	199,900
7	9,900	200,000	117,800	89,300	85,000
8	8,500	200,000	149,000	112,800	208,000
9	10,800	254,000	188,000	196,600	115,700
10	14,100	265,000	115,600	141,100	309,100
11	13,800	265,000	119,000	190,700	203,700
12	23,600	280,000	34,400	107,000	238,000
13	20,100	280,000	66,300	436,200	351,400
14	18,200	300,000	99,900	238,000	246,200
15	17,800	350,000	150,500	450,100	879,800
16	23,300	420,000	60,000	758,300	459,100
17	19,200	480,000	386,500	258,800	496,900
18	37,600	500,000	271,700	218,500	243,300
19	25,800	525,000	272,100	245,000	623,300
20	36,200	563,000	292,200	350,600	309,400
21	31,500	607,000	218,300	339,600	576,200
22	33,800	850,000	526,300	554,200	601,200

[1] Includes interest on investment.

The dependent variable, annual storage cost, may be expressed either as total cost or as average cost per bushel stored. However, fewer complications are encountered in fitting an equation to total costs.[6] Total cost can be readily converted to average cost by dividing total cost by the number of bushels stored.

[6] This arises from the nature of the functions involved. Theoretical considerations indicate that total costs may be expected to increase with increases in degree of utilization. Total cost would logically be expected to increase in either a linear form or at a decreasing rate. In either case, a function could be fitted relatively easily. On the other hand, average costs would be expected to approach infinity as degree of utilization approached zero. As degree of utilization increases, average costs ordinarily are expected to decrease rapidly, level off rather sharply, and remain fairly constant over a considerable range in output. An equation for this type of function is more complicated than that visualized for total costs. Total cost, therefore, was selected as the dependent variable.

Solution of the regression equation[7] by the method of least squares indicated that two of the variables, bushels placed in storage and bushels taken out of storage, were nonsignificant in explaining variations in total costs and consequently were dropped from the equation. A new equation was calculated, using only size of elevator and unused capacity as independent variables. This equation[8] was used to estimate total storage costs for 7 elevators with capacities ranging from 100,000 to 700,000 bushels, when storage space is utilized at 100, 75, 50, and 25 percent of capacity.

Total Storage Cost as Influenced by Size of Elevator and Degree of Utilization

At any given percentage of capacity utilization, increases in total annual costs of storage, as determined by the estimating equation, were proportionately less than increases in size of elevators (table 5). For example, total storage cost for the 100,000-bushel elevator used at full capacity was $8,680 in 1951, and the total storage cost for the 700,000-bushel elevator at full capacity was $49,120. Whereas size of elevator increased 7 times, total storage cost increased 5 1/2 times.

Table 5.--Total annual storage costs by size of elevator and degree of utilization, country elevators, Kansas, 1951[1]

Size of elevator	Total annual storage cost at 4 degrees of capacity utilization[2]			
	100 percent	75 percent	50 percent	25 percent
Bushels	*Dollars*	*Dollars*	*Dollars*	*Dollars*
100,000	8,680	7,880	7,070	6,270
200,000	15,420	13,770	12,110	10,460
300,000	22,160	19,560	16,960	14,360
400,000	28,900	25,400	21,910	18,410
500,000	35,640	31,200	26,760	22,320
600,000	42,380	36,990	31,610	26,220
700,000	49,120	42,790	36,460	30,130

[1] Total costs as determined by estimating equation (3). See Appendix A.
[2] Costs have been rounded to nearest $10.

Table 5 also shows that total storage costs did not decrease proportionately with decreases in degree of utilization. Total storage costs were $35,640 for the 500,000-bushel elevator used at full capacity, and $26,760 for the same size elevator used at 50 percent capacity. Whereas degree of utilization was halved, total storage costs declined only about one-fourth. For an elevator of a given size, changes in total costs, associated with changes in degree of utilization, reflect changes in variable costs. (By definition, fixed costs remain the same at all degrees of utilization.)

Table 6 shows average inventory (or bushels stored) together with unused capacity for 7 sizes of elevators utilized at 4 degrees of capacity. The actual bushels which can be stored are less than the technical capacity expressed as "size" of elevator because elevator operators reserve some space for turning grain. The proportion of total space reserved for this purpose decreases as the size of elevator increases. (See appendix A, p. 25).

Average annual costs per bushel of storing wheat in elevators of various sizes were obtained by dividing total costs (table 5) by the actual bushels stored in elevators when utilized at the 4 degrees of capacity (table 6). Results of these calculations are shown in table 7. Figure 3 also illustrates storage costs for elevators utilized at 100-, 75-, 50- and 25-percent of capacity.

Costs per bushel of wheat stored increase with each decrease in degree of capacity utilization, but these increases are proportionately greater at the lower degrees of utilization. Approximately 67 percent of the total increase in storage costs which occurs if utilization is reduced from 100 to 25 percent of capacity is found between the 25- and 50-percent levels; 22 percent of the increase is found between the 50- and 75-percent levels; and 11 percent between 75-percent and full utilization.

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[7] Equation (2), Appendix A.
[8] Equation (3), Appendix A.

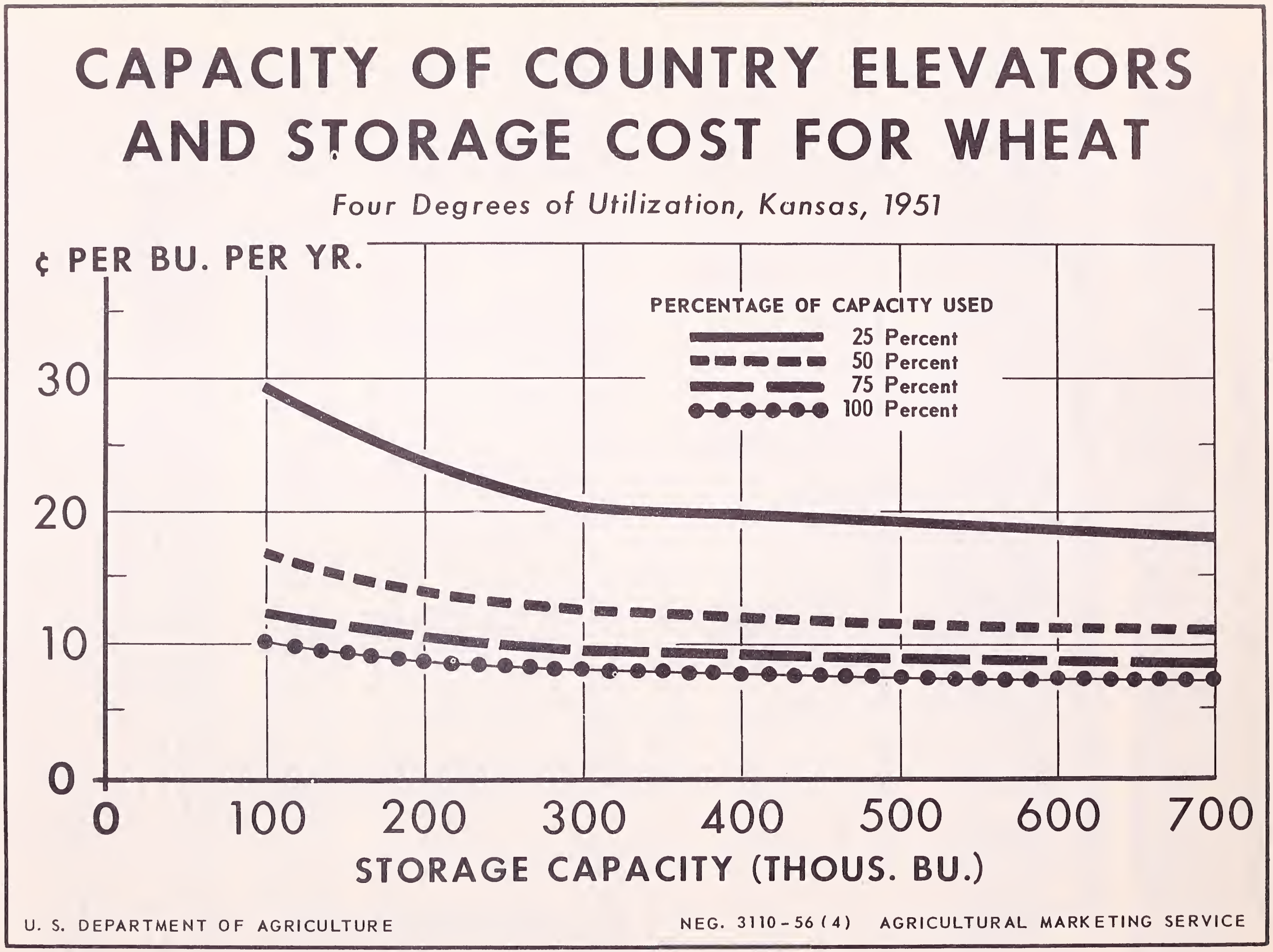
CAPACITY OF COUNTRY ELEVATORS AND STORAGE COST FOR WHEAT
Four Degrees of Utilization, Kansas, 1951
¢ PER BU. PER YR.
30
20
10
0
PERCENTAGE OF CAPACITY USED
25 Percent
50 Percent
75 Percent
100 Percent
0
100
200
300
400
500
600
700
STORAGE CAPACITY (THOUS. BU.)
U. S. DEPARTMENT OF AGRICULTURE
NEG. 3110-56 (4)
AGRICULTURAL MARKETING SERVICE

Figure 3

Table 6. --Average inventory and unused capacity by size of elevator and degree of utilization, country elevators, Kansas[1]

Size of elevator, average inventory, and unused capacity	Degree of utilization			
	100 percent	75 percent	50 percent	25 percent
	Bushels	*Bushels*	*Bushels*	*Bushels*
100,000 bushels:				
Average inventory	85,000	63,750	42,500	21,250
Unused capacity	0	21,250	42,500	63,750
200,000 bushels:				
Average inventory	175,000	131,250	87,500	43,750
Unused capacity	0	43,750	87,500	131,250
300,000 bushels:				
Average inventory	275,000	206,250	137,500	68,750
Unused capacity	0	68,750	137,500	206,250
400,000 bushels:				
Average inventory	370,000	277,500	185,000	92,500
Unused capacity	0	92,500	185,000	277,500
500,000 bushels:				
Average inventory	470,000	352,500	235,000	117,500
Unused capacity	0	117,500	235,000	352,500
600,000 bushels:				
Average inventory	570,000	427,500	285,000	142,500
Unused capacity	0	142,500	285,000	427,500
700,000 bushels:				
Average inventory	670,000	502,500	335,000	167,500
Unused capacity	0	167,500	335,000	502,500

[1] Size indicates technical capacity of elevator whereas average inventory indicates the number of bushels stored. Average inventory and unused capacity are determined after allowing space for turning wheat.

Table 7. --Average annual storage costs per bushel by size of elevator and degree of utilization, country elevators, Kansas, 1951

Size of elevator	Average annual storage cost per bushel at 4 degrees of capacity utilization			
	100 percent	75 percent	50 percent	25 percent
	Cents	*Cents*	*Cents*	*Cents*
100,000 bushels	10.21	12.36	16.65	29.51
200,000 bushels	8.81	10.49	13.84	23.91
300,000 bushels	8.06	9.48	12.34	20.89
400,000 bushels	7.81	9.16	11.84	19.90
500,000 bushels	7.58	8.85	11.39	18.99
600,000 bushels	7.44	8.65	11.09	18.40
700,000 bushels	7.33	8.52	10.88	17.99

Total Storage Cost as Influenced by Scale of Storage Operation

Cost data given in table 7 were used to develop short-run average cost curves for 7 sizes of elevators with storage space utilized at 100, 75, 50, and 25 percent of capacity (figure 4). The points representing costs at the 4 degrees of utilization were connected under the assumption that intermediate points on each curve would approximate costs at various degrees of utilization for elevators of the 7 sizes studied. In general, each short-run average cost curve illustrates changes in costs of storage which result from variation in rate of utilization of elevators of the 7 sizes. (A different short-run cost curve might be drawn for each different size of elevator possible.) The economy-of-scale curve shown in figure 4 connects the lowest points of the 7 short-run average cost curves.

The economy-of-scale curve shows the lowest cost of storage for each possible storage volume, provided size of elevator and rate of utilization are coordinated to obtain the most efficient results. The point on each short-run curve which lies on the economy-of-scale curve represents the one volume which an elevator of corresponding size can store with greater efficiency than any other size of elevator. (See appendix B). The economy-of-scale curve may be considered as a planning curve in that, if an individual were erecting a new elevator or if he were contemplating a change in an existing elevator, he could ascertain with this information the optimum size, in terms of least cost per unit, for any anticipated volume of business.

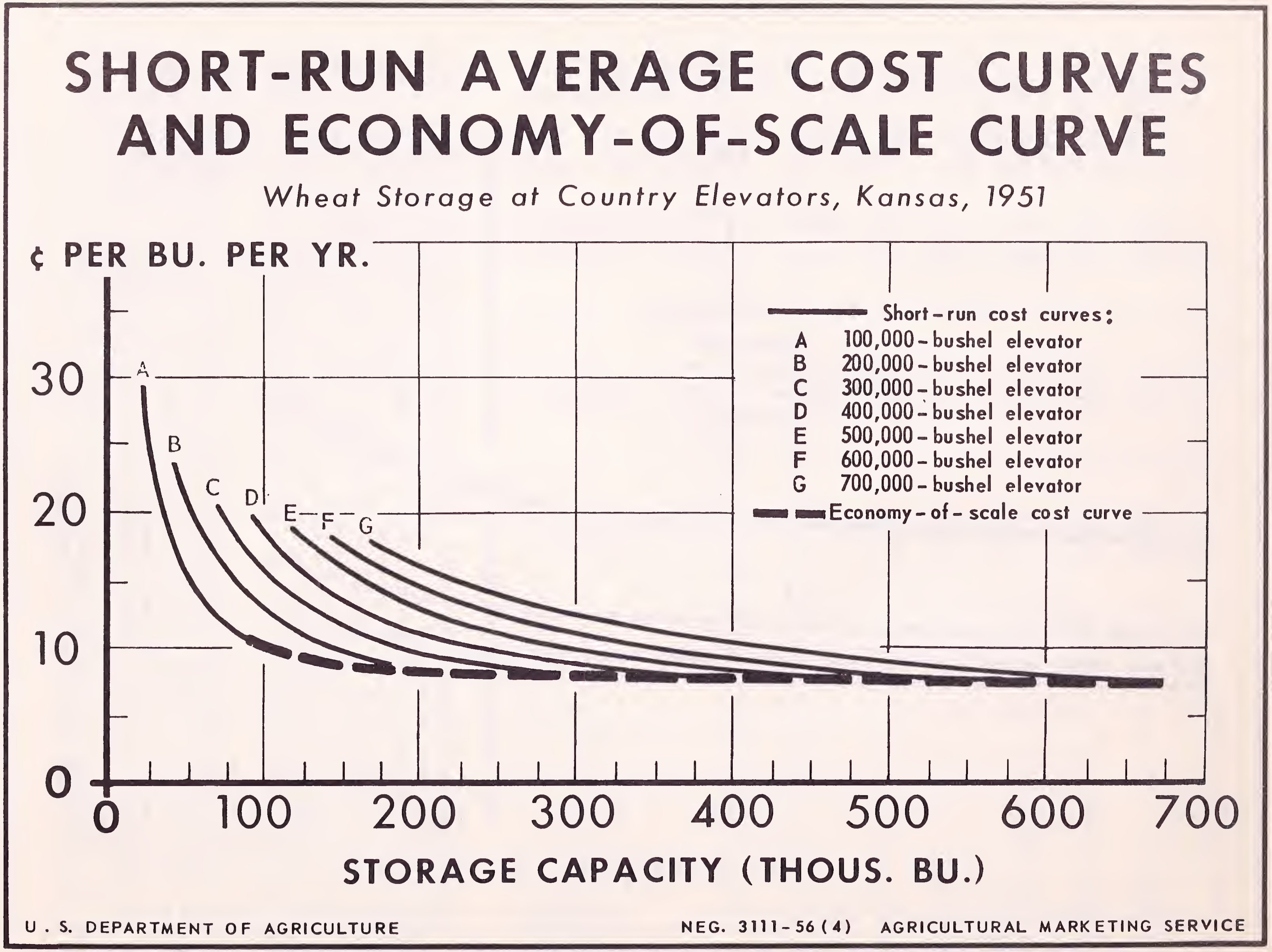
SHORT-RUN AVERAGE COST CURVES
AND ECONOMY-OF-SCALE CURVE
Wheat Storage at Country Elevators, Kansas, 1951
¢ PER BU. PER YR.
30
20
10
0
A
B
C
D
E
F
G
Short-run cost curves;
A 100,000-bushel elevator
B 200,000-bushel elevator
C 300,000-bushel elevator
D 400,000-bushel elevator
E 500,000-bushel elevator
F 600,000-bushel elevator
G 700,000-bushel elevator
Economy-of-scale cost curve
0
100
200
300
400
500
600
700
STORAGE CAPACITY (THOUS. BU.)
U. S. DEPARTMENT OF AGRICULTURE
NEG. 3111-56 (4)
AGRICULTURAL MARKETING SERVICE

Figure 4

It is apparent from the economy-of-scale curve that average costs of storage decline with increases in size of elevator. The curve indicates that costs decline from 10.21 cents a bushel for the 100,000-bushel elevator to 7.33 cents a bushel for the 700,000-bushel elevator--a decrease of almost 3 cents a bushel. The rate of decline is faster for the smaller sizes. Slightly more than two-thirds of the total decline occurred between the 100,000-bushel size and the 300,000-bushel size. Costs declined only about one-half cent a bushel from the 400,000-bushel size to the 700,000-bushel size.

The degree to which capacity is utilized has a pronounced influence on storage costs (table 7 and fig. 4). For the 100,000-bushel elevator, costs were 29.51 cents a bushel at 25-percent utilization, in comparison with 16.65 cents at 50-percent utilization, 12.36 cents at 75-percent utilization, and 10.21 at full utilization. Storage in this size of elevator filled to capacity cost 19.3 cents less a bushel than when the elevator was filled to one-fourth of capacity. For the 700,000-bushel elevator a corresponding decline of 10.66 cents a bushel was indicated. It is evident that economies which might be obtained by using a given size of elevator at full capacity rather than at 25 percent of capacity overshadow economies of scale associated with increases in capacity. The nature of short-run average costs for a given size of elevator reflects the influence of both fixed and variable costs in relation to number of bushels stored. Whereas unit costs for the 700,000-bushel elevator declined about 7 cents when utilization was increased from 25 to 50 percent, a corresponding increase in utilization from 50 percent to 75 percent of capacity was associated with a decline of about 2 1/4 cents; increasing utilization from 75 to 100 percent of capacity was associated with an additional decline of about 1 cent a bushel.

These same relationships often are presented as the influence of unused capacity on average costs. This is simply the inverse of degree of utilization as used in this study. For example, 25 percent utilization of capacity is equivalent to 75-percent unused capacity. It is apparent that an increase in unused capacity results in substantially higher average costs.

These data illustrate the importance of fully utilizing existing facilities. However, in any storage program it may be assumed that storage facilities will be operated at something less than capacity part of the time. To accomplish the functions of storage, grain would move out of storage at times and into storage at other times. This study indicates that in 1951 the larger country elevators in the hard red winter wheat area of Kansas could store wheat at any given degree of utilization at less cost than the relatively small country elevators. The cost advantage in larger elevators becomes progressively greater as percentage of capacity utilized declines.

The influence of size of elevator on storage costs at less than full utilization also is shown in table 7 and figure 3. At 50-percent utilization, for example, costs declined from 16.65 cents a bushel for the 100,000-bushel elevator to 10.88 cents a bushel for the 700,000-bushel elevator--a decrease of almost 6 cents a bushel. At 25-percent utilization the decline over the same capacity range was about 11 1/2 cents. If it were assumed that, over the long-run, storage facilities in reserve operations would be used at about one-half of capacity, economies that might be gained from relatively large country elevators would be greater than is indicated from the conventional economy-of-scale curve shown in figure 4.

It is recognized that considerations other than cost may be important factors in the selection of most appropriate size of elevator. Such factors were not considered in this study which dealt only with costs incurred in storing reserve stocks of wheat over a period of several years.

COST OF STORAGE ON FARMS

Several methods are available to determine costs of storing reserve stocks of wheat on farms and to investigate the relationship between costs and the scale of operation and degree of utilization. Most of these approaches depend to a large extent on the availability of records on costs of storage. However, farmers seldom keep such records in detail. This is especially true for wheat as wheat usually has moved from the farm to market soon after harvest.

Because of limitations of other methods of studying costs, it was decided to use budgetary analysis to obtain farm storage costs. It was possible, in planning this study, to consult with agricultural engineers familiar with conditions in wheat-producing areas to obtain considerable technical data and to draw upon the cost experience and experiments of experts in numerous fields. The budget approach, therefore, appeared to provide the closest approximation to actual costs incurred in storing wheat on farms.

Types and Sizes of Storage Units and Equipment

Three major types of farm bin construction are commonly used in Kansas. These are wood bins, round galvanized steel bins, and quonset-type or flat storage buildings of prefabricated metal construction.

Wood bins were excluded from this study as they appear to be impractical for long-term reserve stock storage. Original investment in wood bins is substantially greater than for any other type of construction per bushel of storage capacity.[9] In addition, recent trends in grain sanitation limit their use for storage of grain over any extended period. Control of insects, rodents, and birds is difficult and would be more costly than in the other types of structures.

On the basis of general usage in Kansas and apparent adaptability to long-range use, two types of bin construction were considered in this study--round galvanized steel bins and a quonset-type metal building. While it is possible to construct storage units with a tremendous range in volume by various combinations of steel bins of different sizes, for purposes of this study five different volumes were used: (1) 1,000 bushels, (2) 2,200 bushels, (3) 3,276 bushels, (4) 6,552 bushels (two 3,276-bushel bins), and (5) 13,104 bushels (four 3,276-bushel bins). Costs were also computed for a 25,000-bushel quonset-type structure.[10]

Volumes of storage units were selected by determining the most prevalent quantity of wheat produced on farms of various sizes and the more common quantities of wheat placed under price-support loans in Kansas. Observed trends in construction were also taken into consideration. In smaller units, size of bins is fairly well standardized by manufacturers.

Typical equipment for farm storage of wheat is not readily adaptable to gradations in size of storage units. For example, the hand sprayer commonly used for fumigation of round steel bins has a capacity of 3 1/2 gallons. Smaller sizes could be obtained at a slightly lower cost. However, since an important consideration in applying fumigant is that the job be done quickly so that chance of injury is reduced, it appeared feasible to make provision for the larger hand sprayer with which to apply the fumigation materials in steel bins of all volumes studied.

Equipment used for aerating round steel bins consists of a system of perforated metal tubes inserted vertically in the grain with a small electric fan connected to the tubes in such a manner as to exhaust air from the bin. In the flat storage building, a tunnel made of concrete blocks and planks covered with window screen is constructed in the center of the building. An exhaust fan driven by a 3-horsepower motor is attached to the tunnel opening on the outside of the building. This installation is semipermanent in that it does not have to be reinstalled each time the building is used. It is assumed that grain which has been in storage prior to the time it would be taken over, as anticipated in this study of reserve stocks, would be quite dry. Therefore, the aeration equipment provided for in this study is not considered to be a grain-drying unit. Aeration equipment is provided only to prevent moisture migration and condensation that would take place within the mass of stored grain with temperature changes.

Similar aeration equipment was provided for both the 2,200-bushel and the 3,276-bushel bins. No aeration equipment was included for the 1,000-bushel bin as it was not customary to aerate this small volume of grain by mechanical means.

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[9] Estimates of agricultural engineers at Kansas State College indicate that the building investment cost per bushel, including construction costs for a 1,000-bushel capacity wood bin, is 65 to 70 cents per bushel. For a 5,000-bushel bin the estimate is 70 to 80 cents per bushel.

[10] For comparative purposes costs were obtained for round steel bins having a combined volume of 25,132 bushels (seven 3,276-bushel bins and one 2,200-bushel bin). See table 12.

Determination of Costs

Technical information on structural and aeration specifications and power requirements was obtained from agricultural engineers of the Kansas Agricultural Experiment Station and Extension Service; from the Agricultural Engineering Research Branch, Agricultural Research Service; and from private industrial sources. Entomological information was obtained from personnel and publications of the Kansas Agricultural Experiment Station and Extension Service; from the Biological Sciences Branch, Marketing Research Division, Agricultural Marketing Service; and from manufacturers of fumigants. Also, in collaboration with technicians, it was determined what structural conditions were deemed necessary to give reasonable assurance of the maintenance of quality in farm structures.

In addition to obtaining technical information, it was necessary to determine such matters as depreciation and labor requirements for the various operations. In the absence of specific studies on these problems, information was obtained from persons who had personal experience in performing such operations. In this respect, the study relied largely upon estimates.

DEPRECIATION

The annual depreciation rate was considered as 5 percent of investment in buildings and 10 percent of investment in equipment. This depreciation rate exceeds that recommended by building manufacturers and agricultural engineers, but it includes estimated costs for maintenance and repair. This industry accounting practice eliminated a separate repair and maintenance account without affecting total operating expenses. It is especially important in a reserve stock program that the grain be held in storage bins that are maintained in the best condition at all times. Therefore, repairs and maintenance are assumed to be fixed costs, rather than variable costs. The amount included for repair and maintenance was estimated at approximately one-third of the depreciation cost item. This amount would permit necessary repairs or replacements before depreciation of the building would reach proportions that would necessitate including spoilage of grain as a cost item.

INTEREST ON INVESTMENT

An annual charge of 5 percent of average investment was made. Average investment is considered to be one-half the original cost of the buildings and equipment.

TAXES ON BUILDINGS AND EQUIPMENT

The annual charge was $1.05 per $100 of average investment, which is typical of taxes levied on real estate in Kansas in recent years (8). One-half the full value was used so as to reflect a longer range situation in which the values of the buildings decline from full value to zero value over the life of the buildings.[11]

INSURANCE ON BUILDINGS AND EQUIPMENT

The annual charge for fire and extended coverage insurance on buildings was $1.22 per $100 of average investment. The rate was determined by the Kansas Inspection Bureau, a regulatory commission that maintains uniformity and control of Kansas insurance rates. Insurance on equipment included fire, extended coverage, and theft. The annual charge on equipment was 52 cents per $100 of average investment.

LABOR

Labor required to fumigate and aerate round steel bins was established for various sizes of bins and degrees of utilization according to estimates made by entomologists and

[11] This corresponds closely with data which indicate that the tax rate on farm property is approximately 30 mills on assessed valuation and that assessed valuation is approximately 30 percent to 40 percent of full value. (6)

agricultural engineers. Labor charges assigned to costs of elevating grain include an estimate of the time required to haul each load to market as well as actual loading time. The 1,000-bushel bin was considered to be loaded out by hand. For all other storage units, it was assumed that an auger would be used for this purpose; actual operating time was determined for the equipment and then doubled to provide for starting, moving, and adjusting the machinery. All time was calculated at the rate of $1 an hour.

ELECTRICITY

No provision was made for power equipment for the 1,000-bushel bin. The power consumption rates for elevating and aerating the wheat in larger bins at the three rates of utilization were established according to operating schedules recommended by agricultural engineers.

FUMIGATION

The fumigant recommended by entomologists was carbon tetrachloride-carbon disulphide (80/20 percent), which was applied to the bins twice a year at the rate of 2 gallons of fumigant per 1,000 bushels of wheat. The cost of the fumigant was based upon prevailing retail prices. It was considered that the flat storage building would be fumigated by professional personnel at a custom rate of 1 cent per bushel, but that the farmer would apply the fumigant to other storage bins.

TAXES AND INSURANCE ON GRAIN

Grain on farms in Kansas is taxed only in the year produced. If it is stored on the farm, no additional tax is applied in subsequent years. Since this study is concerned only with wheat stored after the first year no grain tax applies. The annual insurance charge was 52 cents per $100 valuation and included fire and extended coverage insurance.

INSPECTION

No inspection expense was allocated in this farm study as the facilities selected, plus the entomological control and aeration programs, were designed to maintain quality. The cost of these programs reflects what would otherwise be allocated to inspection.

EXTRA HAULING AND HANDLING

No charge was made for filling bins as it was assumed that the wheat would be in the bin at the beginning of the storage period under consideration. Costs for loading out bins and for extra hauling were included in elevation charges as provided in labor and electricity items.

Degree of Utilization

Experience indicates that utilization of storage capacity influences unit costs of storage to a marked degree. An indication of these relationships was obtained by budgeting costs for each size of storage structure at three different degrees of utilization of capacity--100, 75, and 50 percent. These degrees of utilization were selected somewhat arbitrarily. However, there is some evidence that farmers ordinarily use their available storage space at considerably less than 100 percent of capacity.[12]

Investments in Buildings and Equipment

Table 8 presents original costs for buildings and equipment used to store wheat in farm bins of various volume combinations. Table 9 shows the investment per bushel of storage capacity computed from the original cost data. Per unit costs range from nearly 35 cents to 58 cents a bushel, with the highest cost listed for the 2,200-bushel bin. Invest-

[12] Where and How Much Cash Grain Storage for Oklahoma Farmers (5) reported that farmers surveyed used 41 percent of available storage capacity.

Table 8.--Original cost of buildings and equipment for farm storage of several volumes

Cost	Original cost of buildings and equipment					
	Round steel bins					Flat storage 25,000 bu.
	1,000 bu.	2,200 bu.	3,276 bu.	6,552 bu.	13,104 bu.	
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Original investment:						
Building	429	789	1,058	2,117	4,234	7,500
Equipment	12	490	490	543	750	1,184
Total	441	1,279	1,548	2,660	4,984	8,684

Table 9.--Investment per bushel of storage capacity for farm bins

Cost item	Investment per bushel of capacity					
	Round steel bins					Flat storage 25,000 bu.
	1,000 bu.	2,200 bu.	3,276 bu.	6,552 bu.	13,104 bu.	
	Cents	Cents	Cents	Cents	Cents	Cents
Building	42.89	35.88	32.31	32.31	32.31	30.00
Equipment:						
Hand sprayer	1.25	0.57	0.38	0.19	0.10	-
Conveyor	-	19.27	12.94	6.47	3.24	1.70
Aeration	-	2.43	1.63	1.63	1.63	3.04
Total equipment cost	1.25	22.27	14.95	8.29	4.97	4.74
Total	44.14	58.15	47.26	40.60	37.28	34.74

ment in the conveyor is largely responsible for the high cost for the 2,200-bushel bins since it alone amounts to 19 cents a bushel, or approximately one-third of the entire investment. When the investment in the conveyor is divided among a larger number of bushels, the cost per bushel declines substantially. In the 13,104-bushel unit, it amounts to about 3 1/4 cents per bushel. In the 25,000-bushel flat storage unit, it is slightly less than 2 cents.

Relation of Costs to Storage Capacity and Utilization of Space

Table 10 shows the computed annual fixed, variable, and total storage costs of farm bins used at 100, 75, and 50 percent of capacity. In this computation total fixed costs were constant for all three utilization rates. However, variable costs were computed for the three rates because such cost items vary according to the volume of wheat stored in each bin or group of bins.

Table 11 and figure 5 show annual per bushel costs of storage obtained by dividing storage costs in table 10 by the related storage volumes. To the extent that the budgeted results indicate the magnitude of cost per bushel of wheat stored, these results may be compared with costs of storage in other positions, such as elevators.

In the analysis of fixed and variable costs, three characteristics of the bins were considered: (1) Type of construction, (2) capacity, and (3) utilization of capacity. As previously noted, feasible types of construction were narrowed to two. Actually, all the storage units considered, except the 25,000-bushel flat storage unit, are round steel bins; therefore, volume and utilization are the only relevant variables which affect costs throughout the range of storage most intensively studied, that is, up to about 13,000 bushels. The effect of size of storage unit upon storage costs is indicated by budgeting costs for various sizes of structures, and the influence of utilization rates on storage costs is shown by budgeting costs for each size of storage unit at 50, 75, and 100 percent of capacity utilization.

FIXED COSTS

Fixed costs are those costs that are not influenced by degree of use of the storage unit. Inspection of table 10 indicates the relative importance of the various components

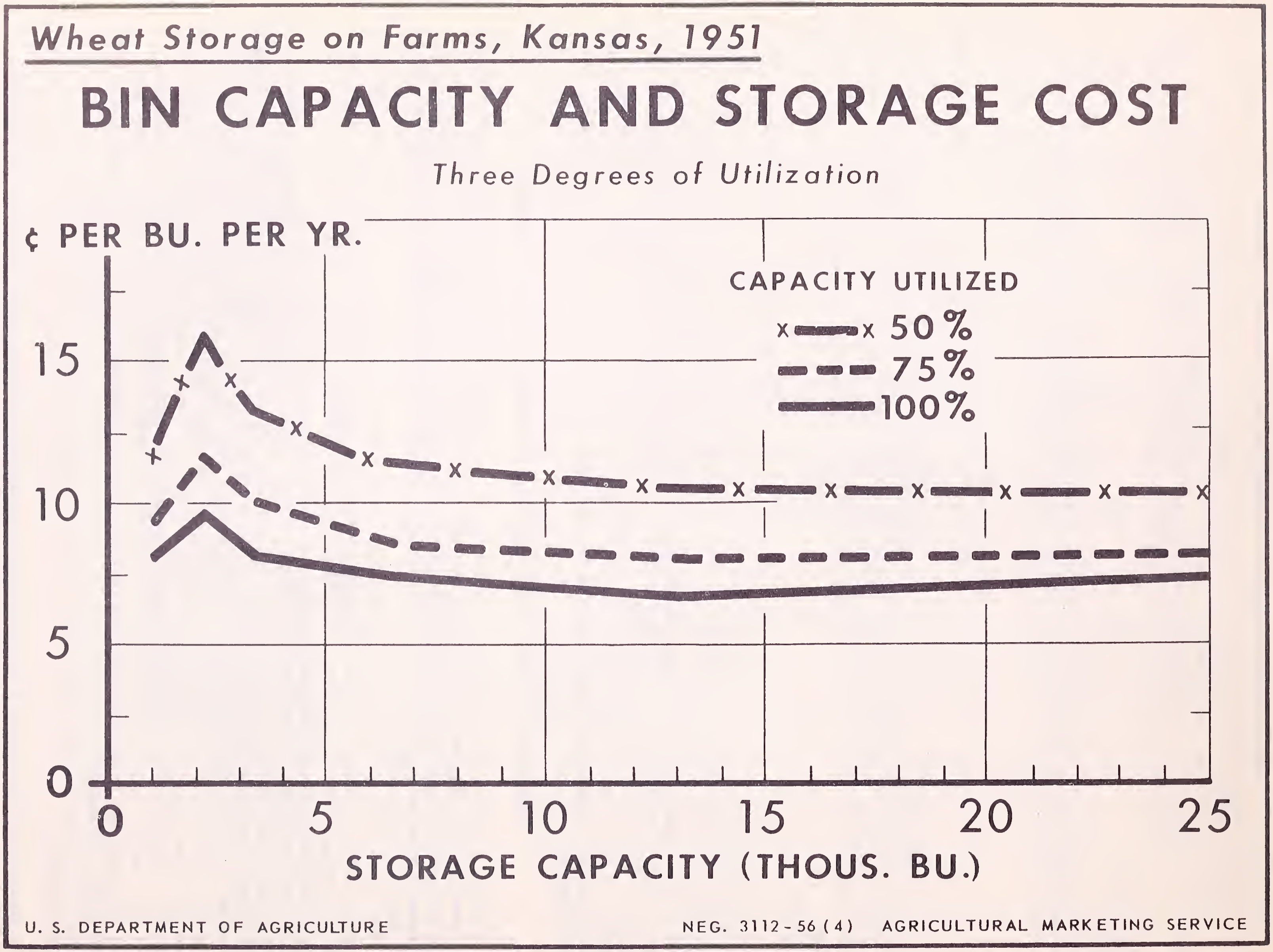
Wheat Storage on Farms, Kansas, 1951
BIN CAPACITY AND STORAGE COST
Three Degrees of Utilization
¢ PER BU. PER YR.
CAPACITY UTILIZED
50%
75%
100%
0
5
10
15
20
25
STORAGE CAPACITY (THOUS. BU.)
U. S. DEPARTMENT OF AGRICULTURE
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Figure 5

Table 10.--Fixed, variable, and total annual storage costs for farm bins of various storage volumes, utilized at 100, 75, and 50 percent of capacity

Cost item and degree of utilization	Annual storage costs in--					
	Round steel bins					Flat storage bin--25,000 bu.
	1,000 bu.	2,200 bu.	3,276 bu.	6,552 bu.	13,104 bu.	
Fixed costs:	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Depreciation	22.69	88.47	101.92	160.19	276.73	493.44
Insurance	2.64	6.09	7.73	14.34	27.53	48.83
Interest on investment	11.03	31.99	38.71	66.51	122.11	217.11
Property taxes	2.31	6.72	8.13	13.96	25.65	45.59
Total fixed costs	38.67	133.27	156.49	255.00	452.02	804.97
Variable costs:						
Insurance (grain):						
100 percent	10.40	22.88	34.07	68.14	136.28	260.00
75 percent	7.80	17.16	25.55	51.11	102.21	195.00
50 percent	5.20	11.44	17.03	34.07	68.14	130.00
Aeration:						
100 percent	0	11.20	13.20	25.40	45.80	52.40
75 percent	0	8.90	10.90	19.80	35.60	26.70
50 percent	0	6.60	8.60	13.20	23.40	13.60
Fumigation:						
100 percent	15.10	30.98	45.67	91.32	169.38	500.00
75 percent	11.04	23.24	34.25	68.51	123.84	375.00
50 percent	7.36	15.49	22.84	45.67	91.32	250.00
Loading out:						
100 percent	16.00	17.18	24.24	48.48	96.96	186.80
75 percent	12.00	12.89	18.18	36.36	72.72	140.10
50 percent	8.00	8.59	12.12	24.24	48.48	93.40
Total variable costs:						
100 percent	41.50	82.24	117.18	233.34	448.42	999.20
75 percent	30.84	62.19	88.88	175.78	334.37	736.80
50 percent	20.56	42.12	60.59	117.18	231.34	487.00
Total costs:						
100 percent	80.17	215.51	273.67	488.34	900.44	1,804.17
75 percent	69.51	195.46	245.37	430.78	786.39	1,541.77
50 percent	59.23	175.39	217.08	372.18	683.36	1,291.97

Table 11.--Annual storage costs per bushel for farm storage units of various sizes, utilized at 100, 75, and 50 percent of capacity

Cost item and degree of utilization	Annual per bushel storage costs in--					
	Round steel bins					Flat storage bin--25,000 bu.
	1,000 bu.	2,200 bu.	3,276 bu.	6,552 bu.	13,104 bu.	
Fixed costs:	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*
100 percent	3.86	6.06	4.78	3.89	3.45	3.22
75 percent	5.16	8.08	6.37	5.18	4.60	4.29
50 percent	7.74	12.11	9.55	7.79	6.89	6.44
Variable costs:						
100 percent	4.15	3.74	3.57	3.55	3.42	4.00
75 percent	4.11	3.77	3.64	3.57	3.40	3.93
50 percent	4.11	3.83	3.70	3.57	3.52	3.90
Total costs:						
100 percent	8.01	9.80	8.35	7.44	6.87	7.22
75 percent	9.27	11.85	10.01	8.75	8.00	8.22
50 percent	11.85	15.94	13.25	11.36	10.41	10.34

of fixed costs. It is evident that depreciation is the major item--accounting for more than one-half of total fixed costs in all bins. Interest is the next most important fixed cost, amounting to about one-fourth of total fixed costs. Taxes and insurance on buildings and equipment are roughly equal in amount and in most cases are about one-tenth of total fixed costs.

For a storage unit of any given size total fixed costs remain the same, regardless of use. Therefore, the greater the degree of utilization the less will be the average fixed cost per bushel stored. The decrease is directly proportional to increases in degree of utilization, as is shown in table 11. At 50-percent utilization, fixed costs per bushel for the 1,000-bushel bin are 7.74 cents and at 100-percent utilization these are halved. This same relationship holds for a storage unit of each size.

The relationship of unused capacity to average fixed costs is clearly illustrated in table 11. For example, 3,276 bushels of wheat could be stored either in a fully utilized bin of that capacity, or in the 6,552-bushel unit utilized at 50 percent of capacity. In the first instance average fixed costs would be 4.78 cents per bushel; in the latter, 7.79 cents.

The effect of type of structure on costs was determined by calculating a budget for a storage unit composed of round steel bins comparable in size to the 25,000-bushel flat storage building. This storage unit was considered to be seven of the 3,276-bushel bins and one 2,200-bushel bin, which, combined, would have a total capacity of 25,132 bushels. Average fixed costs per bushel for this unit are slightly higher than for the flat storage building at all degrees of utilization (tables 11 and 12). However, the difference is relatively small, with the maximum difference about one-tenth of a cent at 50-percent utilization. Type of construction has little appreciable influence on fixed costs for this size storage unit.

Table 12.--Costs of storing wheat in 25,132-bushel storage units composed of round steel bins, by degree of utilization[1]

Degree of utilization of capacity	Total annual costs			Average annual per bushel cost		
	Fixed	Variable	Total	Fixed	Variable	Total
Percent	*Dollars*	*Dollars*	*Dollars*	*Cents*	*Cents*	*Cents*
100	822.77	854.98	1,677.75	3.27	3.40	6.67
75	822.77	640.66	1,463.43	4.36	3.40	7.76
50	822.77	435.93	1,258.70	6.55	3.47	10.02

[1] A 25,132-bushel storage unit is composed of seven 3,276-bushel bins and one 2,200-bushel bin.

Note: This summary of costs was calculated to allow a comparison of costs between this unit and a unit of comparable size in a different type of structure (that is, the 25,000-bushel flat storage building). See tables 10 and 11.

Influence of investment in equipment shows up clearly in table 11. Very little equipment is included in the 1,000-bushel unit. In the 2,200-bushel unit a conveyor and aeration equipment are added and, as a consequence, the annual fixed costs per bushel of wheat stored increased substantially in comparison to the 1,000-bushel unit. However, after the point is reached at which such equipment is considered practical (2,200 bushels), economies can be gained by using it in connection with larger storage units. This is true for any given degree of utilization of existing storage capacity. The data indicate that the decline in average fixed costs is at a decreasing rate and that most economies have been obtained at 13,104 bushels.

VARIABLE COSTS

Variable costs are those that, for any given size storage unit, vary in total amount with the degree of utilization--that is, with the actual number of bushels stored in that unit.

Variable costs were combined in table 10 in a way to show the proportionate amounts used for grain insurance, and for aeration, fumigation, and loading-out costs. A breakdown of costs by size of storage unit, for 100-percent, 75-percent, and 50-percent utilization, is given.

Table 10 indicates that, with one exception, the major item of variable expense is cost of fumigation. (The exception is loading-out charges for the 1,000-bushel bin. For this size of bin, loading out was a proportionately greater expense than fumigation at all degrees of utilization. Use of hand labor in loading out accounts for a large part of the difference.) In general, fumigation costs amounted to nearly two-fifths of the total variable costs. However, the proportion between fumigation costs in the round steel bins and fumigation costs in the flat storage building varied substantially. Fumigation costs amounted to approximately 38 percent of total variable costs in round bins and about 50 percent in the flat building. The different techniques used for fumigating the various types of bins account for much of this difference in costs (page 16).

Insurance on grain amounted to slightly more than one-fourth of total variable costs. Costs for loading out the wheat were about one-fifth of variable costs, with the exception of the 1,000-bushel bin as already noted. (In the 1,000-bushel bin costs for loading out amounted to almost 39 percent.)

In storage units in which aeration was provided, a considerable variation is noted in its relative importance among the variable costs. Aeration costs were from 2.6 percent to 5.3 percent of total variable costs for the flat storage building, and from 10 to 16 percent for round steel bins, depending upon the degree of utilization. Labor requirements for aeration of the different types of buildings largely account for this difference. With round steel bins it is necessary to set up the equipment each time the bins are used.

Grain insurance, which is based on the dollar valuation of grain, remains constant on a unit basis with varying degrees of utilization of a storage unit. This is also true for loading-out costs under the plan of estimating requirements used in this study.

Inspection of table 11 indicates that there is a tendency toward decreasing unit variable costs as utilization of a given capacity approaches 100 percent. However, exceptions are noted in the 25,000-bushel flat storage unit, and in the 1,000-bushel and the 13,104-bushel steel bins; in all units the relative change is small. There is also a tendency for variable costs for any given degree of utilization to decrease as size of storage unit increases, up to the 25,000-bushel flat storage unit. Economies are traceable directly to saving in purchasing fumigant in larger quantities and in labor requirements for aeration.

Variable costs for the 25,000-bushel flat storage building are higher than for the 25,132-bushel round steel bin unit. The difference is about one-half cent per bushel at all degrees of utilization. (See tables 11 and 12.) Apparently the difference is due to type of structure, as average variable costs of the 25,132-bushel unit of round bins maintain the tendency toward decreasing costs evident in the smaller units of round bins, while variable costs for the flat building rise. However, the amount of the decrease from the 13,104-bushel unit to the 25,132-bushel unit is very slight in the case of steel bins and economies are almost exhausted at approximately 13,000 bushels of capacity.

It is difficult to evaluate the significance of the difference in variable costs attributed to type of structure. Average aeration costs are less in the flat building than in round bins, and other variable costs are essentially the same regardless of type of structure. One factor that contributes to higher variable costs in the flat storage building is cost of fumigation, since the estimated custom rate is higher per bushel than if bins are fumigated by farmers. If farmers themselves could satisfactorily fumigate or treat grain in the flat building, unit variable costs in this type of structure would probably be about equal to a comparable size storage unit of round bins.[13]

Cost of "loading out" bins, as used here, is equivalent to "extra handling" in some studies. Under other circumstances it would also be feasible to include cost of loading grain into the bins, but in this study costs include only those incurred after the take-over date when CCC would come into possession of the grain under a price-support program. In such case, the grain would already be in the bin.

Another cost sometimes included in similar studies is extra hauling which is attributed to farm storage. Evidence on hand appears to be insufficient to warrant the conclusion that under present circumstances extra hauling would be involved. It is not sufficient to assume that extra hauling would be involved except where the farm bins were located directly on the route of travel from the point at which grain is harvested to the point at which it is delivered to an elevator. In many instances congested conditions at elevators at harvesttime cause some farmers to haul to neighboring elevators, thereby hauling farther than if they had stored the grain on the farm at harvest and delivered it to the nearby elevator later. Extra hauling was not considered in this study because of lack of definite knowledge on this point, together with some conflicting opinions.

TOTAL COSTS

Total annual costs of storage vary directly with degree of utilization and with size of storage unit (table 10). As determined in this study, total annual costs of storage ranged from $59.23 for the 1,000-bushel bin used at 50 percent of capacity to $1,804.17 for the 25,000-bushel flat building used at 100 percent of capacity. These figures indicate the magnitude of the financial burden in storing wheat on farms under various conditions, but average annual costs per bushel of wheat stored are more meaningful for most comparative purposes.

[13] In recent years wheat protectants have been developed which may take the place of fumigation of wheat in farm structures.

Economies of Scale in Farm Storage

From the data developed in table 11 showing the relationship between costs of storage and degree of utilization of space, short-run cost curves were drawn (figure 6) for six sizes of farm storage units. Each curve was derived from 3 points which represent 100-, 75-, and 50-percent utilization of each storage volume. These 3 points were connected so that the resulting continuous curve would approximate intermediate degrees of utilization for each of the 6 units. The short-run cost curves derived for farm bins ended in the declining phase of a theoretical cost curve for the reasons discussed in appendix B (page 29).

An economy-of-scale cost curve was drawn tangent to the low point of the individual short-run cost curves to indicate the lowest cost of storage for each possible storage volume up to 25,000 bushels. As in the curve prepared for elevators, the economy-of-scale curve for farm bins represents costs at full utilization of storage capacity. In general, this curve indicates that annual costs per bushel of stored wheat decline with increases in size of storage units, but the decline is at a decreasing rate and appears to be about constant from 10,000 bushels to 20,000 bushels. A slight increase in costs is apparent as volume approaches 25,000 bushels.

The question arises as to whether the increase in costs is due to size of storage unit or to type of structure, for the 25,000-bushel storage unit is a flat storage building while the others are round bins. From the data presented in tables 11 and 12 it appears that the decreasing costs, apparent up to and including the 13,104-bushel unit, would continue with the larger unit of round bins, but at a diminished rate. At 50-percent utilization the difference in total annual cost between the flat building and the round bin unit of comparable size is about one-third of a cent per bushel--at 100-percent utilization the difference is about one-half cent. (Reasons for the difference were discussed under variable costs.) From a theoretical standpoint the storage unit in use would be the one in which various factors of production could be most efficiently combined (that is, at least cost) to store a given quantity of wheat. This would mean that for storage at approximately the 25,000-bushel level, as calculated in this study, round steel bins would be used in preference to flat buildings, for costs are lower in round bins.

Even a casual observation of actual conditions shows that many flat quonset-type buildings are being used on farms. It is possible that some farmers are not entirely aware of the costs involved in grain storage. On the other hand, flat farm buildings are used for many purposes other than grain storage. These benefits may outweigh disadvantages encountered when only costs for wheat storage are studied. It is fairly well established also that farmers do not now engage professional fumigation personnel to treat wheat stored in the flat buildings. This study visualizes a long-range storage program in which it is deemed advisable to provide for professional fumigation of these buildings.

It will be noted that the short-run cost curve for the single 1,000-bushel bin in figure 6 does not conform to the theoretical pattern. It is below the general projection of the economy-of-scale curve at the lower end of the size range. As explained previously, this is due largely to the condition that allows storage of a relatively small quantity of wheat without aeration equipment or a mechanical conveyor. The addition of mechanical equipment to the next larger unit (2,200-bushel bin) increases its fixed cost substantially and raises its cost curve.

Data in table 11 emphasize the cost effect of maintaining unused storage space on a farm. For example, the annual cost per bushel for the 1,000-bushel bin used at 100 percent of capacity is 8 cents. If this bin is only half utilized, unit cost increases about 50 percent, that is, to about 12 cents a bushel. This approximate relationship holds generally for each size of storage unit studied.

Size of storage unit also is important in determining costs. When only round bins are considered, costs decrease from 8 cents a bushel to about 6-2/3 cents a bushel when size increases from 1,000 bushels to 25,132 bushels and capacity is fully utilized (tables 11 and 12). The decrease is even more pronounced if the initial point of reference is the 2,200-bushel bin. In this instance costs decrease more than 3 cents a bushel as size increases, that is, from 9.8 cents to 6.67 cents. The decline is also about the same proportionately at 75-percent and 50-percent utilization.

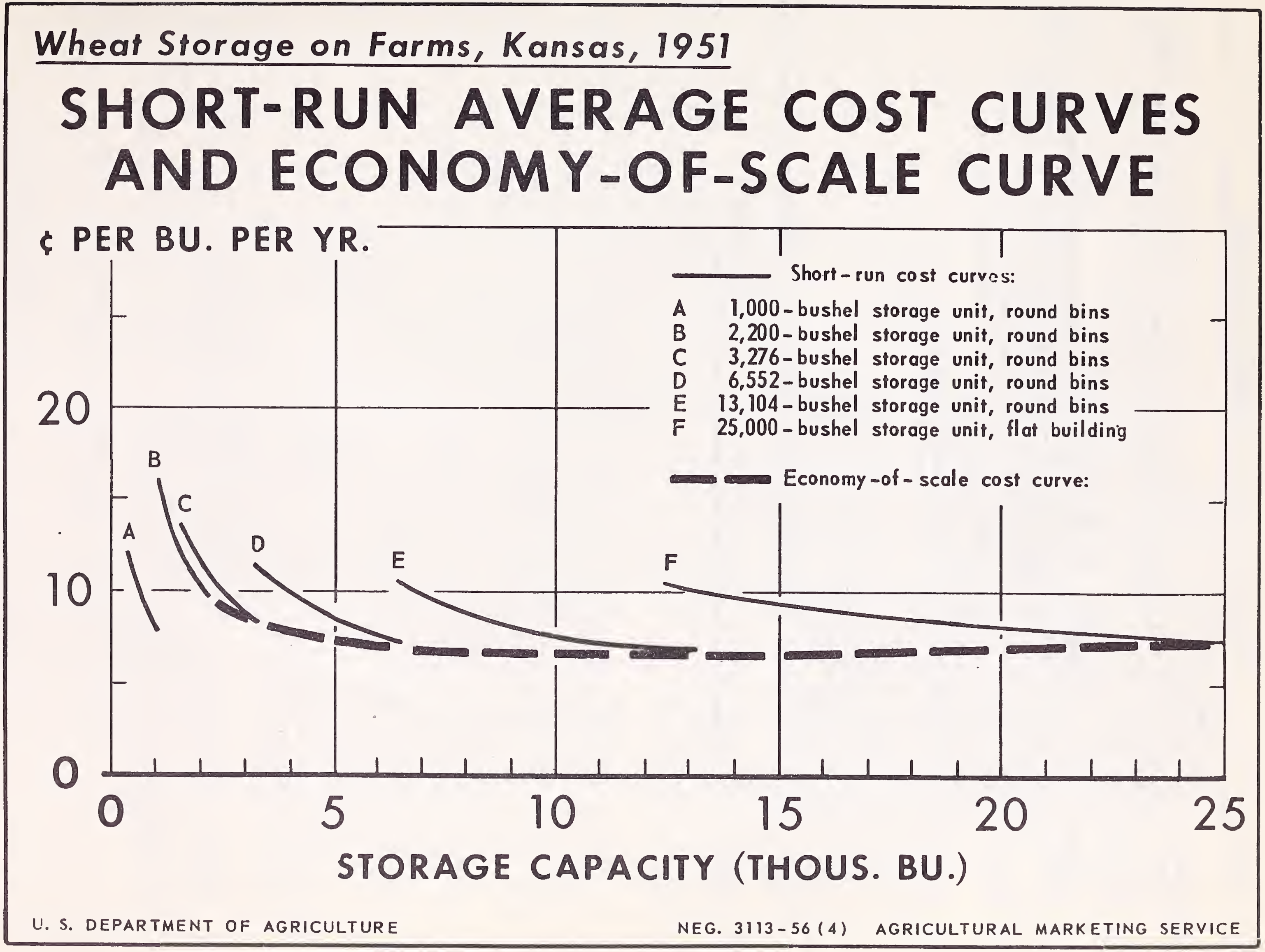
Wheat Storage on Farms, Kansas, 1951
SHORT-RUN AVERAGE COST CURVES
AND ECONOMY-OF-SCALE CURVE
¢ PER BU. PER YR.
Short-run cost curves:
A 1,000-bushel storage unit, round bins
B 2,200-bushel storage unit, round bins
C 3,276-bushel storage unit, round bins
D 6,552-bushel storage unit, round bins
E 13,104-bushel storage unit, round bins
F 25,000-bushel storage unit, flat building
Economy-of-scale cost curve:
A
B
C
D
E
F
0
10
20
0
5
10
15
20
25
STORAGE CAPACITY (THOUS. BU.)
U. S. DEPARTMENT OF AGRICULTURE
NEG. 3113-56 (4) AGRICULTURAL MARKETING SERVICE

Figure 6

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APPENDIX A

Statistical Appendix--Country Elevators

Multiple regression analysis was used to estimate costs of storing wheat in country elevators. Unfeasibility of relatively small and predominantly old elevators for a long-range wheat storage program ruled out consideration of elevators constructed of wood. Relative unimportance in storage capacity was the basis for not including steel and concrete-stave construction.

Thus, the study considered only reinforced concrete elevators in which existed a substantial degree of uniformity in applied technology. This alleviated the necessity of adjusting for uniformity in such items as equipment, plant layout, and use of labor. The sample was drawn in such a manner that size of elevator and degree of utilization could be used as independent variables. Subsequent observation indicated the possibility that stock rotation (as indicated by number of bushels moved into storage and number of bushels moved out of storage) could logically be expected to influence costs of storage.

Total cost of storage was used as the dependent variable rather than average cost. The primary reason for this was the relatively greater ease in fitting a function to total costs and the fact that total cost can be converted to average cost by simple division.

Before attempting to fit an equation to the data, checks were made to determine whether there was evidence of curvilinearity. Plots on scatter diagrams indicated lack of curvilinearity associated with any of the independent variables. This lack was further verified by calculating the additional reduction of the sum of squares by fitting a second degree polynominal, which was found to be nonsignificant when compared with the deviations from the first degree curve.

On the basis of economic logic one would expect total costs to increase at a decreasing rate as size of elevator increased. Investments in buildings and equipment increase at a decreasing rate with size of elevator. Costs of insurance on buildings and equipment, taxes, interest, and depreciation are related to investment. Therefore, it appeared that their influence would produce curvilinearity in total costs.

Explanation of lack of curvilinearity was found in a changing proportion of total elevator costs (including both storage and grain merchandising) attributable to storage as size of elevator increased. In smaller elevators approximately 40 to 45 percent of total plant costs were attributable to storage operations. In larger elevators this proportion increased to 75 to 80 percent. The larger elevators engaged primarily in storage while the smaller elevators did a proportionately larger share of their business in grain merchandising. With costs allocated to storage accordingly, economies of investment apparently were about offset by the greater proportion attributable to storage operations.

It does not follow that no economies could be gained in average cost. As used in this analysis size is measured physical capacity--referred to here as technical capacity. Actual bushels stored are less than technical capacity because some space is reserved for turning grain. The proportion of total space reserved for turning decreases as technical capacity increases. Approximately 15 percent of the space in a 100,000-bushel elevator is reserved for turning, but only about 4 1/2 percent of a 700,000-bushel elevator is required for turning. As size of elevator increases, therefore, a proportionately larger number of bushels can be stored. Thus, even though total costs were linear, and no constants were in the equation, average costs could exhibit a curvilinear tendency. With a constant, the curvilinearity would be accentuated.

Changes in total cost associated with degree of utilization of a given size elevator reflect changes in variable costs only. Absence of economies in variable costs would produce linearity in total cost. Again curvilinearity could be obtained in average costs simply by spreading fixed costs over a larger number of bushels at greater degrees of utilization.

In view of lack of curvilinearity the model selected was as follows:

(1) $Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4$ where

Y = Total annual storage cost

X_1 = size of elevator--total measured technical capacity

X_2 = unused capacity--in bushels equivalent space

X_3 = bushels put in storage

X_4 = bushels taken out of storage

The data were fitted to this model by the method of least squares which resulted in the following multiple regression equation:

(2) $\hat{Y} = 2486.34 + .085823\ X_1 - .051726\ X_2 - .009649\ X_3 - .006460\ X_4$

Significance of the partial regression coefficients and their standard errors were as follows:

$b_1 = .085823^{**}$	$s_{b_1} = .012628$
$b_2 = -.051726^{**}$	$s_{b_2} = .015322$
$b_3 = -.009649$[1]	$s_{b_3} = .007972$
$b_4 = -.006460$[2]	$s_{b_4} = .006183$

**Significant to 1-percent level
[1] Significant to 25-percent level
[2] Significant to 30-percent level

The partial regression coefficients for X_1 (that is, b_1) and X_2 (that is, b_2) were found to be significant to the 1-percent level. The partial regression coefficient for X_3 (that is, b_3) was significant at the 25-percent level and for X_4 (that is, b_4) at the 30-percent level. Thus, it was concluded that X_3 and X_4 were nonsignificant in explaining variation in total cost.

This appeared to be unrealistic and prompted a detailed examination of the original data. The examination revealed that while a substantial variation occurred in turnover of storage stocks the average rate was about 2 1/2 times average inventories. Wheat in storage ordinarily is turned at least once a year if the same wheat is held the entire year. In essence, this is rotation of stocks within the elevator. This in itself would be equivalent to a turnover of two times, so that on the average the handling involved in rotation of stocks was about equal to that which ordinarily occurs in an annual storage operation in which no rotation occurs. Even if the rate of turnover were such as to cause greater handling than would occur in the storage operation, it is probable that the rate of turnover would have to be very high before it would show up as a significant factor in total cost variation. Basis for this is that electricity and labor are the chief costs involved in handling grain.

Examination of the data revealed that total cost of electricity was a relatively minor item in storage operations. It amounted to only about 2 to 3 percent of total costs. Therefore, a considerable change in amount of electricity used would be required to make a significant change in total costs.

It is probable that no additional labor would be required for the extra grain handling envisioned in stock turnover unless the turnover occurred within a relatively short period or was at a very high rate. Considerable flexibility exists in labor utilization in storage operations. In view of these circumstances it does not appear unreasonable that stock turnover observed in the sample elevators was nonsignificant in influence on total storage costs.

The proportion of variation in Y accounted for by the several independent variables in equation 2 was as follows: X_1 = 78.6 percent; X_2 after adjusting for X_1, an additional 6.0 percent; and X_3 and X_4, after adjustment for X_1 and X_2, an additional 2.9 percent. Variables X_3 and X_4 were consequently dropped from the equation.

A new equation was calculated using only X_1 and X_2 as independent variables. Results of this calculation were as follows:

(3) $\hat{Y} = 1940.70 + .0673984\ X_1 - .0378441\ X_2$ where Y, X_1 and X_2 were the same as in equations 1 and 2.

The coefficient of determination (R^2) was .8461 for equation (3). This is interpreted to mean that 84.6 percent of the variation in total costs of storage was associated with variation in the two independent variables used in equation (3).

Significance of the partial regression coefficients and their standard errors was as follows:

$b_1 = .0673984$** $\qquad s_{b_1} = .0089544$

$b_2 = -.0378441$* $\qquad s_{b_2} = .0138812$

**Significant to the 1-percent level
*Significant to the 5-percent level

Simple correlation coefficients (r's) for variables in equation (3) are shown below:

Simple correlation coefficients

	Size of elevator	Unused capacity	Total storage costs
Size of elevator.............	1	.848	.887
Unused capacity		1	.622
Total storage costs			1

On the basis of these simple correlation coefficients it is concluded that:

1. Simple correlations between total storage cost and size of elevator and between total storage cost and unused capacity exceed the 1-percent value, that is, a real relationship exists between total storage costs and the other measures.
2. r = .622 exceeds the 1-percent value, that is, a real relationship exists between size of elevator and unused capacity--the larger the elevator the more the unused capacity.
3. r = .887 is significantly higher than .622, that is, total storage cost is more closely related to size of elevator than to unused capacity.
4. Size of elevator is the principal contributor to total storage cost--a relatively minor additional contribution is made by unused capacity; however, from the standpoint of economic logic it appeared reasonable to retain unused capacity as a variable.

Examples of Use of Estimating Equation for Calculating Storage Costs

For calculation the coefficient of X_1 was rounded to .0674 and the coefficient of X_2 was rounded to $-.0378$. Thus, the estimating equation was as follows:

$\hat{Y} = 1940.70 + .0674\ X_1 - .0378\ X_2$ where $\hat{Y}$ = total cost

X_1 = size of elevator (see table 6)

X_2 = unused capacity (see table 6)

Average cost was obtained by dividing total cost by actual number of bushels stored. Number of bushels stored was equivalent to average inventory as shown in table 6.

Example 1. Average storage cost for a 100,000 - bushel elevator used at full capacity was calculated as follows:

$$\hat{Y} = \frac{1940.70 + .0674\,(100,000) - .0378\,(0)}{85,000}$$

$$\hat{Y} = 10.21 \text{ cents per bushel}$$

Example 2. Average storage cost for a 500,000 - bushel elevator used at 50 percent of capacity:

$$\hat{Y} = \frac{1940.70 + .0674\,(500,000) - .0378\,(235,000)}{235,000}$$

$$\hat{Y} = 11.39 \text{ cents per bushel}$$

Example 3. Average storage cost for a 700,000 - bushel elevator used at 75 percent of capacity:

$$\hat{Y} = \frac{1940.70 + .0674\,(700,000) - .0378\,(167,500)}{502,500}$$

$$\hat{Y} = 8.52 \text{ cents per bushel}$$

APPENDIX B

Short-Run Average Costs and Economies of Scale

An analysis of costs of storage distinguishes between costs associated with (1) variation in utilization of space at a storage unit and (2) variation in the scale of total storage operations. The period within which these variations can be made is of prime importance to a cost analysis. If the period of time is so short that the size of a fixed plant cannot be varied, the quantities to be stored can be varied only by changes in the rate of capacity utilization at the plant. If the period is long enough to permit unrestricted variation in storage volume, change in scale of total storage operations is introduced as a factor influencing storage costs.

The "short" period and the "long" period in question are concerned not so much with chronological limits but are defined functionally. That is, short-run cost calculations are relevant to a plant for a relatively short period during which it cannot greatly expand or contract its facilities. In successively longer periods of time it becomes possible to vary freely the size of factors affecting storage operations. Technically, the relation between variations of all inputs and variations of output are termed the economies of scale (or returns to scale). (7)

Cost curves, as shown in figure 7, are useful in illustrating the relationship between the rate of output and the rate of expenditure on various inputs. Those curves which show costs that are influenced by degree of utilization of a plant's capacity are commonly referred to as the short-run average cost curves. Those drawn to show costs as influenced by scale of operation are referred to as economy-of-scale cost curves (or long-run average cost curves).

An economy-of-scale cost curve is often called a "planning" curve because it shows the cost advantages or disadvantages for prospective plants of various sizes when operations are organized as efficiently as possible under given conditions. More technically, the economy-of-scale curve represents the loci of the lowest average costs that may be achieved with variations in the scale of total storage operations. As the scale is increased, economies will usually be present and will lead to reduced costs, but these economies will eventually be replaced by diseconomies and increasing unit costs. (2)

The theoretical relationship between short-run cost curves for individual plants and the curve representing economies of scale is shown in figure 7. Average short-run curves for several plants are shown in the conventional U-shaped form, first decreasing with the spreading of fixed or overhead costs but finally increasing (in accordance with the law of diminishing returns) as more of the variable factors are combined with the fixed factors. This group of short-run cost curves may be considered as the curves which characterize a single plant if its capacity is increased over a period of time, or as curves for a number of plants of different capacities at any one time. If continuous variation in scale is possible, the economy-of-scale curve will appear as a smooth curve tangent to the short-run curves. (Many other short-run curves might have been added in figure 7 to represent any possible size of plant.) If changes in scale are discontinuous, the economy-of-scale curve will consist of segments of the several short-run cost curves (or plant curves) and will have a scalloped appearance. Assuming continuous variation, capacity output is represented by the points of tangency.

In contrast to the conventional theoretical illustration of short-run cost curves, those derived for sample elevators and farm storage units ended in the declining phase, that is, without reaching a point of constancy or an increasing phase. Thus, the economy-of-scale curves shown in figures 4 and 6 are tangent to the individual short-run cost curves at their low point, which also is the point of 100-percent of capacity utilization. This situation is explained by the nature of storage operations and technical conditions of capacity utilization. Storage capacity of a given elevator or farm bin is a function of technically limited physical dimensions which provide a rigorously definable point of full capacity utilization.[14] Apparently, costs decline to this point so that the economy-of-scale curve

[14] It is recognized that under some circumstances elevator operators can and do fill up the space reserved for turning grain, which would make possible a slight extension of short-run curves with possible increasing costs. Since this is not considered to be standard operating procedure for a long-range storage program, it was not included in this study.

is tangent at the low point of individual short-run cost curves and is identical with costs at 100-percent of utilization as defined in this study.

An economy-of-scale cost curve differs from the "average cost curve" used in many plant cost studies where cost-volume data are presented as a scatter diagram, with an average regression line fitted to the scatter. This regression line shows the average relationship between fixed plant volume and costs. However, it does not distinguish between cost changes that result from the more complete utilization of a plant of a given capacity and the cost changes that accompany changes in scale of operations. Each cost and volume point refers to a plant of some particular size and also is concerned with some particular proportion of unused capacity. As a result, these points may scatter along the short-run cost curves of individual plants such as are shown in figure 7 and only by chance will they approach the level of the economy-of-scale curve. Such a scatter of cost and volume points is given in figure 8.

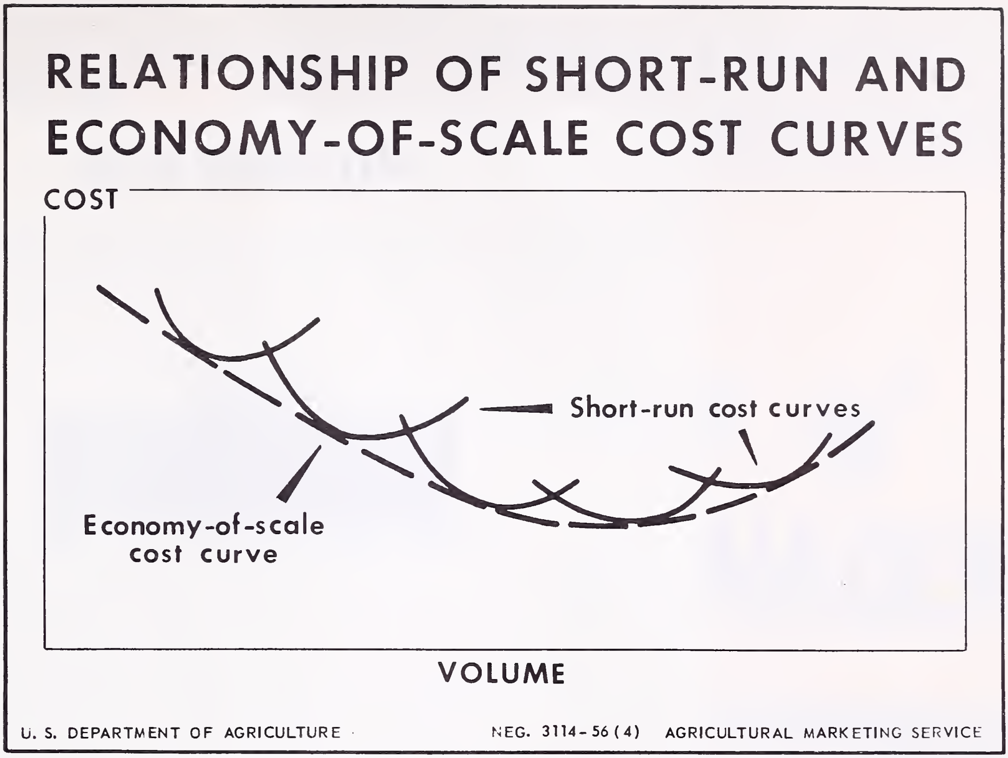

Figure 7

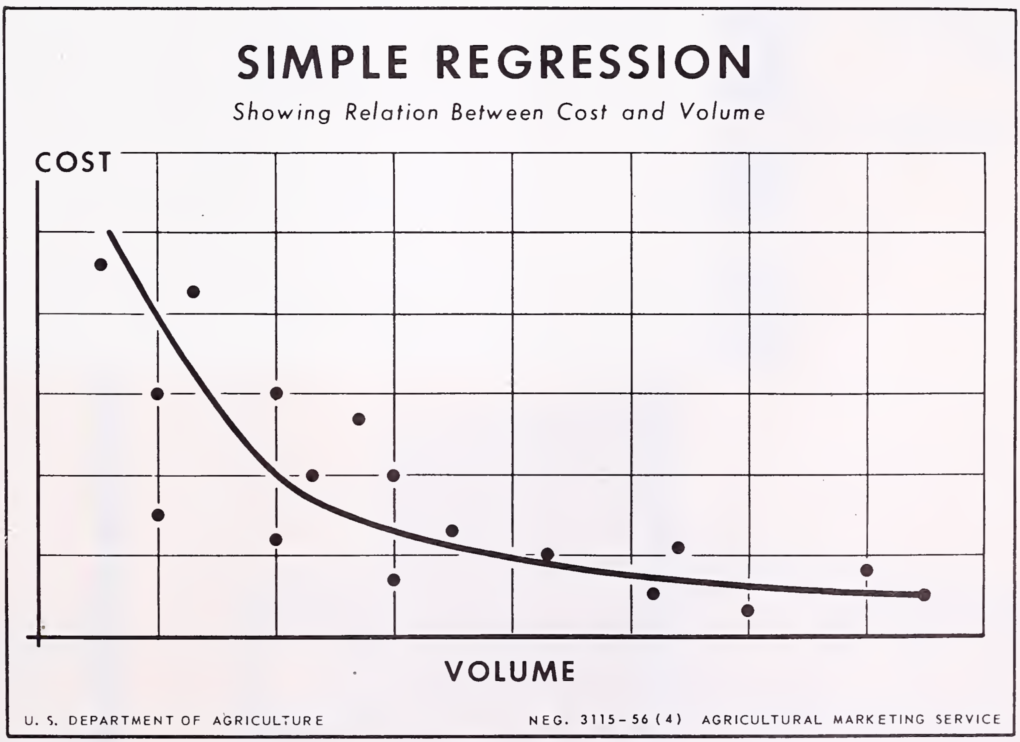

Figure 8

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