Comparison of Costs of Service and Self-Service Methods in Retail Meat Departments

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SUMMARY

The objectives of this study were to compare the costs of service and self-service methods of selling meat and to show the relationship of cost to volume of sales.

Cost data were obtained from 23 self-service and 26 service stores for the period October 6 to 11, 1952. The cost items compared were labor, equipment, market floor space and paper supplies. These costs constitute about 85 percent of the total costs of operating the meat department. The volume of meat sales of the stores in this study ranged from $500 to $7,000 per week. Thus, the following results are applicable only to stores in this range.

Physical hours of labor per dollar of sales averaged lower under self-service than service methods up to a sales volume of about $2,000 per week. Beyond that point the self-service method required more physical hours of labor.

The cost of labor was lower for the self-service method than for the service method. This difference was largely due to substitution of the lower paid labor of women wrappers for journeyman labor in self-service markets with above $2,000 sales volume. In self-service markets at any given volume below $2,000 sales per week, lower labor costs were due to fewer hours worked.

Investment in equipment for self-service markets averaged from $400 higher at $500 sales per week to $3,000 higher at $7,000 sales than for service markets. The difference was due mainly to more linear feet of display case and higher average prices for self-service cases as compared with service cases.

The two methods of operation required the same total square feet of space for the meat market area. The meat market area averaged from 12 to 16 percent of the "retail" area.

The cost of paper supplies averaged about 1.6 percent of sales for the self-service operation as compared with about 1.2 percent of sales for the service operation.

When the four individual cost items were combined, there was no significant difference in cost between the two methods of operation. The costs per dollar of sales for both service and self-service methods decrease as the size of the operation (sales volume) increases. The average combined costs examined in this study decreased from about 19 cents per dollar of sales at a $500 weekly sales volume to 10 cents per dollar of sales at $3,000 sales per week. However, the decline from $3,000 weekly sales to $6,000 was only about 1 cent per dollar of sales.

Neither method of retailing meat offers significant cost advantages over the other at any given volume of sales. Increasing the size of the market appears to be an important means of lowering costs in both types of operation. The greatest opportunity for lowering cost is in the range $500 to $3,000 weekly meat sales volume.

Self-service generally increases the volume of sales. Thus, though there is no cost difference at any given volume of sales between service and self-service methods of selling meat, the conversion to self-service results in a greater volume of sales and decreased average costs. Had the operator been able to increase his meat sales under the service method, the cost also would have been lower than formerly, and for the same reason.

This study indicates that costs are a function of size, where size is interpreted to mean more floor space and display equipment in larger food stores, as well as greater sales volume. The range of data in this study does not suggest any cost limit to the size of operation.

Changes in demand for meat may also result from self-service. It has been observed that inferior cuts have been much easier to sell, and at higher prices, in self-service than in service markets. This may result, in time, in less spread in price between cuts. Presumably, the less desirable cuts may increase in price permitting more expensive cuts to become cheaper, while over-all margins remain the same. There are also indications that impulse buying in self-service markets results in the customer purchasing more meat than was originally on the shopping list. Since self-service encourages standardization, it may help to reflect consumer demand more accurately, back through the marketing channel, to the producer.

Comparison of Costs of Service and Self-Service Methods in Retail Meat Departments[1]

By Fred H. Weigmann[2], E. S. Clifton[3] and
Geoffrey Shepherd[4]

Self-service retailing of meat is relatively new in the retail food industry, although self-service in other food items has been an accepted practice for many years. The general application of this method to meat retailing was delayed by technological problems, particularly wrapping and refrigeration. Successful use of the new technique can be dated from about 1941.[5] Since 1948, the use of self-service in meat departments has increased by over 600 percent.[6]

The implications of this technological change have considerable economic significance. Problems associated with the size of the operating unit, changes in demand, pricing standardization, grading, and practices and policies throughout the meat marketing channel and related service industries are all involved.

Since the introduction of the self-service method of retailing meat, management has been faced with a choice between the older (service) and newer (self-service) method or some combination of the two. One criterion of choice is cost. Costs are usually expected to vary with the size of the business and also with methods of operation. The relationship between cost and volume in meat retailing has received little attention.[7] The relative costs of service and self-service methods are not known. This study attempts to determine what these costs are.

OBJECTIVES

The specific purposes of this study are:

(1) To determine the relationship between volume of sales and the cost of several factors entering into the costs of retailing meat in retail food stores.

(2) To compare these costs between the service and self-service techniques at various volumes of operation.[8]

The analysis may furnish useful information to management insofar as costs form a criterion for choice between service and self-service operation. The analysis may also prove useful by providing some suggestion of analytical and statistical procedures applicable in similar studies.

METHOD OF ANALYSIS

THEORETICAL AND EMPIRICAL FRAMEWORK FOR ANALYSIS

The long-run average cost curve provides the basic economic concept for this study. It will not be necessary, for the purpose of this study, to review in detail the theory of long-run costs. However, the long-run cost curve will be illustrated to serve as a basis for analysis of the empirical results of the study. Figure 1 is a graphic illustration of the economic model, the long-run cost curve AIB or AIC.

DFE and GH represent short-run average cost curves. The short-run cost curve DFE shows the alternative volumes of output and consequent cost levels available to a plant constructed such that its minimum cost would be reached at a volume of OL. GH represents a larger plant with a lower minimum cost. Smaller, larger and intermediate size plants would give rise to short-run curves having minimum points to the left, right and between those shown. The shape and level of the short-run curves is determined, for the most part, during the planning stage by the fixity of plant and equipment. The long-run curve (AIB or AIC) has often been termed the "planning" curve since all factors, including plant and equipment, are considered variable.

Practical considerations make the "planning" curve model particularly useful in this study. Self-service meat retailing accounted for about 14 percent of the total amount of meat sold in grocery stores in April, 1952. These stores represented about 2½ percent of all stores handling meat.[9] Yet it is predicted that
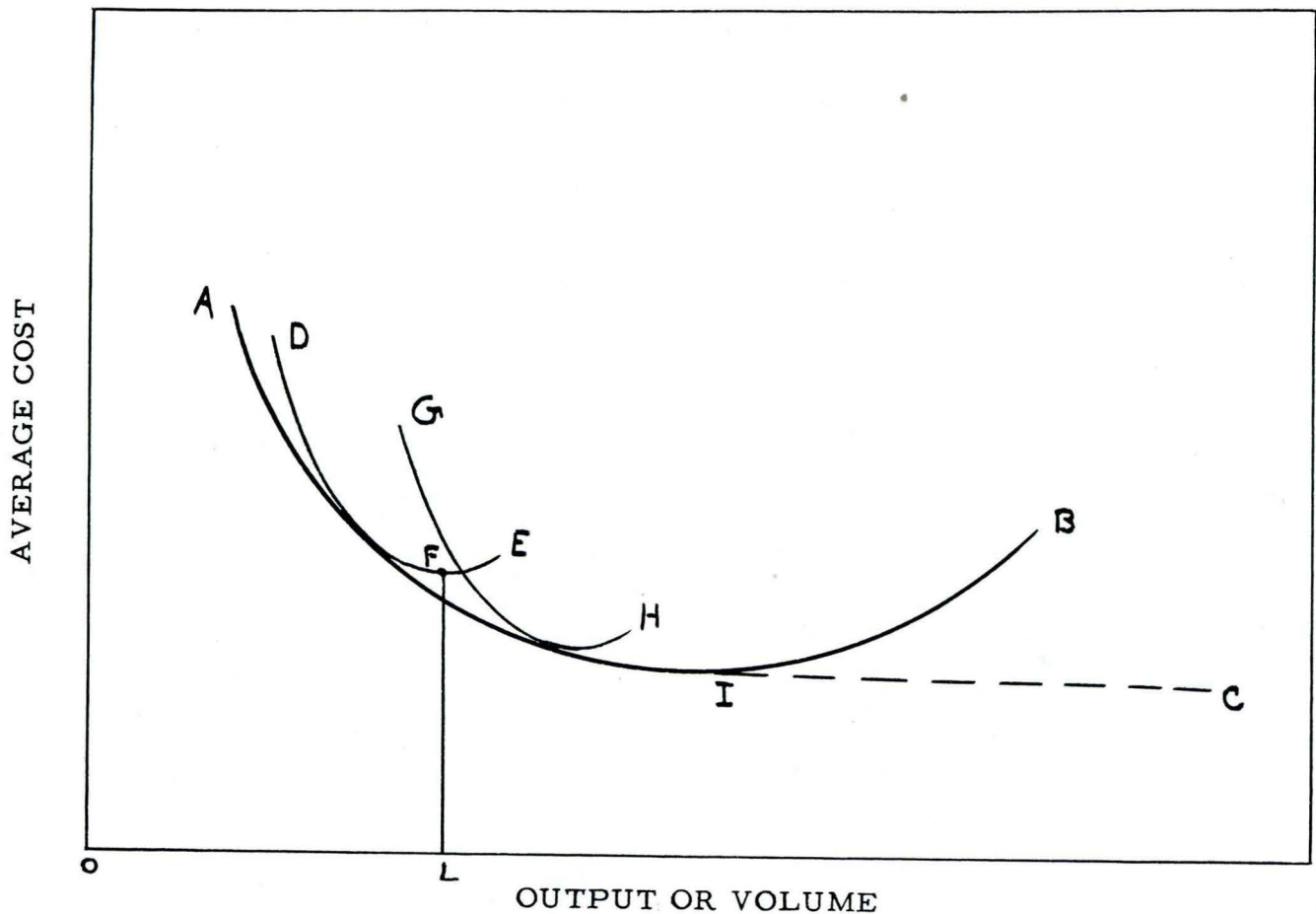

Fig. 1. The long-run average cost curve.

self-service eventually will "take over" the retail meat industry.[10] A change from service to self-service methods generally involves other changes such as remodeling and new construction. There has been a decided trend toward modernization and new construction in the retail food industry in recent years.[11]

The long-run average cost curves in this study were derived from total cost curves fitted by least squares regression to the cost estimates computed from observations made in meat departments in retail food stores.[12] This procedure has at least the implicit approval of the Committee on Price Determination.[13]

Several assumptions were made in this study. These included:

(1) The observed markets were operating efficiently.

(2) There is no difference in management between service and self-service operation (including structural business organization).

(3) There are no indivisibilities in the factors selected for study.

While these assumptions may be somewhat tenuous, they appeared necessary in order to proceed with the primary line of analysis.

The retail grocery industry does not present a very homogeneous structure for study. Both vertical and horizontal integration are characteristic. Ownership and operating practices are quite varied. Extreme variations in size can be observed in proximity.

It was necessary to prevent, as much as possible, the influence of factors other than those under study. Limiting the population of interest is one means of doing this.[14] Another is to use a budgeting approach based on physical data thus eliminating differences in accounting practices. A third means of approximating homogeneity is to use the same base time period for all observations, thus eliminating the effect of changes in the price level. Another is to limit the geographic area of observation. The population may also be separated into strata, each approximately homogeneous, thus increasing the efficiency of estimates. All of these procedures were used in this study to maintain homogeneity and thus to decrease

[10] Meat Merchandising Magazine. New self-service meat manual. p. 5. The Von Hoffman Press, Inc., St. Louis. 1950.

[11] What are they building today? Progressive Grocer. 31:70. October 1952.

[12] The terms "meat departments," "market," "meat market" and "meat stores" are used interchangeably in this study. However, the study was restricted to meat departments in retail food stores.

[13] Committee on Price Determination. The Conference on Price Research. Cost behavior and price policies. p. 26. National Bureau of Economic Research. 1943. This book contains a comprehensive treatment of cost.

[14] The population of interest was considered to be service and self-service meat departments in retail food stores with meat department sales volumes of $500 and over per week.

variations not believed directly due to the two major items of interest.

Fresh meats represent the bulk of sales in retail meat markets. Nearly all stores sell some processed and cured meat products by self-service, and most of the service stores in this study do also. However, those service stores selling a large portion of their fresh meats, as well as processed meats, from self-service cases were excluded from the study. No distinction was made between stores on the basis of ownership or organization.

SELECTION OF THE VARIABLES

Four cost factors were selected for study. These factors were (1) labor, (2) floor space, (3) equipment (including refrigeration)[15] and (4) paper supplies. Selection of these variables was based on the following considerations:

(1) The nature of the two methods of operation to be compared suggests that these factors are the ones most likely to differ between methods of operation.

(2) A study by Farstad and Brensike[16] indicated that the cost of these items accounted for approximately 81 to 86 percent of the total cost of operating the meat department.

Several items were considered for use as a measure of size. Although a physical measure was desired, preliminary analysis indicated that dollar sales volume was the best available measure of output. Dollar volume was therefore used as the measure of size of operation.

SELECTION OF THE SAMPLE

The primary data for this study were obtained from owners and operators of service and self-service meat departments in retail food stores during October and November, 1952. Most of the remaining data were obtained from executive management in the retail food industry and from allied service industries.

The nature of self-service operation in meat departments suggests that some practical lower limiting in volume (size of business) would also provide a lower limit for the sample to exclude the very small stores.[17]

Census data show that approximately 75 percent of the retail stores handling fresh meat in Iowa and operating the full year, had a gross volume of business

[15] Unless otherwise specified, the term "equipment" includes meat preparation equipment, walk-in coolers, scales and display cases throughout this study.
[16] Farstad, op. cit. p. 5.
[17] Approximately 84 percent of all self-service meat markets had a dollar sales volume greater than $2,000 a week in 1951. Armour and Company. Self-service meats today. p. 10. Annual Research Report. April 1951.

TABLE 1. DISTRIBUTION OF RETAIL FOOD STORES HANDLING FRESH MEAT AND OPERATING THE ENTIRE YEAR IN IOWA (1948).°

Annual sales per store	Number of stores	Percent of stores
$300,000 and up	200	5.5
$100,000 to $299,999	732	20.0
$50,000 to $99,999	1,110	30.5
$49,999 and less	1,607	43.8
Total	3,649	99.8

° Adapted from U. S. Bureau of the Census, Census of Business: 1948. Retail trade-general statistics. Vol. 1, Part 1, Table 2E, p. 2.38.

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of less than $100,000 in 1948 (table 1). Assuming meat department sales equal to 25 percent of the total, such stores handle less than $500 per week in the meat department. The study was restricted to those meat departments with sales of approximately $500 per week and over.

A list[18] of the retail food stores in Iowa (and part of Illinois) was used to delimit the population. The list classified stores into A, B, C and D categories based on estimated sales volume and ownership (table 2). The list included 5,749 stores in Iowa (and 286 stores in Illinois) as of January 1952. Groups A, B and C were considered qualified by size to be included in the sample.[19] There were approximately 102 self-service meat departments in Iowa in April 1952.[20] The geographic locations of these retail food stores were secured through the cooperation of Chambers of Commerce throughout Iowa.

Preliminary information permitted a rough stratification of the stores by volume of meat sales.

(1) *Service stores*: The service meat departments were selected in Des Moines. The individual markets were randomly chosen within their estimated volume strata. The sample consisted of approximately 9 percent of those markets in the city with volumes of $500 to $2,000 per week and 64 percent of those markets with volumes above $2,000 per week.

(2) *Self-service stores*: There were few self-service meat stores in Des Moines. It was necessary to supplement those available with stores from other cities. Cities were selected which had the most self-service stores and required the least cost to obtain the data. They were Ames, Des Moines, Ottumwa, Burlington, Clinton, Moline, East Moline, Rock Island and Davenport (fig. 2).

The final make-up of the sample is shown in table 3.

[18] The Des Moines Register and Tribune. The blue book of Iowa retail grocery markets. January 1952.
[19] Class "A"—Estimated sales volume of independent and chain stores with volume over $375,000 per year. Class "B"—Estimated sales volume of chain store members having sales of less than $375,000 annually. Class "C"—Those stores independently owned and operated and doing an estimated annual sales volume of between $75,000 and $375,000. Class "D"—Independently owned and operated outlets with an estimated annual sales volume of less than $75,000. These categories correspond to the group 4, 3, 2 and 1 classifications of the Office of Price Stabilization that were in effect in Iowa in 1952.
[20] Armour and Company. Self-service meats. p. 11. April 1952.

TABLE 2. CLASSIFICATION OF RETAIL GROCERY STORES IN IOWA ACCORDING TO AN ESTIMATED ANNUAL SALES VOLUME, 1952.°

Class	Number	Percent
A	335	5.82
B	237	4.12
C	1,320	22.97
D	3,857	67.09
Total	5,749	100.00

° Adapted from the 1952 Blue Book of The Iowa Grocery Market published by the Des Moines Register and Tribune.

TABLE 3. NUMBER OF STORES OF DIFFERENT SIZES INCLUDED IN THE SAMPLE.°

Volume Range of sales by meat department for 1 week (Oct. 6 to 11, 1952)	Service meat departments (number)	Self-service meat departments (number)
$ 499 to $1,001	3	2
$1,002 to $2,001	7	3
$2,002 to $2,999	3	4
$3,000 to $3,500	2	3
$3,501 to $4,100	3	6
$4,101 to $5,000	3	3
$5,000 and up	5	2
Total	26	23

° This is the distribution resulting after the sample was taken.

The sample provided two major sets of data—cost and volume data for service meat departments and cost and volume data for self-service meat departments. The relationship of factor cost to volume for each of the factors was studied under each of the two methods of operation. However, major emphasis is placed on a comparison of the cost curves for service and self-service operation, both for the individual costs and the total costs when they were combined.

The statistical technique used in view of the objectives of this study was least squares regression. The data were first plotted in the form of scatter diagrams. Various statistical models were then fitted to describe the linear or curvilinear relationships. The criterion of minimum variance was the basis for selecting the final curve. Average cost curves were derived from total cost curves.

ANALYSIS OF THE DATA

This section presents the results of the study.[21]

[21] The statistical analysis and tables E-1 and E-2 for the regression of hours of labor on sales are presented in Appendices D and E to demonstrate the procedure used. Analysis of the subsequent relationships was similar, and the statistical tables are presented in Appendices C and D. For a more complete treatment of the procedure, including sampling and statistical analysis, see Wiegmann, Fred H., Comparison of costs of service and self-service methods of selling meat in retail food stores, unpublished Ph. D. thesis, Iowa State College Library, Ames, Iowa, 1952.

Several points should be remembered throughout the following comparisons.

(1) Generally, physical data were collected. To maintain homogeneity in the data, a partial budgeting procedure was used. The basic physical data were standardized in terms of dollar costs by using the 1952 average prices appropriate to each variable. This procedure removes differences in labor cost, for example, that may be due to the presence or absence of union organization but which are not due either to volume or method of operation. The procedure results in data more comparable between the methods of operation, but it does not change the original situation into a more or less ideal one.

(2) The regression technique is an averaging process.[22] The final curves represent averages of the data, distributed over the volume range. As averages of individual observations, they represent neither an ideal nor any one operation. Individual operators may be found above and below the lines of general relationship.

(3) The data (hours of labor, supplies and weekly sales) were based on a particular week. These data would be expected to vary weekly and seasonally. This, however, does not affect the point of major interest—the comparisons of cost differences between

[22] Ezekial, Mordecai. Methods of correlation analysis. 2nd ed. p. 38. John Wiley and Sons, Inc., New York. 1941.
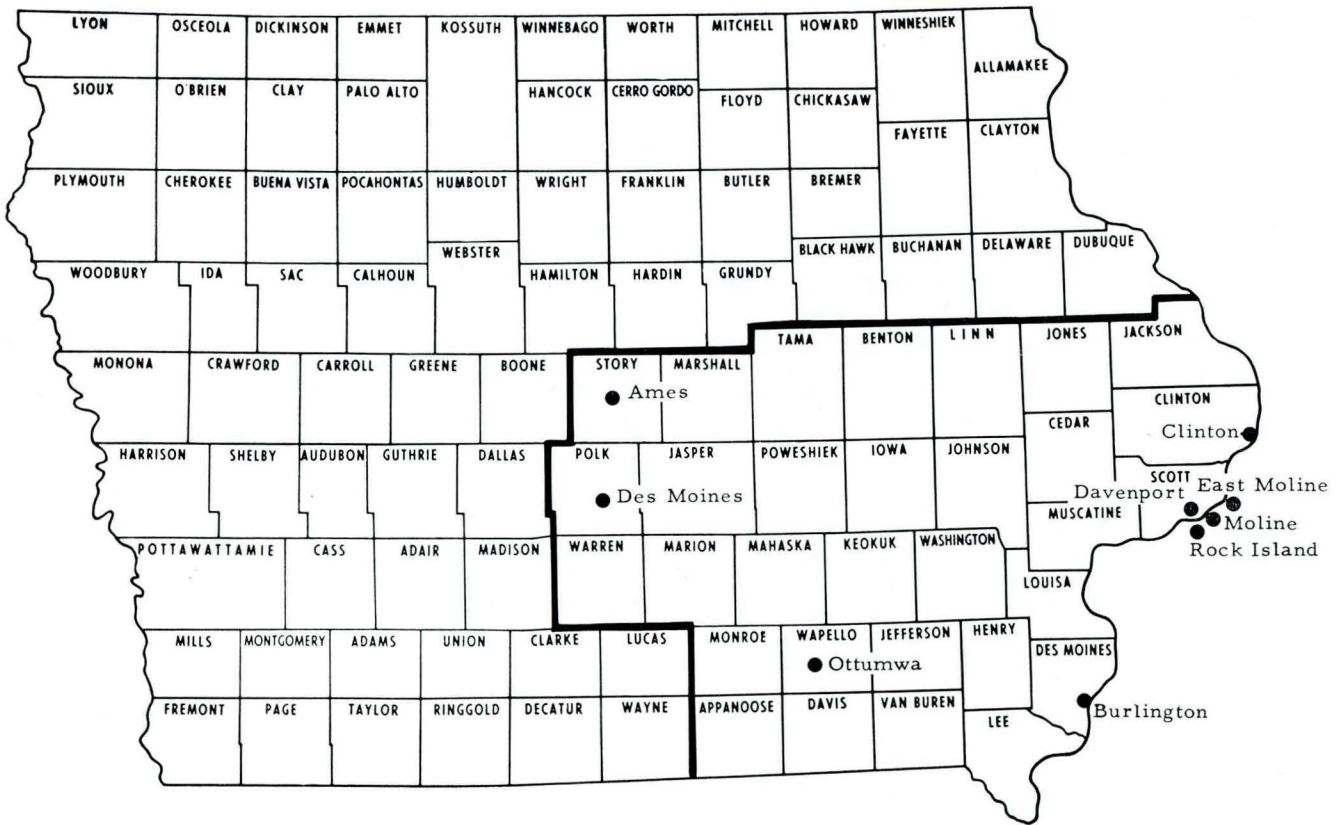

Fig. 2. Area and cities from which sample was drawn.

service and self-service operation. It does affect the level of the resulting cost curves. Variations in these data over time would raise and lower the level of the curves. Participants in the study indicated, however, that October represented an average month in volume of retail meat sales in 1952. Since the variables used are believed to represent approximately 85 percent of the costs of operating the market, the total cost is understated by approximately 15 percent, and thus the level of the cost curves is understated also. The level of the cost curves should be considered with these two points in mind.

(4) The statistical results are supporting evidence to the underlying economic logic and qualitative, as well as quantitative, field observation. Statistical tests do not prove or disprove an hypothesis but rather furnish evidence to substantiate or make doubtful the validity of the hypothesis in question. It should be noted further that there may be a difference in the interpretation of a statistical test of difference and the economic importance of such a difference. An observed difference that is statistically significant may or may not be of practical economic importance.

COMPARISON OF HOURS OF LABOR

A linear relationship would be anticipated between hours of labor and sales in retail meat markets. The physical input of labor can be varied, in terms of numbers working and hours of work, to correspond to sales or product output. This relationship might be different, however, in service as compared with self-service operation. The need for a peak period labor force plus limited pre-sales preparation of meat in service type stores would be expected to under-utilize meat department labor, particularly in stores large enough to be departmentalized. Better utilization of labor is generally considered an outstanding feature of self-service operations. The meat is cut, weighed, labeled, priced and wrapped prior to sale. Depending on the size of the operation, the process becomes more or less an assembly-line technique. Since the meat may be prepared well in advance of sale, it is unnecessary to over-staff the department for peak load purposes, and it is common to find less than half the meat personnel on duty during peak sales periods.[23] This suggests the hypothesis that cost, in terms of hours of labor, probably would be higher for service than for self-service operation. The data (hours of labor and volume of sales) are presented in Appendix A, tables A-1 and A-3. Scatter diagrams indicated a linear relationship between hours of labor and sales. Linear regressions of service and self-service labor hours on sales were computed.[24] Estimates of statistical constants are shown in Appendix E, table E-1. The F values and the variance $(s^2_{y.x.})$ are taken from analysis of variance. Figure 3 shows the nature of the relationship between the two regressions.

The relationship between hours of labor and sales appear to be different for the two types of operation. The results of the F test for homogeneity of variance given in Appendix E, table E-2, indicate that the variance estimates were not significantly different. These variances were pooled for the remainder of the tests. A significant difference is noted in "b" at the 1-percent level of probability and significant differences are shown between regression Y's at values of $3,401 and $5,000 in terms of sales.[25] A difference in the value of "a" would only be acceptable at the 10-percent level of probability.

The highly significant difference in "b" means that there is a high probability that the rate of increase in labor hours observed in service markets, as sales volumes increased, was different from that in self-service markets. The significant difference in $\hat{Y}$ values at sales of $3,401 and $5,000 means that there is a high probability that the required hours of labor differ between the two methods at these levels of sales. This study was not designed in sufficient detail to specifically account for the difference.

Several possible reasons for the difference in labor hours can be suggested, however. Self-service introduces additional labor requirements. All the meat that is pre-packaged does not usually move directly to the display case. Some is placed in storage, from which the cases must be replenished at intervals. A principle of self-service meats is to have a good choice of every possible cut on display. Thus, the display cases require constant attention.[26] It is usual practice to assign to one person the duty of maintaining sanitation, eye appeal and adequacy of display at all times. This may be a full-time job depending on the size of operation. Since the package must "sell itself," pre-packaged meat actually requires more care in trimming and wrapping and this takes more time than in service operations. Meats on display are subject to considerable handling so that re-wrapping is a constant and time-consuming problem. A Michigan Agricultural Experiment Station report shows 10 percent of average daily output were re-wraps.[27]

The statistics supply another suggestion. The variance estimates ($s^2_{y.x.}$, Appendix E, table E-1) associated with the regression of labor hours on sales are greater for self-service than service operation. This may indicate that the physical labor requirements for self-service are, in practice, less well established than for service operation.

Service markets with large sales volume have some flexibility in hours of labor. Arranging the time for reporting for duty in accordance with the daily work to be done and to reach a full force in time for peak periods, permits some flexibility.

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[23] National Grocers Bulletin. Answers to self-service meat questions. 38:46. January 1951.

[24] The regression equations were $\hat{Y}_s = 31.9 + 0.040X_s$ and $\hat{Y}_{ss} = 9.8 + 0.050X_{ss}$ where $\hat{Y}$ = labor hours and X = sales by meat departments, October 6 to 11, 1952. The subscripts s and ss stand for service and self-service, respectively, throughout the study. Scatter diagrams show the actual observations as shown with X's and O's in fig. 4.

[25] The nature of the standard errors associated with "a" and "b" make it unfeasible, for the purpose of this study, to test for significant differences in $\hat{Y}$ values at more than a few sales levels (Ezekial, op. cit. p. 317). $3,401 represents an average of the means of X, which were $3,492 and $3,310.

[26] National Association of Retail Grocers. Self-service meats— is it the answer? p. 78. 1951.

[27] Mich. Agr. Exp. Sta. Special Bul. 385. Retailing pre-packaged meats. p. 26. 1952.
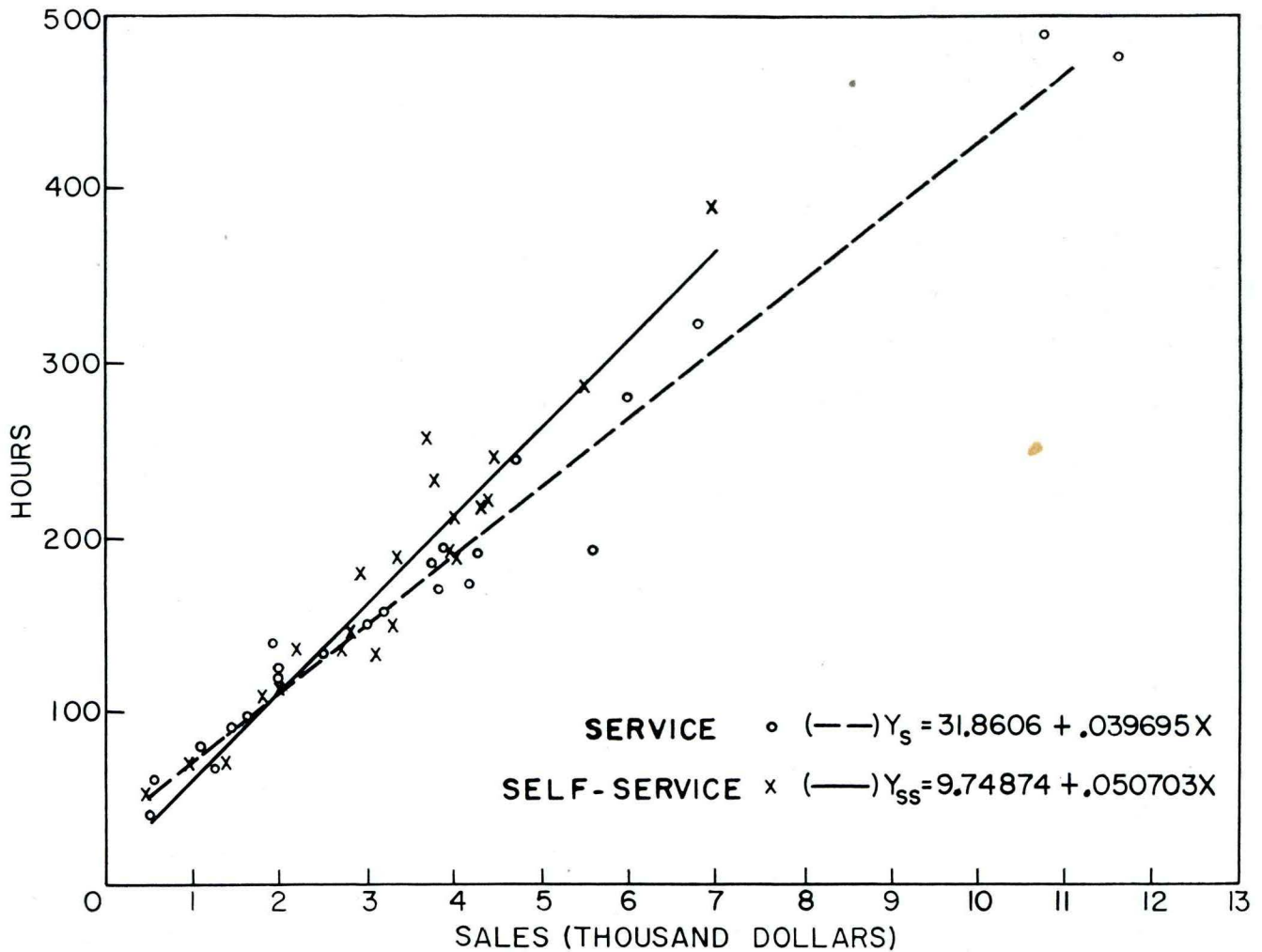
Fig. 3. Relationship of hours of labor to meat department sales for 1 week.

COMPARISON OF LABOR COST

In addition to hours worked, data on labor classification and actual wages were collected in each market. Wages varied for the same job classifications between markets, geographic locations and union and non-union markets. To remove this variation, wages were standardized. The standard used was higher than the actual wages but somewhat lower than union wages. The hourly wages used were: (1) head meat cutter, $1.86, (2) journeyman, $1.62, (3) apprentices, $1.16, (4) wrappers, $0.97, and (5) helpers, actual hourly wage. The standardized wages were multiplied by actual hours of labor to arrive at the total costs (Appendix A, tables A-2 and A-4).

Scatter diagrams indicated a linear relationship between total labor costs and total dollar sales. Linear regressions of total labor cost on sales were computed for service and self-service operation (Appendix C). The total labor costs for service operation are indicated to be higher than for self-service operation (fig. 4).[28] The difference increases from about

[28] Since the standardized wages used were somewhat higher than an average of the actual wages paid, the level of both cost curves would have been slightly lower than those indicated here if the actual wages had been used.

$15.00 per week at a volume of $500 weekly meat department sales to about $20.00 per week at a volume of $6,000 per week.

Tests of significance of differences between the "a" and "b" and selected regression Y values did not clearly indicate that the labor cost of service and self-service differed significantly (Appendix D). The levels of labor cost may be significantly different only at specific sales volumes. Also, the errors associated with estimating Y may have led to non-significant results in some tests.[29]

The labor employed in the market usually represents varying degrees of training or responsibility and is classified and rewarded on this basis. In self-service operation, much of the journeymen and apprentice labor found in the service markets is replaced by that of women wrappers. Since the wage scale for wrappers is lower, this results in a lower total and average labor cost in self-service markets.

In markets with volumes less than $2,000 per week, efficiency in both hour and dollar terms appears higher for self-service operation. This is probably related to the labor flexibility mentioned at the end

[29] Ezekial, op. cit. p. 315.

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of the preceding section. The personnel in service stores must be on duty during slow and peak periods. The self-service operator can prepare an adequate slack period display in advance and need not necessarily be on duty during peak periods. Since there are fewer employees in the smaller markets, there is less variation in classification and less variation in wages. Thus, the difference in total cost below $2,000 sales is likely due to the difference in total hours of work rather than wage rates.

Total labor costs were converted to average labor costs (cents per dollar sales.) These average cost curves are shown in fig. 5. The average cost curve for self-service varies from about 2.8 to 0.8 cents lower per dollar sales than service in the $500 to $2,000 range and to about 0.4 cent lower per dollar sales in markets with a sales volume of $7,000 per week.

Perhaps even more important, economically, than the difference between these curves is the relation that each bears to volume of sales. With an increase in volume of operation from $500 per week to $4,000 per week, labor costs fell from around 15 cents per dollar sales to about 7 cents.

COMPARISON OF EQUIPMENT INVESTMENT

Equipment in grocery meat departments consists, for the most part, of two types; (1) equipment for preparing meat and (2) refrigerated display and storage.[30] Basic meat preparation equipment was fairly standard in both service and self-service markets in this study. The various items of power equipment did vary in size, generally increasing with the size of the markets.

Data on kind, make and size were recorded for the major items of equipment. Refrigerated display cases are enclosed in service markets and open for customer choice in self-service markets. A wide variation exists in types of self-service meat cases available. This variation is mainly in the form of superstructure or canopy. For purposes of this study the medium-canopy type of case was used as a standard for one-shelf cases observed in self-service markets. All other types of cases were inventoried without changes.[31] Average dealer prices, based on the Des Moines vicinity, were applied to the inventory of equipment to arrive at the equipment investment in each market (see Appendix B for method of arriving at investment).

Scatter diagrams suggested a curvilinear relation-

[30] Unless stated more specifically, "equipment" includes refrigerated display cases and walk-in coolers. Preparation equipment includes power saws, grinders, slicers, scales, etc.

[31] Included in case equipment cost were allocated costs for some cases used partly for milk, cheese and delicatessen products, and frozen food cases similarly shared with foods other than meats.

$$Y_s = 50.8785 + .062265 \, X$$
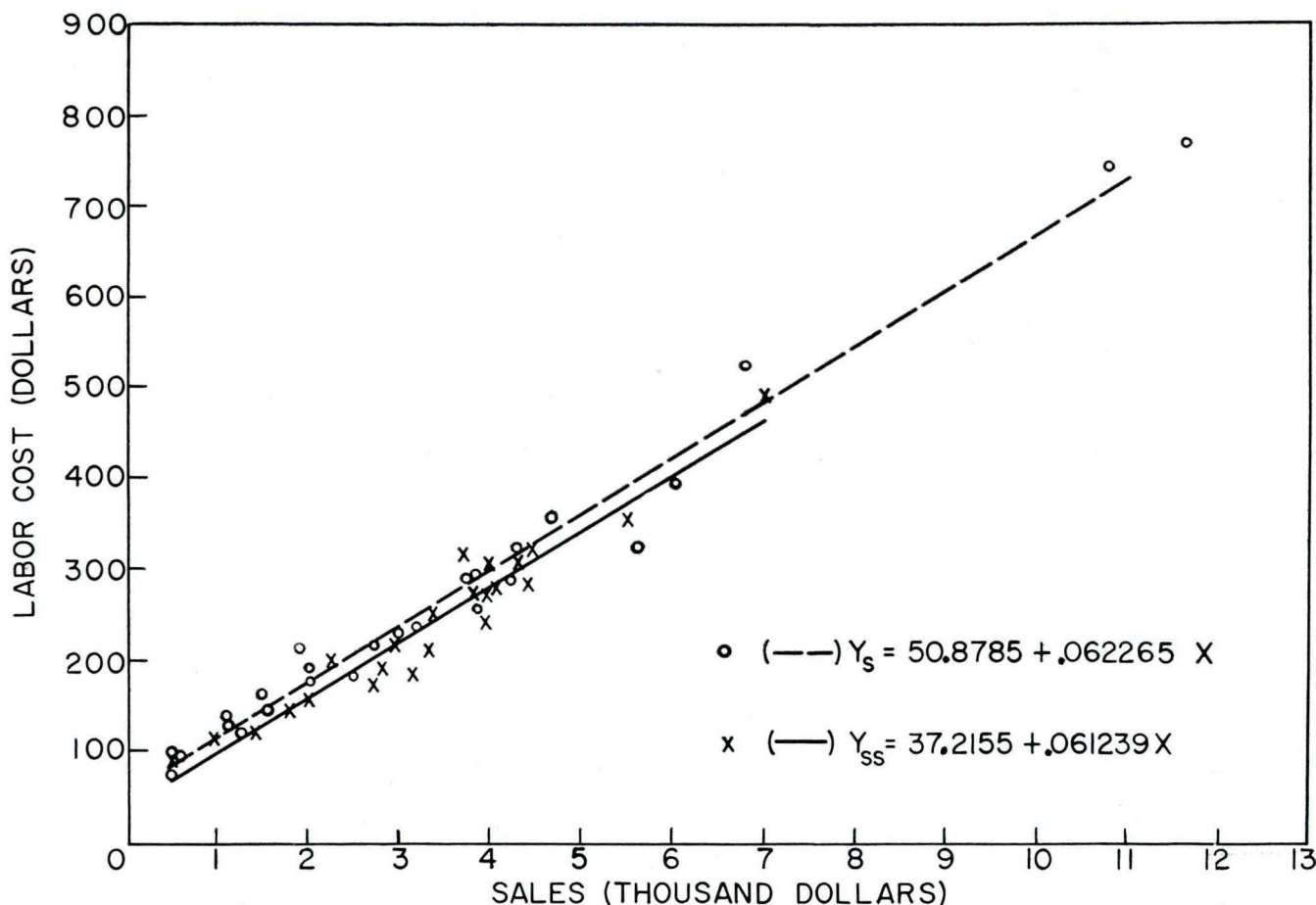
$$Y_{ss} = 37.2155 + .061239 \, X$$

Fig. 4. Relationship of total labor cost to meat department sales for 1 week.
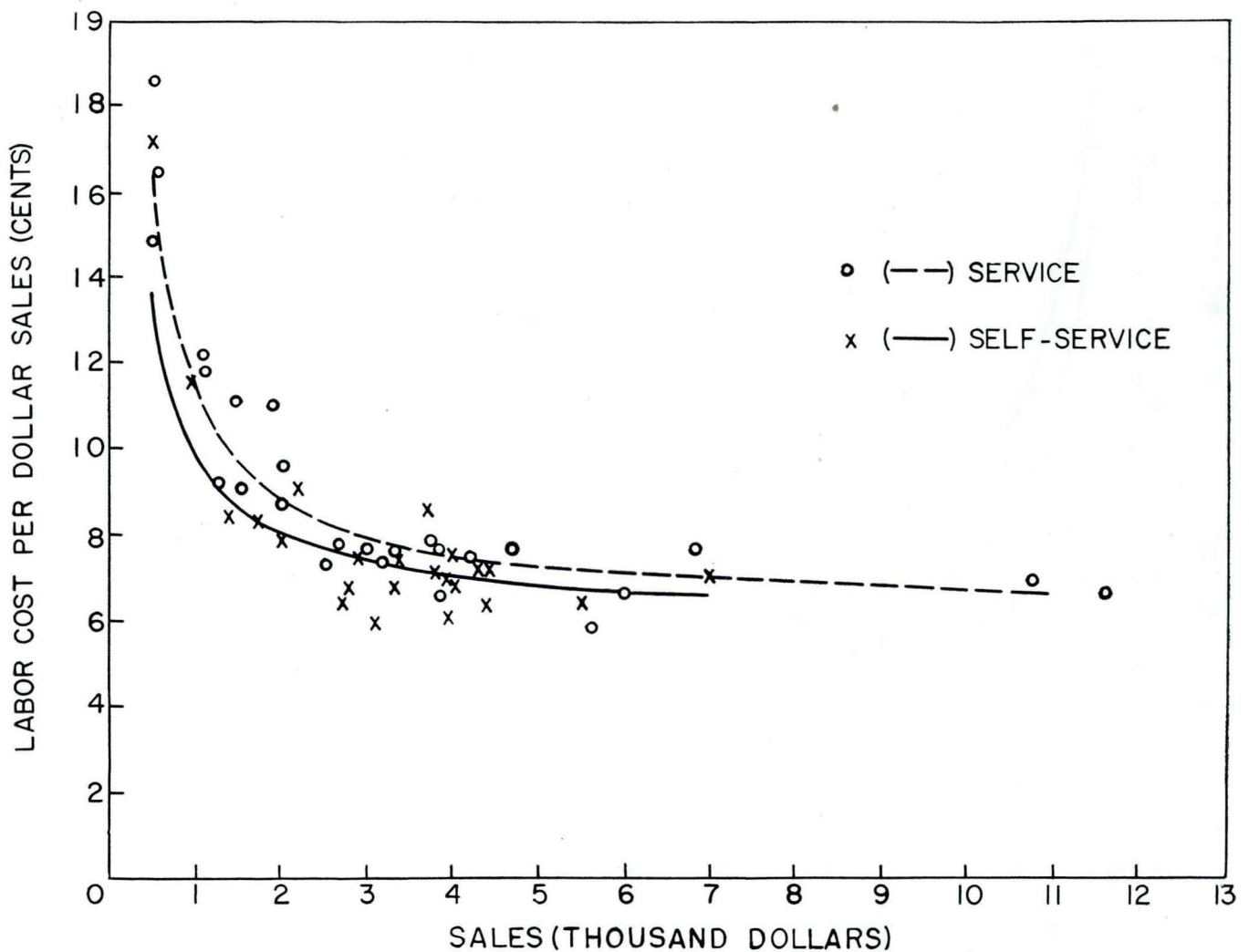
Fig. 5. Relationship of labor cost per dollar sales to meat department sales for 1 week.

ship between equipment investment and sales. Logarithmic regressions of equipment investment on sales were fitted for service and self-service operation (Appendix C).

The regressions show that investment in equipment was higher for self-service than service operation. Tests indicated a significant difference in investments between service and self-service operations (Appendix D).

Average investment curves (investment per dollar weekly sales) were derived from the total investment regression curves. They are shown in fig. 6. As the volume of sales increases, the investment per dollar sales decreases.

The major explanation of the difference in total investment is the difference in the display cases. The linear feet of display case in self-service markets is greater than that of service markets. Prices of self-service cases are higher than prices of service cases. These account for most of the higher equipment investment in self-service markets.

Additional examination of equipment investment was made in terms of the percentage each component was of the total investment (figs. 7 and 8). The per-

centage of investment in each component was relatively constant in self-service markets with approximately 62 percent of investment in cases, 22 percent in coolers and 16 percent in meat preparation equipment. Over-capacity in coolers was observed in many of the service markets, especially the smaller ones. Part of this is because some of the service markets had second-hand coolers not built in view of the needs of the particular market.

EQUIPMENT COST

The equipment investment data were reduced to a cost for equipment use for 1 week (Appendix A, tables A-2 and A-4). This cost is the week's portion of the charge of depreciation, maintenance and interest over a 10-year period on a straight-line basis. Straight-line depreciation ignores actual use and introduces a linear bias. Though depreciation and maintenance is overstated for some equipment, this is partly offset by rapid obsolescence in others. Since this cost is a form of restatement of the investment in equipment, the analysis is not presented. The cost is included, however, as part of the combined cost discussed later.
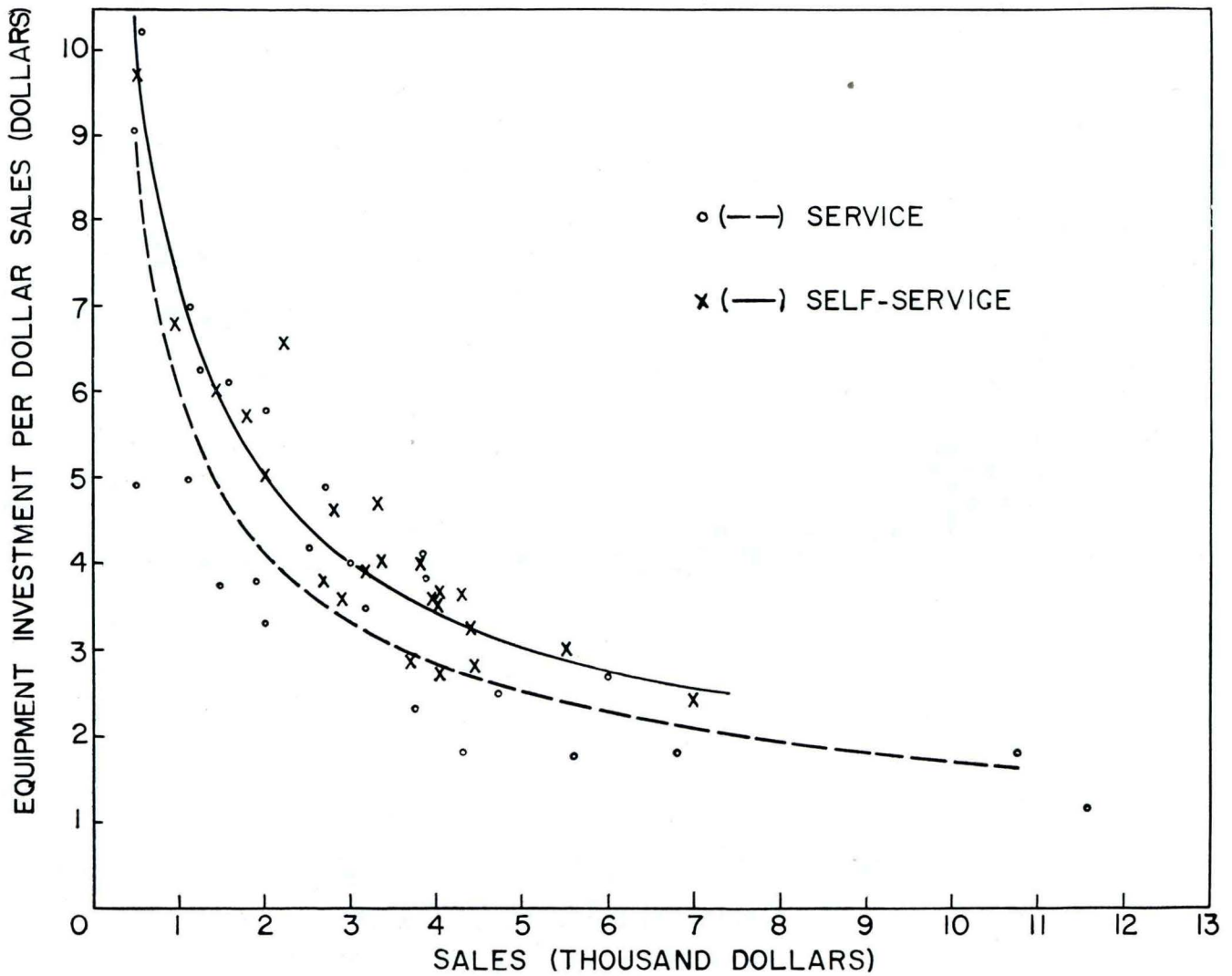
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Fig. 6. Relationship of investment per dollar sales to meat department sales for 1 week.
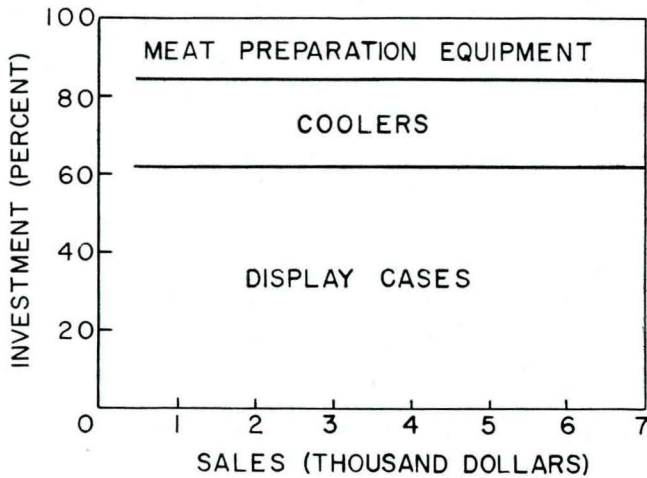

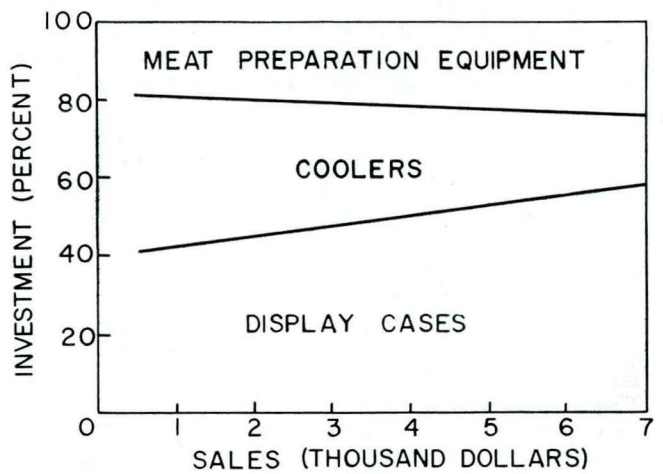Fig. 7. Relationship of percentage investment in equipment to sales in self-service meat departments.

Fig. 8. Relationship of percentage investment in equipment to sales in service meat departments.

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Food store managers usually charge a rental to each department based on the percentage departmental sales are of total sales rather than on space actually occupied. Rent also varies widely, due to numerous factors, particularly the location of the store. To remove such differences and provide a more homogeneous and objective basis for the charge for floor space, the square foot area occupied by the meat department was used. Measurements of square feet of "market area" and of "total retail area" in each store were recorded (Appendix A, tables A-1 and A-3).[32]

Regressions were fitted to the data (Appendix C). Tests of significance of the observed differences showed no significant difference in total space used by the two types of operation (Appendix D). Although self-service requires more floor space for cases and shopping aisle, service markets with less than $3,000 weekly sales used more cooler space than self-service markets (this was over-capacity, however, and not a requirement). These two differences in the use of floor space probably off-set each other in the total floor space used.

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[32] The "market area" included meat preparation area, space occupied by coolers and display cases, and an allocation of 3 square feet of aisle per linear foot of display case. The "total retail area" consists of the "market area" plus the remainder of the store but excluding the storage area or any area not common to most grocery stores such as bakery shops, coffee stands, etc. "Total store area" is defined to include a storage area.

Average curves were derived from the total curves to show the relationship to sales of square feet per dollar sales (fig. 9). The curves indicate a considerable increase in efficiency in use of space as the size (in terms of square feet as well as dollar sales) of the market increased for both types of operation.

Given comparable total rents, the cost chargeable to the meat department for use of floor space would not be different between service and self-service methods. Service markets were generally in older buildings and a better working layout was often limited by separation walls. Remodeling would be necessary to improve efficiency of operation. Self-service markets were generally in newer and more modern buildings and some definite planning had gone into the size and layout of the meat department. Some self-service markets are converted from service markets with limited or no structural changes in the building.

The relationship of the market area to the "total retail area" (defined in footnote 32) was also examined. The self-service market area declined from about 16 percent of the total retail area in markets with $1,000 meat sales volume per week to about 12.5 percent at $6,000 sales. The service market area represented about 16 percent of the total retail area throughout the range $500 to $7,000 sales. Variation in market space as a percent of "total retail area" was greater in service operation than in self-service.
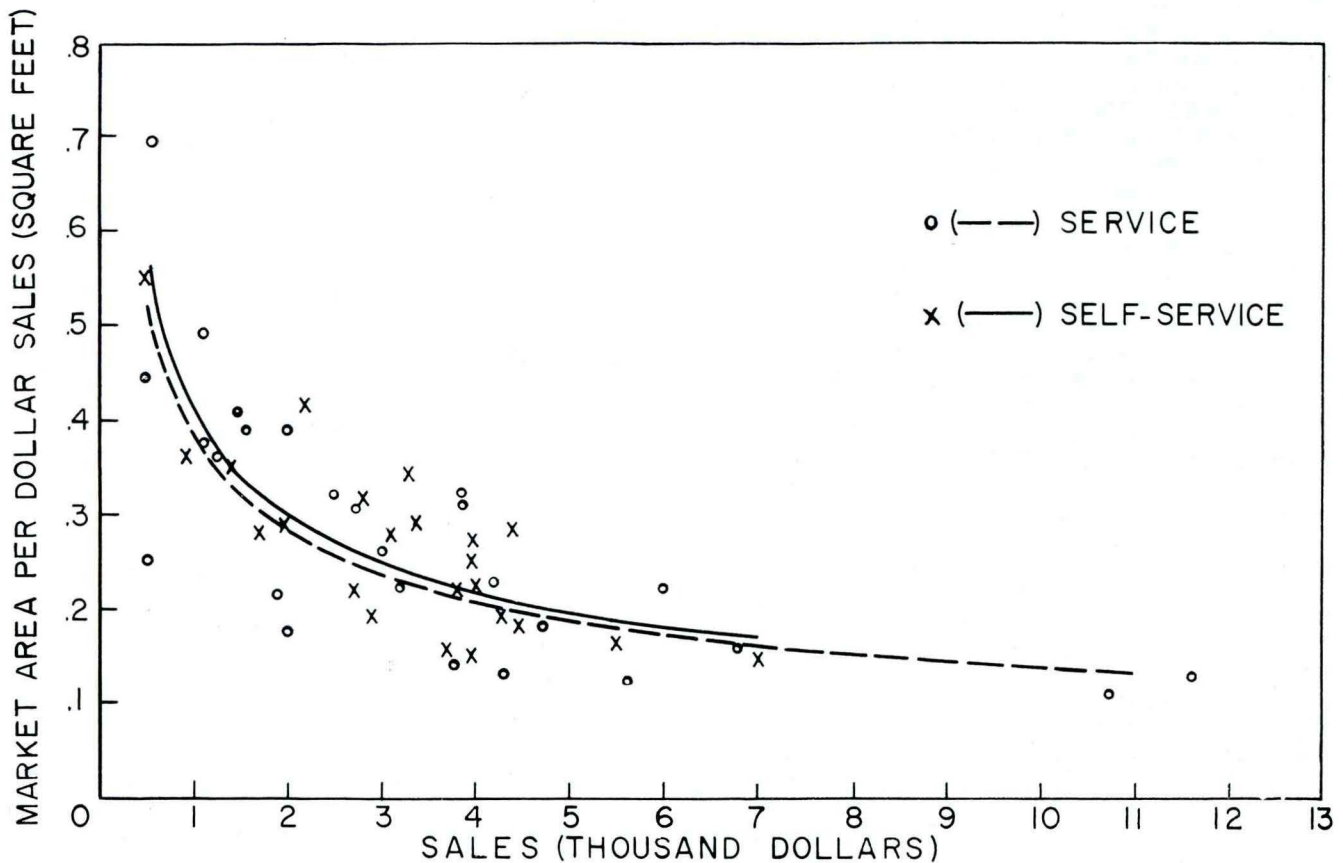

Fig. 9. Relationship of square feet of meat department area per dollar sales to meat department sales for 1 week.

If the total store area (including storage) had been used as a base, the proportions used by the market would be even less than those shown above. Meat departments are expected to average at least 25 percent of the total store sales, resulting in a rental charge much above one based on floor space used.[33]

COST OF THE MARKET AREA

To arrive at a cost figure for floor space (in lieu of rent) a budgeting procedure was used. The amount of storage space varies considerably between stores and is affected by many factors, usually dependent on the individual case. The square feet of floor space used for storage was measured in nine of the stores taken at random. Suggestions on the amount of storage space that would be recommended in the construction of new stores were obtained from people in the retail food business who were concerned with store planning. On the basis of this information, a 25 percent addition was made to "total retail area" in each store for storage purposes, and the total square feet was also adjusted upward for space occupied by outside walls.

Boeckh's Building Cost[34] was used to compute a cost of construction for various size rectangular grocery store buildings of modern design. The base price per square foot was adjusted to 1952 prices by Boeckh's current index for the Des Moines area.[35] A graph was constructed based on these data. The curvilinear relationship indicated a decreasing cost of construction per square foot as size of store increases. Costs were taken from the graph and applied to the square foot area computed for each store to furnish a cost of construction in the Des Moines area for 1952.[36] These data are entered in Appendix A, tables A-1 and A-3 as building investment.[37]

A depreciation and maintenance charge of 2 percent per year plus an annual interest charge of 2 percent of investment were computed and reduced to a single week.[38] The percentage that the meat department space was of total store space was applied to this figure to yield a charge to the meat department for floor space for 1 week (in lieu of rent). These costs are shown as "building costs" in Appendix A, tables A-2 and A-4.

These costs appear low.[39] The simple average cost ("rent") per dollar sales was 0.18 cent in service markets and 0.15 cent in self-service markets.

[33] National Association of Retail Grocers. op. cit. p. 4.
[34] Boeckh, E. H. Building costs—a statistical service published monthly. Vol. 7, No. 2. E. H. Boeckh & Assoc. Washington, D. C. 1950.
[35] Boeckh, E. H. Building costs—a statistical service published monthly. Vol. 9, No. 12. E. H. Boeckh & Assoc. Washington, D. C. 1952.
[36] The construction costs based on these data are in substantial agreement with those computed for a somewhat more elaborate store by the National Association of Retail Grocers (National Grocers Bulletin. Super market of tomorrow. Vol. 38, No. 2. p. 38-39. 1951).
[37] The investment is for the building only and does not include investment in land. It also does not include investment in shelving, check-out and similar selling equipment.
[38] This rate of depreciation reduces the investment in building to 20 percent in 40 years and is suggested by Boeckh for buildings of this type (Boeckh, E. H. Boeckh's manual of appraisals. 4th ed. The Rough Notes Co., Inc., Indianapolis. 1945). However, this rate may be conservative in terms of use for grocery stores because of obsolescense.
[39] The charge for space (in lieu of rent) arrived at in this way understates actual cost since the investment in building did not include land. It likely further understates a rental charge since rental (of which the meat market commonly bears a percentage based on sales) often includes a charge for selling equipment, such as shelving, and for parking space. It probably further understates usual rental charges because it was based on space used rather than percent of sales.

Whether the costs for floor space were high or low would not affect the comparison between service and self-service operation in this study since the square feet of floor space used, as well as cost per dollar sales, are shown not to differ significantly. If the estimates are slightly low for these costs ("rents"), then the only effect is to lower both cost curves a small amount.

COMPARISON OF COST FOR PAPER SUPPLIES

Estimates were made by market managers of quantities of each kind of paper material used for 1 week. An average of prices of several suppliers was applied to the quantity data (by kind of paper) to arrrive at a total cost (Appendix A, tables A-2 and A-4). Linear regressions were fitted to the data (Appendix C, table C-1).[40]

The relationship of total costs of paper supplies to sales for both methods of meat retailing was ascertained. Tests of significance of the observed difference are given in Appendix D, table D-1.

Average cost curves were derived from the total cost curves (fig. 10). Paper supplies are about constant at 1.6 percent of sales for self-service and 1.2 percent of sales in service markets above $3,000 weekly volume. The observed differences in cost of paper supplies are due to higher cost for transparent paper and the use of backing boards, trays and labels in self-service operations.

Since average paper supply cost is relatively constant while other costs declined considerably at the lower volumes, paper supply cost would tend to be an increasingly greater percentage of the combined costs as sales volume increases. Thus, percentage-wise this item may offer greater opportunities for cutting costs at larger volumes than at smaller volumes. In the larger market, the paper supply cost, because of its size and variable nature, may be more important than the charge for equipment and rent together.

COMPARISON OF COMBINED COSTS

The costs of labor, equipment, market space and paper supplies for 1 week were added to yield a "combined cost" (Appendix A, tables A-2 and A-4). Scatter diagrams of combined cost plotted against sales volume indicated a linear relationship between the combined cost and the size of market. Linear regression equations were fitted to the data (Appendix C).

The differences in "a", "b" and regression Y values were not significant (Appendix D). Although significant differences were observed in some of the individual cost items analyzed earlier, they apparently tend to offset one another when the individual costs are combined.

The regressions of combined cost on sales were converted to average long-run cost curves in terms of cents per dollar sales (fig. 11). The important economic relationship of average cost and size is well illustrated by both curves. A considerable decrease in cost of operation is evident as the size of the market increases to about $3,000 weekly sales

[40] The data on paper supplies consisted of fewer observations than in most of the regressions.
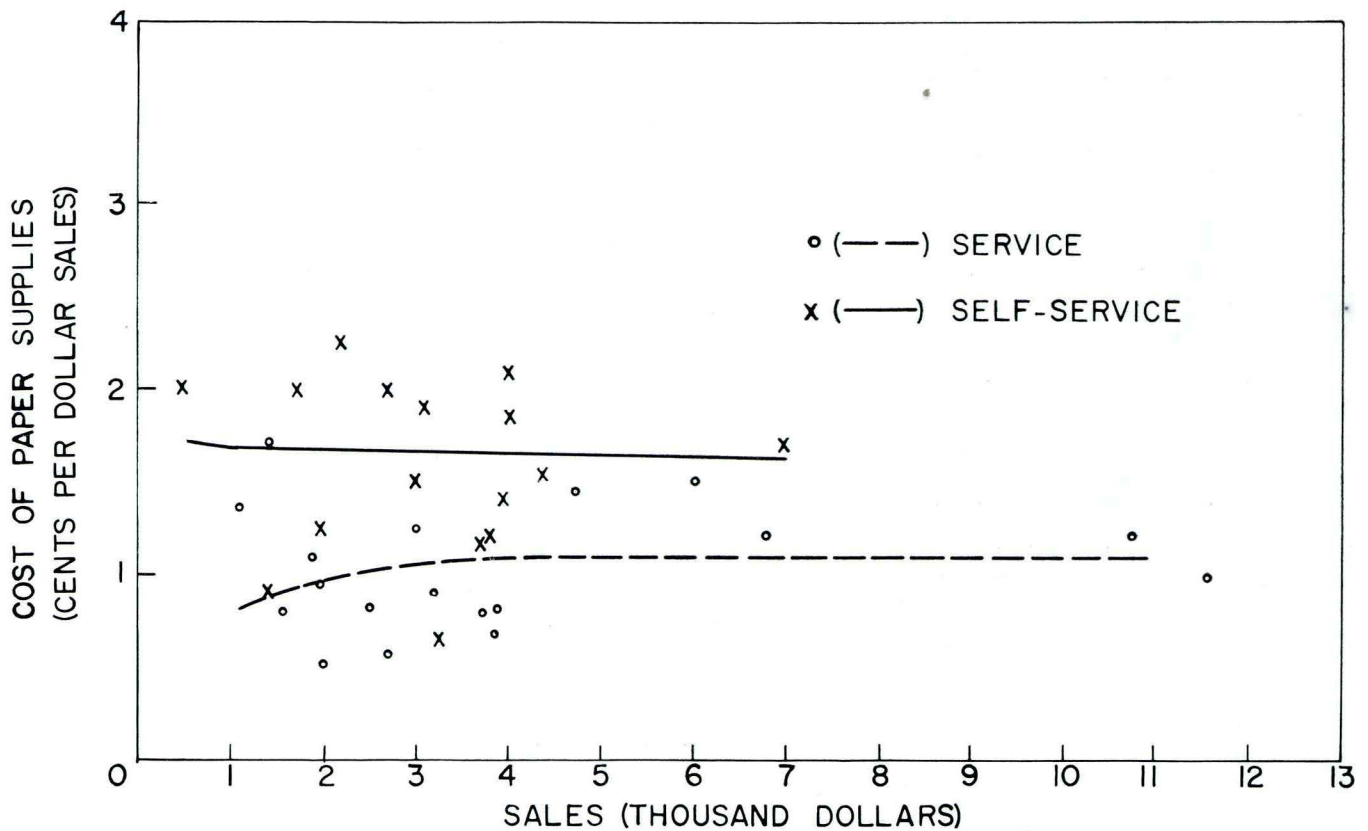
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Fig. 10. Relationship of cost of paper supplies per dollar sales to meat department sales for 1 week.

volume. The level of the combined cost curve is subject to some fluctuation, as noted earlier, and must be interpreted with this in mind.

DISCUSSION

Costs in this study represented about 85 percent of the total costs. Except for electricity, the remaining costs would not be expected to differ between the service and self-service method in markets of of the same sales volume and relatively homogeneous in other respects. There is probably some difference in use of electricity with self-service consumption, presumably higher. It seems likely, however, that the costs covered in this study are indicative of results that could be expected if extension were made to all cost items.

Within the range $500 to $7,000 sales per week, costs for both service and self-service methods tend to fall as the size of the operation (sales volume) increases. The average combined cost examined in this study decreases from about 19 cents per dollar sales at a $500 weekly sales volume to 10 cents per dollar sales at $3,000 sales per week. From a $3,000 size market to one with sales of $6,000 per week, the decline in cost was about 1 cent. Increasing the size of the market is an important means of lowering average costs in both types of operation. The greatest opportunity for lowering costs is in the range $500 to $3,000 weekly sales volume. Beyond $3,000 sales

per week, costs can still be lowered but the decline is not as great as in the lower sales volume range.

It has been generally accepted that self-service increases the volume of sales. Thus, though there is no cost difference at any given volume of sales between service and self-service methods of selling meat, the conversion to self-service may result in a greater volume and move the market out farther on the long-run average cost curve and thus to a lower cost level. When market operators are heard to say that their costs are lower after converting to self-service, it is not because of the transfer from one cost curve to the other but it is this movement along the cost curve that is really taking place. Had the operator been able to increase his market size under the service method, the cost would also have been lower than before and for the same reason.

Most food stores could expand their meat department sales without needing to add floor space or equipment. Generally, however, costs are a function of size where size means more floor space, more display equipment and larger food stores, as well greater sales volume. This study does not suggest any cost limit to the size of operation. This may be particularly significant when related to self-service. The self-service method of selling meat has favorably influenced the trend toward the supermarket type of operation by encouraging modernization and expansion. To the extent that they encourage the trend toward larger markets, self-service meats also result in
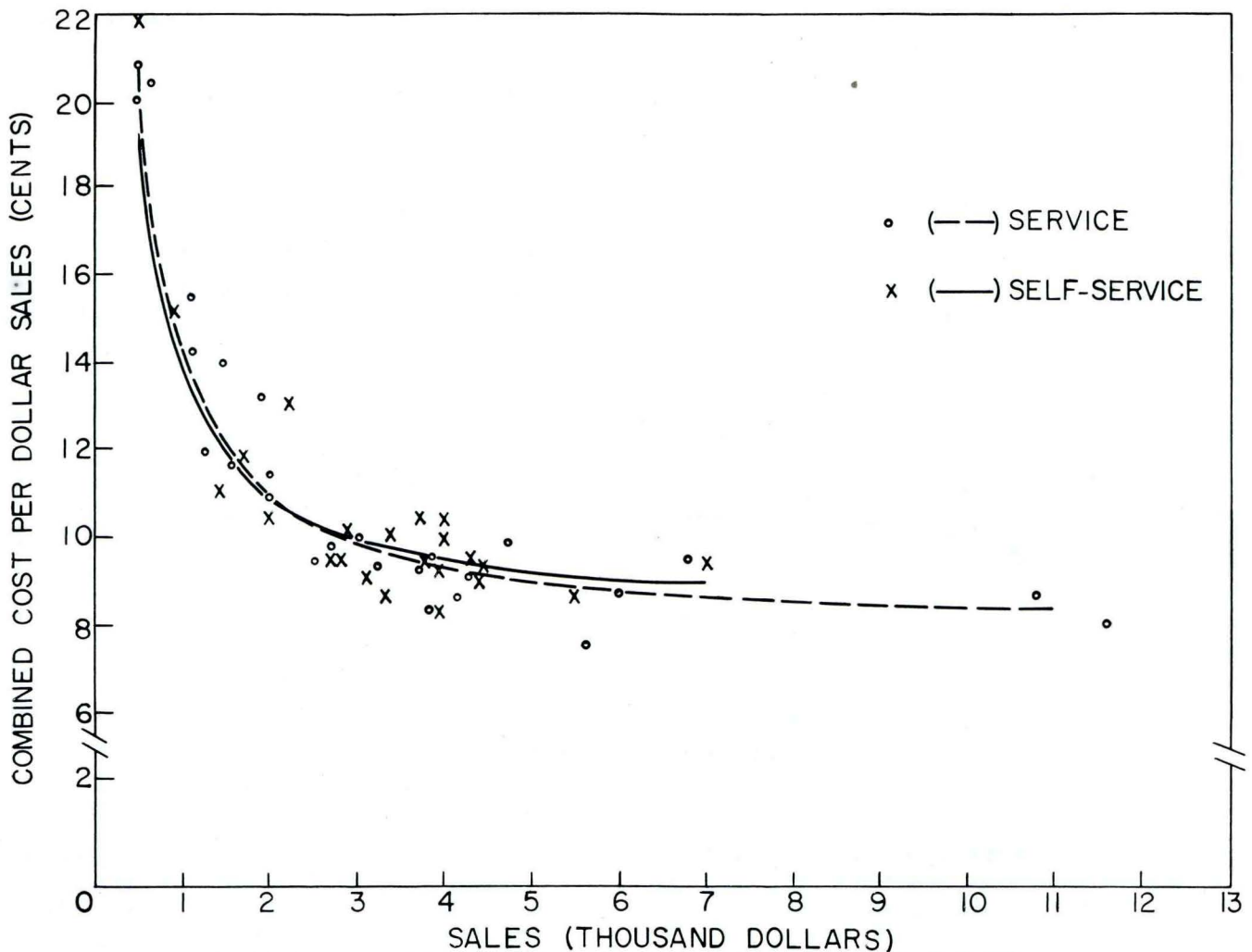
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Fig. 11. Relationship of combined costs per dollar sales to meat department sales for 1 week.

lower costs of operation since the market is then located farther out on the long-run cost curve.

The above does not mean that self-service is not adaptable to small stores. At any given volume, self-service and service markets have comparable costs. The analysis suggests, however, that an increase in the average size of small stores is encouraged by self-service meats. The "corner grocery" is gradually being replaced by the "superette," and the change is one of physical size and sales volume as well as of name.

The change to self-service methods will likely continue even though there is no cost advantage over the service method at any given volume. The major incentive is the expected increase in volume of sales (which then results in lower cost). Self-service has proved to be an excellent solution to the "rush hour" problem in meat markets. Consumer acceptance, an early deterrent to adoption of self-service meats, is no longer considered a major problem. The self-service method of operation reduces the need for skilled labor, increases the percentage of meat sales as a percentage of total sales and promotes rapid turn-over of meat. This decreases the need for large in-

ventory and permits better control over the meat supply in the market. Although self-service also introduces new problems, it appears from the rapid adoption of the method that the advantages outweigh such problems.

It is most likely that self-service methods will, in time, acount for the greatest proportion of meat sales, as compared with about 14 percent in 1952, but the service method will continue to be used for many years. Some meat markets have established their trade on the basis of personal service, and in these cases it could well be that converting to self-service would destroy the particular distinction which makes them preferable to some consumers.

The supermarket type of operation requires a relatively large investment in building and equipment. The initial investment, generally much greater than in the past, is a problem of financing and tends to restrict entry into the trade.

Self-service may eventually lead to centralized pre-packaging and may in some cases eliminate the need for meat market facilities in stores, except for display cases. Centralized pre-packaging of many frozen meats, poultry and fish, and processed meats has al-

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ready proven successful. Packers and others are investigating the problems of centralized pre-packaging. Although it is likely that technological and other problems will continue to delay centralized pre-packaging of fresh meats for some time, this may be the next step.

Changes in demand for meat may also result from self-service. It has been observed that inferior cuts have been much easier to sell, and at higher prices, in self-service than in service markets. This may result, in time, in less spread in price between cuts. Presumably the less desirable cuts may increase in price permitting more expensive cuts to become cheaper while over-all margins remain the same. There are also indications that impulse buying in self-service markets results in the customer buying more meat than was originally on the shopping list.

Whether the new emphasis in the retail food industry on greater efficiency, new methods, better record keeping and modernization will eventually bring about over-all differences in costs between the service and self-service methods of selling meat remains to be seen. It is more likely, for the next decade or so, that these new trends will pervade both methods in the industry so that both become more efficient with no marked difference in over-all costs.

APPENDIX A

TABLE A-1. SALES AND LABOR HOURS FOR OCTOBER 6 TO 11, EQUIPMENT INVESTMENT, MEAT DEPARTMENT AND TOTAL STORE AREA, AND BUILDING INVESTMENT IN SERVICE MEAT DEPARTMENTS IN A SAMPLE OF 26 RETAIL FOOD STORES IN IOWA, 1952.°

Market	Meat department sales	Labor hours	Equipment investment	Meat department area	Total retail area	Building investment
	(dollars)	(hours)	(dollars)	(sq. ft.)	(sq. ft.)	(dollars)
1.	2,000	118	6,634	350	2,873	33,500
2.	1,466	93	5,449	603	3,350	36,000
3.	6,800	323	12,268	1,008	2,856	33,500
4.	1,100	80	7,794	535	3,910	40,100
5.	550	58	5,636	382	1,851	26,000
6.	3,000	149	11,851	791	5,789	50,200
7.	1,100	81	5,499	414	3,311	37,000
8.	6,000	282	16,075	1,333	7,563	58,200
9.	4,700	244	11,670	869	6,219	52,200
11.	2,500	130	10,546	803	4,121	41,500
10.	1,900	141	7,016	411	1,170	21,800
12.	2,050	123	11,883	800	5,073	46,500
13.	3,850	189	15,955	1,242	7,546	58,200
14.	3,850	173	14,539	1,224	8,144	61,100
15.	3,750	185	8,554	530	2,327	30,000
16.	11,642	475	14,255	1,547	6,043	51,400
17.	500	40	4,508	224	1,237	21,000
18.	4,300	192	7,866	576	2.494	31,000
19.	1,550	94	9,532	603	4,607	44,000
20.	10,750	490	19,593	1,089	7,133	56,900
21.	3,200	157	11,518	717	5,453	48,500
22.	500	50	2,457	129	985	18,000
23.	1,250	70	7,843	451	3,088	35,200
24.	2,700	132	13,178	828	5,345	48,000
25.	4,200	171	11,555	974	6,132	52,000
26.	5,608	193	10,348	703	6,789	55,000

° See Appendix B for definition of variables and computational procedure.

TABLE A-2. COMPUTED COSTS OF LABOR, EQUIPMENT, BUILDING AND PAPER SUPPLIES IN SERVICE MEAT DEPARTMENTS IN A SAMPLE OF 26 RETAIL FOOD STORES IN IOWA OCTOBER 6 TO 11, 1952.°

Market	Labor cost	Equipment cost	Building cost	Paper supplies cost	Combined cost
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
1.	192.00	15.31	2.35	19.00	228.66
2.	163.62	12.50	3.74	25.00	204.86
3.	526.60	28.31	6.82	83.00	644.73
4.	134.76	17.99	3.16	15.00	170.91
5.	91.14	13.01	3.10	5.00	112.25
6.	228.92	27.35	3.96	38.00	298.23
7.	130.86	12.70	2.67	11.00	157.23
8.	394.07	37.09	5.92	89.00	526.08
9.	363.58	27.10	4.21	68.00	462.89
10.	210.69	16.19	4.41	21.00	252.29
11.	182.30	24.34	4.71	21.00	235.35
12.	178.38	27.42	4.23	11.00	221.03
13.	297.71	36.82	5.52	26.00	366.05
14.	252.88	33.55	5.30	31.00	322.75
15.	294.45	19.74	3.94	31.00	349.13
16.	777.00	32.89	7.59	116.00	933.48
17.	74.40	10.40	2.19	4.00	99.99
18.	322.56	18.16	4.13	47.00	391.85
19.	141.94	22.00	3.32	13.00	180.26
20.	747.30	45.22	5.01	129.00	926.53
21.	237.23	26.58	3.68	30.00	297.49
22.	93.00	5.68	1.41	4.00	104.08
23.	115.68	18.10	2.96	12.50	149.24
24.	210.56	30.41	4.29	15.00	260.26
25.	289.48	26.66	4.76	46.00	366.90
26.	325.15	23.88	3.28	62.00	414.90

° See Appendix B for definition of variables and computational procedure.

TABLE A-3. SALES AND LABOR HOURS FOR OCTOBER 6 TO 11, EQUIPMENT INVESTMENT, MEAT DEPARTMENT AND TOTAL STORE AREA, AND BUILDING INVESTMENT IN SELF-SERVICE MEAT DEPARTMENTS IN A SAMPLE OF 23 RETAIL FOOD STORES IN IOWA (AND PART OF ILLINOIS), 1952.°

Market	Meat department sales	Labor hours	Equipment investment	Meat department area	Total retail area	Building investment
	(dollars)	(hours)	(dollars)	(sq. ft.)	(sq. ft.)	(dollars)
1.	4,000	212	14,571	1,100	6,412	53,100
2.	2,713	134	10,349	621	5,015	46,200
3.	1,400	70	8,392	487	2,591	31,900
4.	500	50	4,858	276	1,428	23,000
5.	1,770	107	10,146	498	4,056	40,900
6.	3,961	191	14,409	984	7,379	57,600
7.	950	70	6,495	343	1,854	26,500
8.	2,800	145	12,787	886	6,420	53,200
9.	3,800	232	15,292	853	5,041	45,000
10.	3,700	255	10,527	585	4,114	41,000
11.	4,015	188	14,031	902	9,654	67,200
12.	3,120	128	12,511	867	6,265	52,500
13.	2,000	111	10,009	575	4,080	41,000
14.	3,970	189	10,685	603	4,311	41,000
15.	2,910	178	10,369	555	4,000	40,500
16.	4,400	217	14,337	1,248	8,475	62,900
17.	3,300	148	15,478	1,113	8,250	56,800
18.	2,214	135	14,508	919	5,307	47,900
19.	5,500	285	16,879	881	8,033	60,500
20.	3,350	188	13,514	969	6,954	55,000
21.	4,300	216	15,602	833	7,603	58,500
22.	4,472	244	12,407	821	5,326	47,900
23.	7,000	392	16,732	1,000	6,125	51,800

° See Appendix B for definition of variables and computational procedure.

TABLE A-4 COMPUTED COSTS OF LABOR, EQUIPMENT, BUILDING AND PAPER SUPPLIES IN SELF-SERVICE MEAT DEPARTMENTS IN A SAMPLE OF 23 RETAIL FOOD STORES IN IOWA (AND PART OF ILLINOIS), OCTOBER 6 TO 11, 1952.°

Market	Labor cost	Equipment cost	Building cost	Paper supplies cost	Combined cost
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
1.	304.19	33.62	5.22	75.00	418.03
2.	174.48	23.89	3.30	54.00	255.67
3.	117.74	19.35	3.46	13.00	153.55
4.	86.10	11.21	2.56	10.00	109.87
5.	147.40	23.41	2.90	36.00	209.71
6.	273.49	33.25	4.43	55.50	366.67
7.	110.62	14.99	2.83	15.50	143.94
8.	190.49	29.51	4.24	40.50	264.74
9.	276.00	35.29	3.03	45.00	359.32
10.	318.11	24.29	2.21	43.00	387.61
11.	272.24	32.38	3.61	89.00	397.23
12.	186.45	28.85	4.21	59.00	278.51
13.	156.97	23.10	3.33	25.00	208.40
14.	242.24	24.64	3.31	56.00	326.19
15.	218.84	23.93	3.24	49.00	295.01
16.	284.10	33.08	5.34	69.00	391.52
17.	223.20	35.72	4.39	22.00	285.31
18.	200.25	33.48	4.79	50.00	288.52
19.	356.22	38.95	3.82	78.00	476.99
20.	253.50	31.19	4.55	47.50	336.74
21.	311.63	36.00	3.70	60.00	411.33
22.	322.24	28.63	4.26	63.50	418.63
23.	495.90	38.62	4.86	119.00	658.38

° See Appendix B for definition of variables and computational procedure.

Definition of the variables and computational procedures concerning data in Appendix A, tables A-1, A-2, A-3, and A-4.

(1). Meat department sales:

These are managerial estimates of meat department sales from October 6 to 11, 1952. Analysis of both service and self-service sales indicated that these are probably a better indiciaton of an average week for this season than recorded data would be.

(2). Labor hours:

This is the total of the number of hours of labor in the meat department.

(3). Equipment investment:

This is a computed figure. The kind, model, size and manufacturer of each piece of meat preparation and refrigerating equipment was inventoried. Information was then obtained from four or more manufacturers and dealers for each type of equipment. Condensing unit requirements for refrigeration, quoted prices for each item, model and size, usual discounts, and servicing and installation charges were all used in the computations to arrive at an average of dealers' prices for similar models and sizes of equipment. These prices were then applied to the equipment inventory (including all meat department refrigeration and display cases) to arrive at equipment investment for each meat department.

(4). Meat department area:

This is the square feet of area of the meat department measured inside the walls of the store. It includes the cutting (work area), display cases and cooler area, and 3 square feet of aisle per linear foot of display case.

(5). Total retail area:

This figure includes the square feet of the meat market area (4) above and the rest of the retail selling area of the store (also measured within the store walls). It excludes the storage (warehouse area) and any area (such as a coffee stand, flower shop or bakery) not common to most retail food stores. A steel tape was used to measure (4) and (5) as well as the sizes of coolers and display cases in the market.

(6). Building investment:

Total retail area (5) was adjusted upward to allow for a 25-percent storage area and the area of outside walls. Boeckh's Building Costs (page 58) was used to compute the cost of construction per square foot of various size rectangular retail food stores of mod-

ern design. The construction cost per square foot was adjusted to 1952 prices by Boeckh's current index for the Des Moines area. A graph was made of the relationship of construction cost to square feet. These costs were applied to the square foot area for each store to arrive at a building investment.

(7). Labor cost:

Meat department employees were classified as head meat cutter, journeyman, apprentice, wrapper and helper. Actual wages were recorded and an average wage computed from them for each job classification. Union wages in several cities in and around Iowa were also averaged for each job classification. A standardized wage was computed as a simple average of the actual wages and the average of union wages for each job classification. The standardized wage was higher than the average of actual wages paid and lower than the average of the several union wage schedules.

(8). Equipment cost:

Straight line depreciation over a 10-year period was used to reduce the equipment investment to zero value. An interest rate of 2 percent was charged on investment. The depreciation and interest charge reduced to 1 week was used as equipment cost.

(9). Building cost:

The building investment in (6) was depreciated to 80 percent of its value in 40 years. A depreciation and maintenance charge of 2 percent per year plus an annual interest charge of 2 percent of investment were computed and reduced to a single week. The percentage that the meat department was of the total store area (including storage area) was computed and multiplied by this figure to arrive at a charge for square feet used by the meat department for 1 week. This charge (used in lieu of rent) understates rent somewhat because no charge was made for investment in land and none for selling equipment both of which often enter the rental.

(10). Paper supplies cost:

Managers' estimates of paper supplies used, by kind and size, were recorded. These were multiplied by an average of prices of several suppliers to arrive at cost of paper supplies. This data could not be secured in a few stores. The cost for supplies in these cases, for use in "combined cost," were taken from the regressions of the available data.

(11). Combined cost:

Combined cost is the sum of the total cost for 1 week under (7), (8), (9) and (10) above.

APPENDIX C

TABLE C-1. SUMMARY OF REGRESSIONS OF LABOR COST, EQUIPMENT INVESTMENT, MARKET SPACE, PAPER SUPPLIES AND COMBINED COSTS ON SALES; SERVICE AND SELF-SERVICE OPERATION.

Regression	Method of operation	"a"	"b"	r^2	F	$s^2 y.x$
Labor cost on sales	Service	50.88	0.062265	0.98	1,131**	698
	Self-service	37.22	0.061239	0.94	316**	563
Equipment investment on sales	Service	2.418610	0.454787	0.71	58**	0.012506
	Self-service	2.452846	0.468601	0.81	90**	0.003492
Market space on sales	Service	0.913056	0.556951	0.71	30**	0.028052
	Self-service	0.989303	0.541407	0.69	47**	0.008959
Paper supply cost on sales	Service	-3.810920	0.011669	0.91	152**	139
	Self-service	0.540463	0.016194	0.73	38**	233
Combined cost on sales	Service	66.3600	0.076509	0.98	1,489**	799
	Self-service	55.7173	0.080918	0.95	445**	697

** Denotes significance of difference at the 1-percent level of probability.

APPENDIX D

The curves showing relationship of cost to sales under service and self-service operation were tested for statistical significance of difference. Tests were first made to determine the homogeneity of the variances.[41] When homogeneity was accepted, the variances were pooled. The differences between "a" coefficients, "b" coefficients, and selected regression ($\hat{Y}$) values for service and self-service operation were then tested by means of the "t" test.[42] When homogeneity did not appear acceptable, variances were not pooled and a test procedure suggested by Snedecor[43] was used.

The statistical tests of differences between regressions used in this study do not appear to have been used extensively in empirical economic studies. This may be due to two reasons: (1) The more common use of regression techniques is concerned primarily with determining the relationship between a dependent and independent variable rather than with a comparison between groups of data (or several regressions). (2) Even where regression techniques would appear more suitable, many studies concentrate interest only on means. Tests of significance of difference are commonly made on the means alone when groups of data are examined for significant differences.

It should be noted that where regression is applicable, tests of means alone (or of "a" and "b" alone) could easily lead to erroneous inferences. Even where regression is used and tests of significant differences between various coefficients are made, the tests do not necessarily lead to the same answers and must, therefore, be interpreted from a knowledge of the subject matter.

[41] Snedecor, George W. Statistical methods. 4th ed. p. 249. The Iowa State College Press, Ames, Iowa. 1946.
[42] The nature of the "t" tests used here may be found in various statistics texts, for example; McNemar, Quinn. Psychological statistics. p. 223, John Wiley and Sons, Inc., New York, 1949. A parallel procedure using "F" in analysis for covariance is illustrated by Snedecor, op. cit. p. 326.
[43] Snedecor, Statistical methods. op. cit. p. 83.

TABLE D-1. SUMMARY OF TESTS FOR HOMOGENEITY OF VARIANCE AND SIGNIFICANCE OF DIFFERENCES BETWEEN REGRESSIONS OF TOTAL LABOR COST, EQUIPMENT INVESTMENT, MARKET SPACE, PAPER SUPPLY COST AND COMBINED COSTS ON SALES.

Regression	Homogeneity of Variance	Significance of differences Value of "t" for			
		a_s-a_{ss}	b_s-b_{ss}	$\hat{Y}_s$-$\hat{Y}_{ss}$ at:	
	F			X=3,401	X=5,000
Labor cost on sales	1.23	0.89	0.252	2.32*	1.90
Equipment investment on sales	3.58†	0.123	0.178	2.83**	2.59*
Market space on sales	3.13†	0.070	0.117	0.529	0.368
Paper supply cost on sales	1.67	0.332	1.81	4.35**	4.37**
Combined cost on sales	1.15	0.637	0.999	0.556	1.02

* Denotes significance of difference at the 5-percent level of probability.
** Denotes significance of difference at the 1-percent level of probability.
† Denotes significance of difference at the 10-percent level of probability.

APPENDIX E

TABLE E-1. SUMMARY OF ANALYSES OF REGRESSIONS OF HOURS OF LABOR ON SALES.§

Method of operation	a	b	r^2	F	$s^2_{y.x}$
Service	31.86	0.039695	0.97	860°°	373
Self-service	9.75	0.050703	0.92	237°°	514

§ The "a" indicates the level of Y at X=O and "b" is the coefficient of regression. The "r^2" measures the proportion of the variance in Y associated with X. F is a test of the significance of regression. The variance estimate ($s^2_{y.x}$) is a measure of unexplained variation about regression.

°° Denotes significant (at the 1-percent level of probability) reduction in total sum of squares, due to regression.

TABLE E-2. SUMMARY OF TESTS FOR HOMOGENEITY OF VARIANCE AND SIGNIFICANCE OF DIFFERENCES BETWEEN REGRESSIONS OF HOURS OF LABOR ON SALES.§

Homogeneity of variance	Significance of differences			
			Values of "t" for	
F	a_s-a_{ss}	b_s-b_{ss}	$\widehat{Y}_s-\widehat{Y}_{ss}$ at:	
			X=3,401	X=5,000
1.38†	1.72	3.26°°	2.56°	2.02°

§ $F = \dfrac{s^2_s}{s^2_{ss}}$ tests the hypothesis of homogeneity of variance (Snedecor, op. cit. p. 249). This is a "two-tailed" test. The hypothesis $\widehat{Y}_s = \widehat{Y}_{ss}$ and similar hypotheses were tested by the "t" test where

$$\text{"t"} = \frac{\widehat{Y}_s-\widehat{Y}_{ss}}{s^2_{\widehat{Y}_s-\widehat{Y}_{ss}}}$$

Snedecor cites a modification when variances are not homogeneous (Snedecor, op. cit. p. 83).

† Not significant at the 10-percent level of probability.

° Denotes significance of difference at the 5-percent level of probability.

°° Denotes significance of difference at the 1-percent level of probability.