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To the Graduate Council:

I am submitting herewith a dissertation written by John P. Kuehn entitled "Costs and Efficiencies of Model Meat Packing Plants in the Tennessee Valley." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Agricultural Economics.

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COSTS AND EFFICIENCIES OF MODEL MEAT PACKING
PLANTS IN THE TENNESSEE VALLEY

A Dissertation
Presented to
the Graduate Council of
The University of Tennessee

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

by
John P. Kuehn
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ABSTRACT

The overall objective of this study was to generate short and long range planning data for combined beef and pork packing plants in the Tennessee Valley. The effects of prices received by packers for meat products and variations in plant utilization rates were also considered.

The general approach involved application of an economic engineering or synthetic cost analysis. Four kinds of plant operations (beef slaughter, beef boning, hog slaughter, and hog cutting and boning) were described so that each could be considered as an autonomous plant. Each operation had its own total cost function and was "constructed" in three different sizes. Complete plants that handled both beef and pork were formed by summing total cost functions for the four operating stages, and plant capacities depended on the particular combinations of different sized operating stages.

A series of least cost specialized slaughter and boning operations was determined for five different levels of slaughter animal availability: (1) 100 percent utilization of capacity; (2) seasonal utilization of capacity (88.13 percent for beef and 94.15 percent of capacity for hogs); (3) 80 percent; (4) 70 percent; and (5) 60 percent utilization of capacity. Each of the model combined operations was examined under both full shift, eight-hour day operating schedules and a half shift schedule involving two four-hour shifts of slaughtering,

boning, and/or cutting, respectively. Slaughter animal and processed product prices were used to estimate net revenues and the dollar value of total sales for the dual species plants at the five rates of plant utilization indicated above under both full and half shift operating schedules. Data for the model plants were used in a feasibility test that estimated ability of the plants to repay initial aggregate investment costs over a ten year period.

Average total unit costs ranged from \$8.15 to \$13.07 in specialized beef slaughter and boning operations, and from \$1.94 to \$3.60 in the specialized hog slaughter, cutting, and boning operations at full capacity. The net values per head processed in the model operations (gross value minus slaughter animal cost minus processed animal delivery cost minus annual plant operating cost) were relatively low in relation to the gross value for both cattle and hogs. The net values ranged from -\$0.60 to \$4.32 per head of beef and from -\$0.36 to \$1.30 per hog in the specialized model operations at full capacity. As these low margins per head change from one period to another, there will be proportional changes in annual net revenue to the plant (net revenue = net value per head times the number of head processed in a given operation) for the time period involved. In absolute terms, however, changes in annual net revenue can be quite large.

The specialized hog slaughter, cutting, and boning operations had higher estimated rates of return on annual operating costs than both the specialized beef slaughter and boning operations and the plants that slaughtered both species. Plants handling both beef and pork,

however, would be able to offset decreases in net revenue from one species with possible higher returns from operations with the other species. Plant operation at less than full capacity in all model operations reduced estimated returns as well as the ability to repay initial aggregate investment costs over a ten year period. The model plants on full shift operating schedules had lower total unit costs and higher rates of return on annual operating costs than plants operating on half shift schedules at all levels of utilization of capacity. And, in all cases, the largest plants had the lowest unit costs, the highest annual net revenues, and the greatest ability to repay initial investment costs over a limited planning horizon.

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CHAPTER I

INTRODUCTION

I. THE PROBLEM AND REASONS FOR STUDY

The Southern Marketing Research Committee stated that the basic "problem confronting Southern agriculture is to improve the inherent quality of the products leaving the farm and to reduce costs--the cost of marketing as well as the cost of production" [40, p. 1]. Many public agencies share this concern with improving the competitive position of Southern agriculture. They include the State Agricultural Experiment Stations, the United States Department of Agriculture, and the Tennessee Valley Authority. These agencies express this interest by furthering programs to promote agricultural development and economic growth in their respective geographic areas of concern. Their general objectives are to increase incomes in the region by increasing and upgrading the level of resource use. Specifically, they want to initiate and conduct research programs designed to develop improved techniques of production and management along with adult education programs to disseminate this new information. One that is particularly important in this connection is the meat and meat products industry. Growing population and rising levels of income in the region have served to increase the demand for meat and meat products and to open new market potentials for the industry in the South.

Raunika, Purcell, and Elrod reported that, in Georgia, meat, meat products, and eggs accounted for 39 percent of the home food budget, based on a 1962 consumer panel. Red meat alone accounted for 26 percent of total food expenditures. The corresponding figures for poultry, eggs, and seafood were six, five, and two percent, respectively [35, p. 9].

As in most agricultural industries, significant structural and organizational changes have occurred in the meat packing industry. The industry has been described as consisting of a few large firms controlling a major share of the market and many smaller firms sharing the rest [54, pp. 316-317]. But, according to the National Commission on Food Marketing, in 1950 the four largest meat packing and processing firms accounted for 51.5 percent of all the federally inspected U. S. cattle slaughter. This decreased to 28 percent in 1964. The hog slaughter figure decreased from 48.5 percent to 36.9 percent [32, p. 14]. These figures indicate a decline in concentration.

Specialization of operations, however, has increased, particularly in cattle slaughter. According to Anthony, the number of federally inspected plants in the U. S. slaughtering only one species increased from 73 in 1950 to 193 in 1962. The number of plants slaughtering only two species increased from 81 in 1950 to 154 in 1962. The largest increase in two species plants was in cattle-swine slaughter. They increased from 21 to 52 from 1950 to 1962 [3, p. 22]. In 1967, the Consumer and Marketing Service and the Statistical Reporting Service showed that of the 579 federally inspected plants in the U. S., 479

or 82.7 percent killed cattle and 253 or 43.7 percent butchered hogs [46, p. 79].

Several reasons have been offered to explain increased specialization and decentralization:

1. improvements in refrigerated truck and "piggy-back" transportation for meat movement;
2. lessening dependence on rail transportation;
3. new products can be built incorporating new technology at considerable cost savings;
4. livestock transportation savings have occurred to new plants located close to fast growing cattle feeding areas;
5. wage rates are frequently lower at interior locations;
6. wide use of Federal grade standards has permitted new plants to compete in the total beef market;
7. concessions made by local communities to attract local industry; and
8. the cattle industry has itself been expanding at a rapid rate [5, p. 27].

Franxman and Kuntz emphasized that

Plant efficiency kill levels have increased from one head to around two head per man hour with the development of "on the rail" kill floors and associated equipment such as hydraulically operated lift platforms, dehorner, hock cutters, hide pullers, air powered knives, moving top viscera tables and electrically operated splitting saws and hoists [19, p. 5].

As a result, meat packers must adjust their managerial and organizational structures in order to compete with other packers who adopt improved techniques of operation.

New information is continuously needed to supplant that which no longer pertains. Individuals within the industry must have knowledge of their relative production alternatives as well as current market facts in order to operate intelligently in their own best interests [32, p. 2].

Purcell stated that

. . . changes in the location of livestock production and the consuming population (demand for meat) require continued adjustments in livestock and meat marketing with respect to location of facilities, and livestock and meat movement patterns. . . . Technological changes in transportation, processing, refrigeration, and distribution contribute to the problems and opportunities of adjustment [34, p. 11].

The most important single factor affecting in-plant costs from one region to another is labor efficiency and utilization. Another important factor is the rate of plant utilization. Because of seasonality factors, most plants cannot operate at full capacity at all times using normally available supplies of slaughter animals. And, when plants consistently operate below capacity, efficiency decreases and costs increase [37, pp. 5-6].

Livestock slaughtered under Federal Inspection has accounted for more than 80 percent of total commercial production and the trend has been rising (Table 1). Total commercial cattle slaughter increased 24.4 percent between 1963 and 1967 while hog slaughter decreased 1.4 percent. The percent of commercial slaughter that was federally inspected increased from 79.5 to 82.3 percent for cattle between 1963 and 1967 and for hogs the increase was from 85.9 to 86.4 percent. Commercial cattle slaughter, therefore, increased from 1963 to 1967 while commercial hog slaughter decreased. But a greater percentage of the total commercial slaughter was accounted for by federally inspected hog slaughter facilities than by cattle slaughtered under Federal Inspection [46, p. 63].

TABLE 1

COMMERCIAL LIVESTOCK SLAUGHTER AND THE NUMBER OF ANIMALS SLAUGHTERED
UNDER FEDERAL INSPECTION IN THE UNITED STATES, 1963 TO 1967

Year	Cattle slaughter		Hog slaughter	
	Total commercial	Federally inspected	Total commercial	Federally inspected
	-----1,000 Head-----			
1963	27,232	21,662	83,324	71,577
1964	30,818	25,133	83,018	71,667
1965	32,347	26,614	73,784	63,708
1966	33,727	27,319	74,011	63,729
1967	33,869	27,780	82,124	70,915

Source: U.S.D.A., Livestock and Meat Statistics, Supplement for 1968 to Statistical Bulletin No. 333, E.R.S. (Washington: Government Printing Office, July, 1969), p. 63.

Commercial cattle slaughter in Tennessee increased from 432,500 head in 1962 to 572,000 head in 1967. Hog slaughter amounted to 2,362,000 head in 1962 and 3,033,000 in 1967 [46, p. 65],

The total number of slaughtering establishments increased 27 percent from 1950 to 1967 while the number of these establishments slaughtering cattle increased 21.6 percent and the number killing hogs decreased 4.2 percent [46, p. 79]. This large increase in commercial slaughter, with a relatively smaller increase in the number of cattle slaughter establishments and a decrease in the number of hog slaughter establishments, implies a relatively high rate of plant closings in the industry and a trend toward larger sized operations.

The most recent study of the characteristics of Tennessee livestock slaughter plants was conducted in 1962. Table 2 shows that the majority of the slaughter plants operated in the lower ranges of weekly slaughter rates. It was reported that in Tennessee 40 plants slaughtered beef cattle and 34 butchered hogs. The weekly slaughter of beef animals ranged from one to 800 head and for hogs from four to 7,000 head. Only five slaughterers were completely diversified, killing beef cattle, hogs, and sheep [26, p. 20].

The Economic Problem of the Firm

Profit maximization is generally assumed to be the primary objective of the firm. Complete attainment of this goal over time, however, is made difficult by changes in available technology and by related and unrelated changes in the economic and institutional

TABLE 2
AVERAGE WEEKLY SLAUGHTER OF LIVESTOCK BY CLASS

Number of head per week	Number of plants reporting		
	Beef cattle	Hogs	Sheep
1 - 25	12	9	2
26 - 50	10	12	-
51 - 100	7	7	1
101 - 500	9	4	1
501 and over	2	2	-

Source: Knight, E. B., and V. W. Plummer, The Management and Marketing Practices of the Small Independent Purses of Tennessee, Prepared by Tennessee Polytechnic Institute under the Small Business Administration Management Research Grant Program (Washington: Government Printing Office, June, 1962), p. 20.

environment. Technological, economic, and institutional factors must be considered by managers in short and long range decision making. In order to make such decisions, two types of problems must be solved: input-output and optimizing problems.

Input-output problems "involve specifying the alternative methods of performing specific marketing operations, itemizing the resource requirements, specifying the performance rates, and estimating the cost for each of the alternatives" [40, p. 5]. Problems of this nature are studied by first estimating the entire input-output budget of the firm. This may be done by collecting the actual data from industry sources, technical publications, personal interviews, and the like. From these sources, cost data may be synthesized and an efficient set of input-output schedules can be determined for each of several alternative operating situations.

The Southern Marketing Research Committee stated that optimizing problems

. . . are concerned with either the least-cost combinations of the methods of production, the least-cost combinations of ingredients to make a particular product, the maximum profit combinations of products that may be produced in a particular type and size of plant, or the most profitable allocation of a product among markets and among seasons [40, p. 5].

An optimizing problem with a cost minimization objective may be solved after determining the appropriate input-output and cost coefficients. Appropriate product prices could then be assigned to these coefficients to set up and solve profit maximization problems.

Dorfman characterizes the

. . . entrepreneur at the beginning of a production planning period as having certain fixed factors of production at his disposal and as having access to competitive markets in which he can procure the variable factors needed to make use of his fixed factors. His problem is essentially to derive a production program which will utilize the fixed factors to best advantage, that is, secure the greatest possible profit from their use [16, p. 23].

His generalized firm has n factors whose supply is fixed and non-substitutable. There are k processes, each of which utilizes one or more of the n factors. So the problem is one of deciding which processes are to be used and at what level to utilize them [16, p. 23].

The present study is concerned with both input-output and optimizing problems of firms in the meat packing industry. The analysis is designed to develop information that would be applicable to meat packing plants slaughtering both cattle and hogs.

II. OBJECTIVES

The overall objective of this study is to generate short and long run planning data for diversified (in terms of species slaughtered) meat packing plants in the Tennessee Valley. The effects of demand, technology, institutional, and supply characteristics, along with other relevant factors on generalized synthetic model plants in the Tennessee Valley, are examined.

The specific objectives are:

1. To develop budgets for resource requirements, performance rates, and costs per unit of output for diversified meat packing

plants that would be feasible in the Tennessee Valley. Diversified plants are those that slaughter and disassemble both cattle and hogs. The plants will be studied in respect to differing sizes of plant and rates of utilization of capacity.

2. To determine least-cost combinations of activities required for the disassembly of slaughter animals according to differing plant sizes and levels of diversification.

3. To determine maximum-profit production and marketing schedules for these plants under both existing and estimated demand and supply conditions.

4. To determine the effects of changes in slaughter animal availabilities on model plant operating costs and to specify the slaughter animal supply flows required to support different rates of utilization of capacity.

5. To determine the effects on costs and efficiency of differing levels of labor and capacity utilization.

III. GENERAL APPROACH AND PROCEDURE

There is no single ideal method for measuring and comparing costs. In any given case, the best procedure depends on the particular objectives of the study and on the resources available for conducting the research. For example, the "economic engineering approach . . . is designed for studies concerned with comparing the relative efficiency of alternative technologies and with deriving specific cost

functions for individual plants and long-run functions involving plants of differing size" [20, pp. 579-580].

The analytical process for estimating physical input-output and cost-output relationships consists of three steps: "(1) development of the physical standards of performance; (2) verification of these standards; and (3) development of cost standards" [20, p. 583].

These measurement procedures provide a set of "building blocks" for estimating plant cost functions. The resulting cost functions are the foundation for comparing alternative technologies and economies and diseconomies of size.

The general procedures for combining these building blocks . . . involve first, a simple combination of the fundamental cost output relations into cost functions for the alternative technologies at each plant stage and, second, a comparison and integration of these and the general cost functions to determine the most efficient technologies and their total costs for the plants of varying size of operation under varying conditions--i.e., the long-run optimum cost function [20, pp. 591-592].

The general approach of this study involved the design of several model operations of differing sizes and production procedures. By means of the economic engineering approach, complete input-output and cost schedules were derived for each of the model operations. The model operations were then combined to form complete plants of varying sizes, each with an associated total cost curve.

The cost data were then presented as functional relationships showing how costs vary with differences in plant size. These curves determined the economies of size curve. According to Bressler, "the

economy of scale curve tells us the levels of costs that may be expected from the operations of plants of various sizes, when operations are organized as efficiently as possible under the given conditions" [10, p. 526]. This locus of lowest average costs is needed for "intelligent planning." It shows the prospective cost situation for plants of differing sizes.

The least-cost plant was determined for different levels of slaughter animal availability and labor utilization. Raw and processed product prices were determined for the Tennessee Valley and maximum-profit plant configurations were specified for various rates of slaughter animal and labor availabilities. The plants were then subjected to a test of ability to repay their initial aggregate investment costs plus a normal rate of return over a limited planning horizon.

CHAPTER II

BACKGROUND AND PROCEDURE

I. REVIEW OF LITERATURE

Costs and Efficiency

Viner [53] elaborated on Marshall's concept of internal and external economies and diseconomies and presented concepts of short and long run equilibria. The notions of "net" economies and "net" diseconomies were introduced and classified into "technical" and "pecuniary" economies and diseconomies of large scale production.

His treatment of long run cost behavior was in terms of the "envelope curve." He discussed the effects of decreasing and increasing long run average costs on the firm and the industry, and he proposed a universal long run "law of increasing money costs as output changes in response to shifts in wants in an economy of constant national money income" [53, pp. 230-232].

Bressler defined an "efficient" organization as

. . . one that yields a greater output for a given input than does some alternative organization or, conversely, that requires a smaller input to obtain a given output. It follows, of course, that the most efficient organization will be that alternative which maximizes the output for a given input or minimizes the input for a given output [9, pp. 1-2].

Bressler assumed that "while it appeared impossible to measure social welfare, it was possible to develop useful efficiency concepts

that had bearing on the problems of the individual and/or social choice." He elaborated on the "theory of efficient production of marketing services with the immediate objective of refining our general theories of production economics into useful research tools" [9, p. 66].

He illustrated how "perfect market mechanisms are consistent with efficiency and how efficiency at the plant and firm level does not result in an efficient aggregate organization for the economy if pricing is imperfect or monopolistic" [9, p. 66].

Bressler also concluded that "elements of economic and technological uncertainty make it impossible to define any organization that represents a true maximum--or even to say with complete assurance that one organization will be more efficient than another" [9, pp. 66-67].

He suggested several avenues of approach:

(1) the use of several sets of relative prices to test the modifications induced in the efficiency models; (2) entering prices as compound expectation distributions, and so determining the organization that has the greatest probability of being most efficient; and (3) adaptations to uncertainty through plant flexibility and adaptability" [9, p. 67].

French, Sammet, and Bressler argued that the nature of plant operations necessitates four modifications or elaborations of the conventional cost and production theory in order to take account of: (1) variation in the time dimension in order to vary plant output; (2) plant segmentation involving the use of many identical machines; (3) discontinuities in rates at which output can be varied; and (4) multiple rather than single stage plants" [20, p. 707].

Erdman discussed the problem which arises when costs of operation for separate firms are related to the volume of business by plotting the data on scatter diagrams. He observed "that such a cross section of operation costs for a given period must 'catch' many of the firms in some sort of maladjustment which in important cases are not explained by the usual correlation approach" [17, p. 388].

Erdman suggested a judgment subclassification of the different firms as a first step in the analysis. In this way firms could be classified into least-cost groups on the basis of capacity. He also suggested further subdivision on the basis of several orders of management [17, p. 388].

This type of reasoning justifies using a "synthetic approach." According to Bressler, the simplest and most direct approach to the determination of economies of scale or long-run average cost curves, "involves the selection of a sample of plants that are well designed and efficiently operated without excess capacity" [10, pp. 538-539]. This approach, however, may not always be applicable.

. . . the best alternative would appear to be the detailed analysis of cost-volume relationships for each of a small group of plants. If these plants are selected so as to be well organized and to represent a wide range in capacity, and if historical data are available over a period when output varies greatly, it will be possible to produce or at least approximate important portions of the cost curves Approximation to these same curves may be synthesized, partially or completely, by following methods essentially similar to those used by architects, contractors, and engineers in forecasting to costs of building, equipping, and operating plants [10, p. 539].

Bressler pointed out also that "the first and usually most time-consuming and difficult aspect of any study of the efficiency of marketing is the determination of the appropriate service production relationships" [9, p. 68]. He discussed two approaches: (1) the synthetic approach and (2) the analytical approach.

In the synthetic approach, we may depend almost entirely on engineering data and scientific laws. Or we may obtain data on the operational elements and analyze them and then combine the results into a fraction for the whole operation. In the analytic approach, we may take input-output data for a particular plant and subject them to a multiple correlation analysis in order to determine the net effects of several input elements on output [9, p. 70].

Each of these approaches has its advantages and disadvantages.

Black [7] discussed the theory of the synthetic method of cost estimation with a critique of its various applications. He noted that up to 1955 a number of insights were gained which may have had an impact on the thinking of production theorists:

(1) The synthetic studies have emphasized the discontinuities that appear in cost curves because of the incomplete divisibilities of men and machines; (2) one of the surprises in synthetic studies has been the discovery that once a least-cost position is established, fairly important changes are required in the cost rates of factors of production before a major adjustment in the plant organization will yield a new and lower least cost combination; (3) synthetic studies generally have had fairly broad objectives; (4) the building block studies have been too few in number to support firmly any broad generalization as to the shape of a typical economies-of-scale curve for an industry [7, pp. 278-279].

In discussing Black's article, Gerhard Tintner [45] mentioned the relation between the above methods and the technique of linear programming. "Both have in common that they push the analysis back

into the technological field and are able to deal with the very choice of the technological methods actually employed from a whole array of possible technologies" [45, p. 279].

Cost and efficiency studies are necessary in order to answer broader questions regarding optimum number, size, and locations of processing plants for a given product. Polopolus discussed several areas which must be considered in determining these kinds of optima. They include: (1) market potentials, (2) raw product supplies, (3) efficiencies of different sized plants, (4) feasibilities of using idle processing capacities, (5) optimum numbers, sizes, and locations of plants, and (6) abilities of new entrants into the market to repay investment costs [33, pp. 157-169].

Empirical Applications

Many studies of costs and efficiencies have been applied in agricultural processing industries. Table 3 shows characteristics of some of these studies with respect to the particular industry studied, the geographic area, analytical techniques, objectives, and researchers involved.

II. DETAILS OF THE PROCEDURES

Specific Questions to Be Answered

It was decided to use the synthetic approach to cost analysis to accomplish the objectives of this study. The specific questions to be answered were: (1) What are the resource requirements, performance

TABLE 3

COSTS AND EFFICIENCY STUDIES IN AGRICULTURAL INDUSTRIES

Industry	Geographic area	Analytical technique	Objectives	Researcher(s)	Reference number
Pear packing	California	Economic Engineering	To develop effective research approaches to problems of plant operation and to apply these techniques to specific problems	French, Sammet, and Bressler	[20]
Cotton farming	Texas	Economic Engineering Linear programming	To determine average costs of production of farms of differing sizes over the next few years	Davis and Madden	[15]
Farm machinery	Iowa	Budgeting	To determine the long run costs in relation to farm size and differing machinery technology	Ihnen and Heady	[24]
Plum packing	California	Cost comparisons	To determine and compare economies of scale of three different packaging methods	Stallings and Sammet	[41]
Egg packing	Georgia	Economic Engineering	To provide long-range planning guidelines for egg marketing firms	Jones	[25]
Egg handling	Oklahoma	Economic Engineering	To determine economies of size in egg handling operations	Bird	[6]
Evaporated milk	California	Economic Engineering	To isolate the effect of a change in scale of plant on unit operating costs	Boles	[8]

TABLE 3 (Continued)

Industry	Geographic area	Analytical technique	Objectives	Researcher(s)	Reference number
Poultry feed manufacturing	Mannitoba	Linear programming	To examine method and procedure in determining several types of least cost poultry rations using linear programming	Gilson, Yeh, and Hodgson	[21]
Cattle and hog slaughter	Georgia	Economic Engineering	To determine slaughter functions, labor, and physical inputs and evaluate the interrelationships and their effects on efficiency	Sanders, Frazier, and Padgett	[37]
Cattle slaughter	California	Economic Engineering	To determine the least cost technology at a given level of output and to determine cost variation with different sized plants	Logan and King	[29]
Cattle slaughter	Michigan	Budgeting of accounting data	To identify costs involved and to compare costs based on accounting records and on direct observation. To make a comparative cost analysis of four packing plants and identify the problems of making such a study	Wissman	[56]
Hog slaughter	North Carolina	Economic Engineering	To estimate average costs of slaughter and to determine the cost of assembly	Cassell and West	[12]

TABLE 3 (Continued)

Industry	Geographic area	Analytical technique	Objectives	Researcher(s)	Reference number
Cattle slaughter	Oklahoma	Economic Engineering	To determine construction and operating costs of different sized plants at several alternative output levels	Franzman and Kuntz	[19]
Cattle slaughter	California	Inter-regional Competition	To estimate optimum number, size, and location of cattle slaughter plants and the optimum shipping patterns for live animals and carcass beef.	Logan and King	[30]
Sausage manufacturing	Indiana	Linear Programming	To develop a quantitative model to analyze simultaneously the factors involved in decision making	Armbruster and Snyder	[4]
Pork processing	--	Linear Programming	To determine the applicability of linear programming as an aid to decision making	Green, Chatto, and Hicks	[22]
Pork processing	Indiana	Linear Programming	To delineate the long run profit position of the firm	Snyder and French	[39]
Non-slaughtering meat processing plants	Oklahoma	Economic Engineering	To estimate costs and economies of size relationships	Schnake	[38]

rates, and costs per unit of output for efficient diversified meat packing plants? (2) What are the least cost combinations of activities required for assembly, processing, storage, and distribution at different plant sizes and levels of diversification? (3) What are the maximum prefit production and marketing schedules for model plants under existing and estimated demand and supply conditions? (4) What are the effects of changing supply conditions on model plant operating costs and what are the slaughter animal supply flows required to support different rates of utilization for each plant size? (5) What are the effects on costs and efficiency of differing levels of labor and capacity utilization.

Area Covered

The geographic area covered in this study was the Tennessee Valley watershed. The 1963 T.V.A. Census of Agriculture grouped the 125 Tennessee Valley watershed counties into 14 sub-areas. "The counties in each sub-area are similar in type of farming, land use, and topography Therefore, each sub-area may be regarded as an economic area" [13, p. ii]. Slaughter animals in 1964, labor force, and population figures for 1967 were cited for the 14 economic areas and product markets were specified for Tennessee and the surrounding states for 1967. The specifications of these markets paid special attention to the metropolitan areas in the Valley states. Figures on population, number of households, retail food sales, effective buying income, and buying power were taken from Sales Management [36]

and specified for the major metropolitan areas in Tennessee and the surrounding states.

Analytical Procedure

French, Sammet, and Bressler define a plant as consisting of several operating stages, each with an associated cost curve. These cost curves along with several "overall cost components not associated with specific stages, form the total cost function of the plant" [20, p. 555]. The conventional analysis, therefore, sums the costs of the individual plant operating stages to form the total cost curve. The procedure is repeated for several different sized plants. This study, however, is primarily concerned with the total costs of different sized operating stages (beef slaughter, beef boning, hog slaughter, and hog cutting and boning), and how they may be efficiently combined to form complete diversified plants. It was, therefore, decided to modify the conventional analysis by designing the individual operating stages such that each could be considered as an autonomous plant. Each operation would then have its own total cost function and could be "constructed" in various sizes. A complete diversified plant, therefore, was formed by summing the total cost functions of the four operating stages and the plant capacity depended on the particular combination of different sized operating stages.

There were several problems associated with this modification. There was the problem of "finding 'harmonious' combinations of capacities for the units of fixed (but discreetly divisible) equipment

used at each plant stage." There was also the problem of "overall cost components not associated with a particular stage" [20, p. 555].

The first of these problems was overcome by designing the operating stages such that each could disassemble the maximum amount of raw product that could be passed on by the preceding stage. The second problem was overcome by assigning the "overall costs" to the individual operating stages rather than to the complete plant. Office building and equipment costs, for example, are usually associated with the complete plant. But since the objective was to design the individual operating stages to be autonomous, each of these stages had to have its own office building and equipment. This was accomplished by determining what office buildings and equipment cost, as a percentage of total building and equipment costs, in a complete plant. This figure was then applied to the total building and equipment costs of the various individual operations to determine the individual cost of office buildings and equipment. Therefore, the total cost of a diversified plant was complete when the individual operating stage costs were summed.

The procedure was divided into four main components: (1) model plant synthesis, (2) cost analysis, (3) revenue analysis, and (4) estimation of repayment capacity.

Model plant synthesis. The model plants consisted of four operating stages: beef slaughter, beef boning, hog slaughter, and

hog cutting and boning.¹ The labor, building, equipment, and utilities requirements were taken from Logan and King [29] for the beef slaughter operations and from Cassell and West [12] for the hog slaughter operations. The costs assigned to these physical requirements, however, were those of the Tennessee Valley. The beef boning and hog cutting and boning operations were synthesized from equipment company specifications. The four operating stages were each "constructed" in three different sizes. Output rates for each of the operations were based on both a single shift eight-hour day of slaughter, cutting, and boning and on a half shift four-hour day with slaughter taking place during one four-hour shift and cutting and boning occurring during another four-hour shift using the same labor crew. Activities such as clean-up, however, would still be carried on for a full eight-hour day in the half-shift operations.

Cost analysis. Costs per unit of output were calculated for the layouts and equipment budgets of each of the operating stages on both full and half shift operating schedules. Seasonal indexes for supplies of slaughter animals were computed from U.S.D.A. quarterly slaughter figures and applied in the cost analysis to measure the effect of this factor on plant operating costs. The beef slaughter operations were then combined with the beef boning operations to determine the costs per unit of output when the two operations are combined

¹It was assumed that the cost of rendering inedible by-products would be equal to the revenue from the sale of processed by-products, so inedible rendering operations were not included in this study.

in three different sizes. The procedure was repeated for hog slaughter and hog cutting and boning operations. Plant operating costs per unit of output were then determined for the combined operations at full utilization of capacity and for less than full capacity utilization. Less than full capacity utilization was assumed to be due to an uneven supply of slaughter animals caused by seasonal variation in slaughter animal production. Further examination of less than full utilization of capacity was accomplished by assuming a plant would produce at 80, 70, and 60 percent of capacity. The costs per unit of output at varying levels of capacity utilization were determined for both full and half shift operating schedules of the combined slaughter and boning operations.

Revenue analysis. Yearly average slaughter animal prices for 1968 were determined for the Tennessee Valley from the Nashville Union Stockyards weekly quotations and by means of a weighted average were assigned to the model operations on a per head basis. Processed product prices for 1968 were taken from The National Provisioner [43] and the gross value per head processed was derived from these prices by means of a weighted average of the various processed cuts of meat. Freight costs were then determined for transportation of the processed product to wholesalers in the Tennessee Valley by means of a telephone survey of local freight agencies. These figures, along with the plant operating costs per head determined previously, were used to determine the

net value per head processed at full utilization and at less than full utilization of capacity for the combined slaughter and boning operations:

Weighted average gross value per head

- weighted average cost per slaughter animal
 - weighted average delivery cost per processed animal
 - operating cost per head for the given combined operation
-

Net value per head processed in a given combined operation

This net value per head processed in each operation was multiplied by the number of head processed in each operation to determine the annual net revenue for each operation. The annual net revenue for each operation was then divided by the annual total plant operating cost to examine net revenue as a percent of annual operating cost. The average gross value per head was then multiplied by the number of head in each operation to compare net revenue with total sales.

The combined beef slaughter and boning operations were then merged with the combined hog slaughter cutting and boning operations to form complete diversified plants, each consisting of the four basic operational stages in various sizes. Net revenue per head processed was then determined for these complete plants at both full and less than full utilization of capacity.

Repayment ability. Each of the complete model plants was then subjected to a test of feasibility (see Chapter VI, Section IV). The estimated capital value of the plant was determined for a ten-year

period. This was then compared to the initial aggregate investment cost of land, buildings, and equipment. The test of feasibility determined the ability of a plant to repay its initial investment in a limited time horizon (ten years) plus earning a normal rate of return.² In order to be "feasible" then, a plant's estimated capital value in ten years had to be greater than the initial aggregate investment cost of land, buildings, and equipment. The repayment capacities of complete plants were then compared to the repayment capacities of the separate beef and hog slaughter and boning operations to determine the relative advantages of specialization versus diversification.

Specific Data Requirements

The synthetic model construction required complete layouts and budgets of land, building, equipment, labor, utilities, investment, and miscellaneous operating costs for each model operation. Physical input-output specifications were required to compute costs per unit of output.

There were then five main components of data that were needed: (1) input-output specifications of the model operations; (2) basic in-plant costs--labor, land, buildings, equipment, and miscellaneous costs; (3) overall costs not associated with particular operations--

²A six percent capitalization rate was used to estimate the capital value in ten years. It should be noted, however, that this rate is low by current standards (1969). The bank prime rate was seven percent as of January 7, 1969 [51, p. A-31].

office and employee dressing land, labor, buildings, and equipment;

(4) the number of slaughter animals available; and (5) slaughter animal and processed product prices.



CHAPTER III

SUPPLY AREA, MARKET AREA, AND PLANT CHARACTERISTICS

I. DESCRIPTION OF THE GEOGRAPHIC AREA

The area covered in this study is the Tennessee Valley watershed. The 125 Tennessee Valley watershed counties were grouped into 14 sub-areas by the 1963 T.V.A. Census of Agriculture. "The counties in each sub-area are similar in type of farming, land use, and topography . . . therefore each sub-area may be regarded as an economic area" [13, p. ii]. The basis for using these delineations was the need to identify logical location points for existing or proposed meat-packing facilities. The model plants in this study were "constructed" so that the derived costs would be representative of the Tennessee Valley. Figure I shows a map of the Tennessee Valley that indicates the boundaries of each economic area. Also, Table 4 lists the counties included in each of these areas.

Production Densities

Live animal production for the 14 economic areas was aggregated from county data taken from the 1964 U. S. Census of Agriculture. Production of cattle ranged from 17,911 animals on 1,249 farms in Area VIII to 182,724 head on 7,339 farms in Area II. Hog production

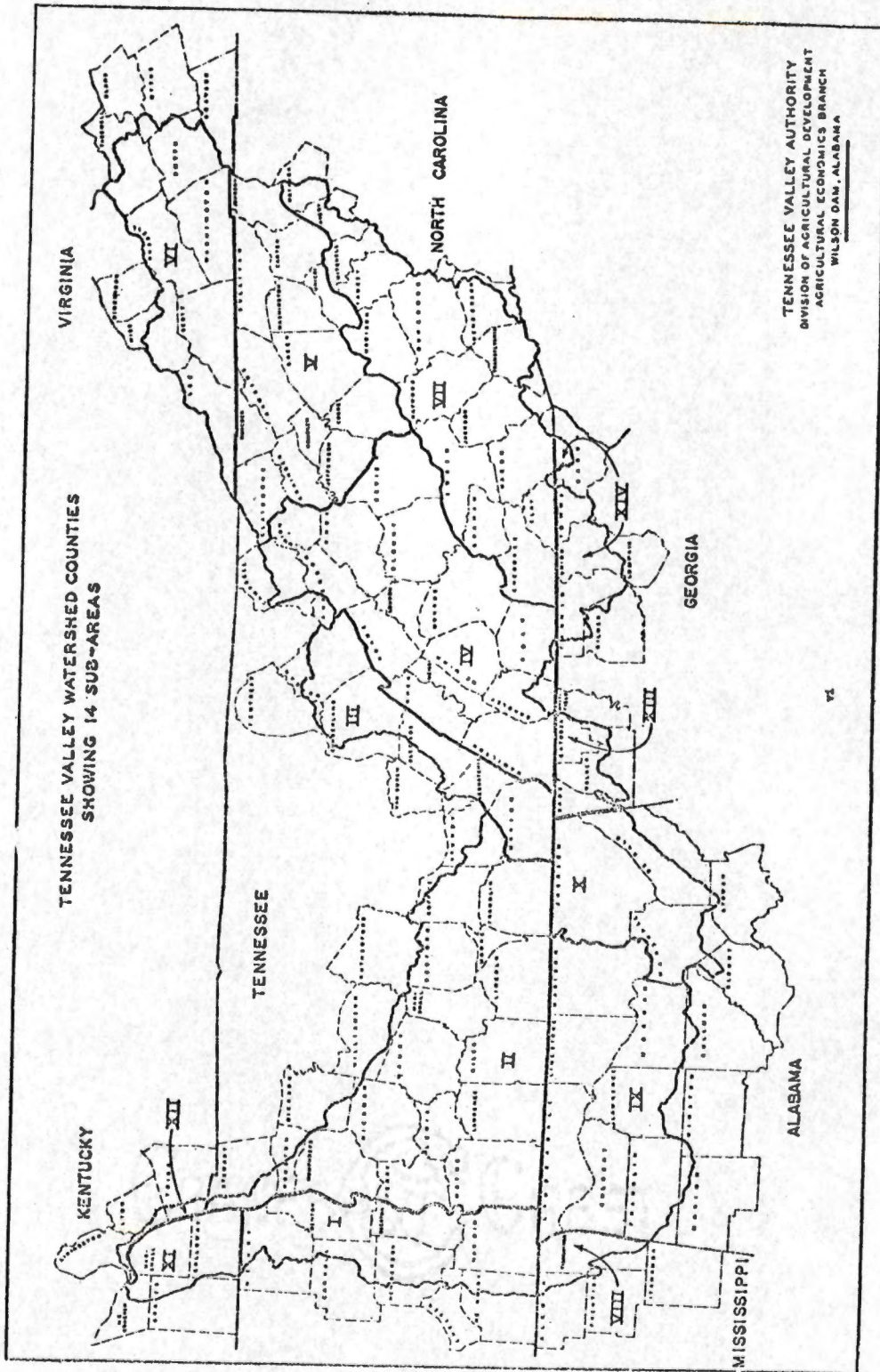


Figure I. Tennessee Valley Watershed Counties showing 14 sub-areas.

TABLE 4

ECONOMIC AREAS OF THE TENNESSEE VALLEY.

Economic Area I

Tennessee
 Benton
 Carroll
 Chester
 Decatur
 Hardin
 Henderson
 Henry
 McNairy

Economic Area II

Tennessee
 Bedford
 Coffee
 Dickson
 Franklin
 Giles
 Grundy
 Hickman
 Houston
 Humphreys
 Lawrence
 Lewis
 Lincoln
 Marshall
 Maury
 Moore
 Perry
 Rutherford
 Stewart
 Wayne
 Williamson

Economic Area III

Tennessee
 Bledsoe
 Cumberland
 Fentress
 Marion
 Morgan
 Sequatchie
 Van Buren

Economic Area IV

Tennessee
 Anderson
 Blount
 Bradley
 Campbell
 Hamilton
 Knox
 Loudon
 Meigs
 Monroe
 McMinn
 Polk
 Rhea
 Roane
 Sevier
 Union

Economic Area V

Tennessee
 Carter
 Claiborne
 Cocke
 Grainger
 Greene
 Hamblen
 Hancock
 Hawkins
 Jefferson
 Johnson
 Sullivan
 Unicoi
 Washington

Economic Area VI

Virginia
 Bland
 Dickeson
 Grayson
 Lee
 Russell
 Scott
 Smyth

TABLE 4 (Continued)

Economic Area VI
Virginia (continued)
Tazewell
Washington
Wise
Wythe

Economic Area VII
North Carolina
Avery
Buncombe
Cherokee
Clay
Graham
Haywood
Henderson
Jackson
Macon
Madison
Mitchell
Swain
Transylvania
Watauga
Yancey

Economic Area VII
Mississippi
Alcorn
Itawamba
Prentiss
Tishomingo

Economic Area IX
Alabama
Colbert
Cullman
Franklin
Lauderdale
Lawrence
Limestone
Madison

Economic Area IX
Alabama (continued)
Marion
Morgan
Winston

Economic Area X
Alabama
Blount
De Kalb
Etowah
Jackson
Marshall

Economic Area XI
Kentucky
Calloway
Graves
Marshall
McCracken

Economic Area XII
Kentucky
Livingston
Lyon
Trigg

Economic Area XIII
Georgia
Catoosa
Dade
Walker
Whitfield

Economic Area XIV
Georgia
Fannin
Gilmer
Lumpkin
Rabun
Towns
Union

Source: Census of Agriculture for the 125 Tennessee Valley Watershed Counties (Wilson Dam, Alabama: Tennessee Valley Authority, January, 1963), pp. vii-viii.

ranged from 9,687 animals on 704 farms in Area XIII to 239,504 head on 11,180 farms in Area II.

Cattle sold ranged from 3,457 head with a total value of \$365,715 in Area XIV to 78,555 head with a total value of \$9,416,988 in Area II. In Area XIII, 12,758 hogs and pigs were sold with a total value of \$360,519 while 391,507 head were sold with a total value of \$8,986,790 in Area II (Tables 5 and 6).

Labor Force

The labor force is defined in the Census as all persons 14 years and older who are working or who are willing to work. Estimates of the labor force for each of the 125 Tennessee Valley watershed counties were aggregated to determine the number of people in the labor force in the 14 economic areas in 1967.

Estimates ranged from 6,155 people in Area XII to 449,850 in Area IV. The total labor force for the Tennessee Valley was estimated to be 1,531,528 (Table 7).

Population

Population figures for the economic areas were aggregated from county data in Sales Management [36, pp. D189-192]. The population figures consisted of "an updating of the April 1960 population census."¹

¹"The following factors played an important role in making each estimate: (1) local growth trends established over ten years, and current economic development; (2) population growth established through analysis of changes in births, deaths, and school enrollment; (3) reports from chambers of commerce and other responsible agencies, such as planning commissions, utilities, and the like" [36, p. c-3].

TABLE 5

TOTAL LIVESTOCK BY AREA ON FARMS, 1964

	Area I	Area II	Area III	Area IV	Area V	Area VI	Area VII
Cattle and calves							
Farms	6,850	21,774	3,310	13,108	19,449	12,188	13,058
Number	131,934	549,224	70,159	250,604	276,069	216,349	136,339
Cows and heifers							
Farms	6,520	20,553	3,125	12,220	18,391	11,654	12,218
Number	65,639	286,073	37,274	132,676	155,801	118,177	69,793
Milk cows							
Farms	3,302	11,214	2,050	6,890	13,782	9,087	9,830
Number	12,892	103,345	10,045	55,188	81,517	48,706	33,992
Cows and heifers-- no milk cows							
Farms	3,218	9,339	1,075	5,330	4,609	2,567	2,388
Number	52,747	182,724	27,229	77,488	74,284	69,471	35,801
Heifers and calves							
Farms	5,422	17,417	2,618	10,119	12,679	7,217	7,708
Number	38,608	156,973	20,638	77,714	72,680	52,132	38,731
Steers and bulls							
Farms	4,623	15,629	2,026	8,502	9,512	5,793	5,802
Number	27,687	106,178	12,247	40,214	46,868	46,040	27,851
Hogs and pigs							
Farms	5,692	11,180	2,099	4,883	8,411	6,190	5,756
Number	152,946	239,564	34,177	38,919	38,906	32,915	18,278

TABLE 5 (Continued)

	Area VIII	Area IX	Area X	Area XI	Area XII	Area XIII	Area XIV
Cattle and calves							
Farms	4,186	13,791	8,580	4,639	1,361	2,151	2,444
Number	59,676	271,286	124,045	91,553	50,434	46,242	26,277
Cows and heifers							
Farms	4,008	13,003	8,024	4,211	1,319	1,977	2,346
Number	31,452	135,722	51,871	46,491	26,185	24,113	14,263
Milk cows							
Farms	2,759	7,088	5,001	1,507	408	963	1,928
Number	13,541	28,234	15,091	13,696	1,969	7,452	5,004
Cows and heifers-- no milk cows							
Farms	1,249	5,915	3,023	2,704	911	1,014	418
Number	17,911	107,488	45,480	32,795	24,216	16,661	9,259
Heifers and calves							
Farms	3,269	10,651	6,306	3,640	1,077	1,724	1,655
Number	19,939	79,858	37,735	26,530	11,401	13,863	7,704
Steers and bulls							
Farms	2,499	8,894	5,329	3,277	1,131	1,599	1,234
Number	8,285	55,706	25,739	18,532	12,848	8,266	4,310
Hogs and pigs							
Farms	2,336	7,468	5,028	2,251	849	704	1,322
Number	24,224	117,340	92,111	52,918	40,845	9,687	12,771

Source: U.S.D.A., U.S. Census of Agriculture, 1964, Tennessee, Vol. I, Part 31, Bureau of the Census (Washington: Government Printing Office, 1966), County Table 10.

TABLE 6

TOTAL LIVESTOCK AND LIVESTOCK PRODUCTS SOLD BY AREA, 1964

	Area I	Area II	Area III	Area IV	Area V	Area VI	Area VII
Cattle and calves							
Farms	5,493	19,376	2,658	10,560	16,518	10,308	9,109
Number	62,749	262,439	32,228	118,475	155,464	129,787	71,179
Dollars	6,618,548	20,804,421	2,900,178	9,192,971	12,239,564	11,850,945	5,589,797
Cattle--no calves							
Farms	2,896	10,949	1,226	5,566	7,813	4,902	4,657
Number	26,319	78,555	8,585	37,167	43,220	52,357	27,056
Dollars	4,029,039	9,416,988	1,240,276	4,549,554	5,716,632	7,175,607	3,201,279
Calves							
Farms	4,921	17,636	2,475	9,579	15,456	9,559	8,062
Number	36,430	183,884	23,643	81,308	112,244	77,160	44,123
Dollars	2,589,509	11,387,163	1,659,902	4,643,417	6,522,932	4,675,338	2,388,518
Hogs and pigs							
Farms	4,418	8,727	1,441	1,751	1,838	1,429	971
Number	223,929	391,507	61,652	50,815	37,918	34,881	24,279
Dollars	5,759,461	8,986,790	1,102,503	1,155,396	787,347	600,042	514,118

TABLE 6 (Continued)

	Area VIII	Area IX	Area X	Area XI	Area XII	Area XIII	Area XIV
Cattle and calves							
Farms	2,817	9,343	5,129	4,087	1,309	1,542	1,622
Number	20,518	114,863	45,335	47,386	27,494	19,028	12,036
Dollars	1,286,551	10,533,192	3,907,656	3,902,277	3,048,226	1,318,125	883,376
Cattle--no calves							
Farms	1,412	4,772	2,577	2,193	657	785	774
Number	5,550	39,769	15,293	13,773	8,240	5,095	3,457
Dollars	575,886	5,573,776	1,967,564	1,593,508	1,366,445	540,973	365,715
Calves							
Farms	2,411	8,219	4,337	3,670	1,222	1,373	1,468
Number	14,968	75,094	30,042	33,613	19,254	13,933	8,579
Dollars	710,665	4,959,416	1,940,092	2,308,769	1,681,781	777,152	467,661
Hogs and pigs							
Farms	1,021	3,969	3,060	1,736	768	264	481
Number	30,981	160,960	131,501	129,549	63,046	12,758	19,075
Dollars	803,196	4,078,596	3,307,754	3,599,004	1,765,936	360,519	423,796

Source: U.S.D.A., U.S. Census of Agriculture, 1964, Tennessee, Vol. I, Part 31, Bureau of the Census (Washington: Government Printing Office, 1966), County Table 11.

TABLE 7
LABOR FORCE ESTIMATES FOR THE ECONOMIC AREAS OF THE
TENNESSEE VALLEY, 1967

Economic Area	Labor Force ^a
	---Number---
I	54,180
II	134,857
III	25,300
IV	449,850
V	181,550
VI	97,744
VII	141,780
VIII	28,290
IX	220,710
X	86,110
XI	49,522
XII	6,155
XIII	42,320
XIV	13,160
	<u>1,531,528</u>

^aThe sources of the county data for each state were as follows:

1. Tennessee--Tennessee Department of Employment Security, Nashville.
2. Alabama--Department of Industrial Relations, Montgomery.
3. Georgia--Employment Security Agency, Georgia Department of Labor, Atlanta.
4. Kentucky--Department of Economic Security, Frankfort
5. Mississippi--Mississippi Employment Security Commission, Jackson.
6. North Carolina--North Carolina Department of Employment Security, Raleigh.
7. Virginia--Virginia Employment Commission, Richmond.

The population ranged from 21,700 in Area XII to 919,200 in Area IV. The total population of the Tennessee Valley was estimated at 3,935,300 (Table 8).

II. PRODUCT MARKETS

Product markets which can be supplied by packing plants in the Tennessee Valley were taken from a list published yearly in Sales Management [36, pp. C-125-126]. The selected product markets are in the form of metropolitan areas which are current or potential consumption zones in the Tennessee Valley area. Characteristics of these areas are defined below and relevant purchasing power data pertaining to these areas are presented in Tables 9-15.

1. "Metre-Area--A group of contiguous counties featuring at least one central city of 50,000 inhabitants or more, or 'twin cities' with a combined population of 50,000" [36, p. c].

2. Households--The number of households in 1967 were determined by a statistical updating of the 1960 U. S. Census of Housing. A household is defined as including "all the persons occupying a housing unit as distinguished from a family which consists of two or more persons related to each other by blood, marriage, or adoption. A housing unit is a house, apartment or other group of rooms or a single room when it is occupied or intended for occupancy as separate living quarters" [36, p. c-4].

TABLE 8
TOTAL POPULATION OF THE ECONOMIC AREAS OF THE
TENNESSEE VALLEY, 1967

Economic area	Population
	--Number--
I	128,600
II	400,100
III	89,500
IV	919,200
V	470,300
VI	315,100
VII	383,800
VIII	79,000
IX	557,100
X	261,900
XI	132,400
XII	21,700
XIII	136,900
XIV	49,700
	<u>3,935,300</u>

Source: County data from Sales Management, The Marketing Magazine, Vol. 100, No. 12, June, 1968, pp. D, 189-192, were aggregated to determine populations in the economic areas.

TABLE 9
PRODUCT MARKETS IN TENNESSEE, 1967

Metro area	Population (000)	Households (000)	Retail sales food (000)	Effective buying income		Index of of buying power
				Per capita	Per house	
Bristol, Johnson City, Kingsport ^a	296.4	82.5	83,549	2,042	7,336	.1257
Chattanooga ^b	313.3	92.3	119,584	2,437	8,272	.1512
Knoxville ^c	394.0	116.3	139,519	2,158	7,310	.1776
Memphis ^d	785.4	218.3	239,233	2,189	7,875	.3535
Nashville ^e	534.7	157.8	182,554	2,641	8,951	.2707

^aCounties in the area are: Carter, Sullivan, Washington, Tennessee; Washington, Virginia.

^bCounties in the area are: Walker, Georgia; Hamilton, Tennessee.

^cCounties in the area are: Anderson, Blount, Knox.

^dCounties in the area are: Shelby, Tennessee; Crittendon, Arkansas.

^eCounties in the area are: Davidson, Sumner, Wilson.

Source: Sales Management, The Marketing Magazine, Vol. 100, No. 12, June, 1968, pp. 125-128.

TABLE 10
PRODUCT MARKETS IN NORTH CAROLINA, 1967

Metro area	Population (000)	Households (000)	Retail sales food (000)	Effective Buying income		Index of buying power
				Per capita	Per house	
Asheville ^a	143.3	43.0	58,168	2,495	8,315	.0738
Burlington ^b	95.6	27.3	32,283	2,663	9,325	.0460
Charlotte ^c	386.9	110.2	130,019	2,813	9,878	.2037
Durham ^d	173.9	47.6	52,991	2,610	9,535	.0827
Fayetteville ^e	186.5	44.6	40,223	2,031	8,493	.0766
Gastonia	138.6	38.8	47,986	2,384	8,517	.0619
Greensboro, Winston-						
Salem, High Point ^g	591.5	170.0	187,834	2,650	9,222	.2911
Kannapolis, Salisbury ^h	160.3	46.8	48,514	2,430	8,324	.0711
Raleigh	207.0	56.5	66,252	2,578	9,445	.1025
Rocky Mount ^j	122.8	30.7	32,105	1,654	6,615	.0460
Wilmington ^k	100.8	28.9	38,559	2,193	7,647	.0460

^aCounty in the area: Buncombe.

^bCounty in the area: Alamance.

^cCounties in the area: Maklenburg, Union.

^dCounties in the area: Durham, Orange.

^eCounty in the area: Cumberland.

^fCounty in the area: Gaston.

^gCounties in the area: Forsyth, Guilford, Randolph, Yadkin.

^hCounties in the area: Cabarrus, Rowan.

ⁱCounty in the area: Wake.

^jCounties in the area: Edgecombe, Nash.

^kCounties in the area: Brunswick, New Hanover.

Source: Sales Management, The Marketing Magazine, Vol. 100, No. 12, June, 1968, pp. C, 101-

TABLE 11

PRODUCT MARKETS IN KENTUCKY, 1967

Metre area	Population (000)	Households (000)	Retail sales food (000)	Effective buying income		Index of buying power
				Per capita	Per house	
Huntington, Ashland, West Virginia, Kentucky	259.5	76.7	93,299	2,232	7,552	.1172
Lexington ^b	162.9	48.0	55,592	2,944	9,990	.0883
Louisville ^c	799.7	234.5	207,760	2,752	9,387	.4039
Owensboro ^d	80.4	23.2	23,915	2,301	7,975	.0359

^aCounties in the area are: Boyd, Kentucky; Lawrence, Ohio; Cabel and Wayne, West Virginia.

^bCounty in the area is: Fayette.

^cCounties in the area are: Clark, Floyd, Indiana; Jefferson, Kentucky.

^dCounty in the area is: Daviess.

Source: Sales Management, The Marketing Magazine, Vol. 100, No. 12, June, 1968, pp. C, 61-62.

TABLE 12

PRODUCT MARKETS IN MISSISSIPPI, 1967

Metro area	Population (000)	Households (000)	Retail sales food (000)	Effective buying income		Index of buying power
				Per capita	Per house	
Biloxi, Gulfport ^a	142.5	37.4	37,160	2,234	8,511	.0593
Jackson ^b	260.4	69.5	74,221	2,282	8,550	.1155
Meridian ^c	74.3	21.8	19,284	2,071	7,060	.0315

^aCounty in the area is: Harrison.

^bCounties in the area are: Hinds, Rankin.

^cCounty in the area is: Lauderdale.

Source: Sales Management, The Marketing Magazine, Vol. 100, No. 12, June, 1968, pp. C, 78-80.

TABLE 13

PRODUCT MARKETS IN ALABAMA, 1967

Metro area	Population (000)	Households (000)	Retail sales food (000)	Effective buying income		Index of buying power
				Per capita	Per house	
Anniston ^a	100.0	27.7	30,996	1,900	6,906	.0379
Birmingham ^b	771.8	223.4	243,002	2,128	7,350	.3319
Florence ^c , Sheffield ^c	120.7	33.9	39,054	2,232	7,946	.0513
Gadsden	100.2	28.8	32,950	1,929	6,711	.0411
Huntsville ^e	225.0	62.5	54,813	2,710	9,757	.1037
Mobile ^f	413.9	112.1	112,387	1,953	7,212	.1633
Montgomery ^g	217.9	60.8	64,064	2,233	8,002	.0977
Tuscaloosa ^h	119.6	30.9	34,417	2,100	8,127	.0483

^aCounty in the area is: Calhoun.^bCounties in the area are: Jefferson, Shelby, Walker^cCounties in the area are: Colbert, Lauderdale.^dCounty in the area is: Etowah,^eCounties in the area are: Limestone, Madison.^fCounties in the area are: Baldwin, Mobile^gCounties in the area are: Elmore, Montgomery.^hCounty in the area is: Tuscaloosa.Source: Sales Management, The Marketing Magazine, Vol. 100, No. 12, June, 1968, pp. C, 16-18.

TABLE 14

PRODUCT MARKETS IN GEORGIA, 1967

Metro area	Population (000)	Households (000)	Retail sales food (000)	Effective buying income		Index of buying power
				Per capita	Per house	
Albany ^a	86.3	23.2	20,968	2,367	8,806	.0390
Atlanta ^b	1,278.6	373.8	463,646	3,025	10,346	.7102
Augusta ^c	256.4	67.6	75,919	2,169	8,225	.1128
Columbus ^d	247.4	65.6	59,732	2,077	7,832	.1017
Macon ^e	206.0	60.3	48,236	2,576	8,799	.0995
Savannah ^f	202.5	57.8	51,818	2,156	7,553	.0846

^aCounty in the area is: Dougherty.

^bCounties in the area are: Clayton, Cobb, DeKalb, Fulton, Gwinnett.

^cCounties in the area are: Richmond, Georgia; Aiken, South Carolina.

^dCounties in the area are: Russell, Alabama; Chattoahoochee, Muscogee, Georgia.

^eCounties in the area are: Bibb, Houston. ^fCounty in the area is: Chatham.

Source: Sales Management, The Marketing Magazine, Vol. 100, No. 12, June, 1968, pp. C, 38-40.

TABLE 15

PRODUCT MARKETS IN VIRGINIA, 1967

Metro area	Population (000)	Households (000)	Retail sales food (000)	Effective buying		Index of buying power
				income Per capita	Per house	
Danville ^a	112.2	31.0	23,970	1,815	6,570	.0404
Lynchburg ^b	124.3	34.1	37,755	2,241	8,168	.0545
Newport News, Hampton ^c	281.6	75.8	73,064	2,547	9,464	.1283
Norfolk, Portsmouth ^d	666.5	178.5	186,094	2,188	8,168	.2844
Petersburg, Hopewell ^e	127.1	32.4	36,295	2,196	8,615	.0547
Richmond ^f	514.6	150.0	164,401	2,781	9,540	.2652
Roanoke ^g	178.9	53.4	69,325	2,515	8,426	.0919

^aCounty in the area is: Pittsylvania.^bCounties in the area are: Amherst, Campbell.^cCounties in the area are: Newport News, York.^dCounties in the area are: Norfolk, Princess Ann.^eCounties in the area are: Dinwiddie, Prince George.^fCounties in the area are: Chesterfield, Hanover, Henrico.^gCounty in the area is: Roanoke.Source: Sales Management, The Marketing Magazine, Vol. 100, No. 12, June, 1968, pp. C, 134-

3. Effective Buying Income--"Effective buying income" or disposable personal income is a sum of

. . . estimates of what individuals receive in the form of wages, salaries, and commissions; proprietors' income, rental income from real property, dividends and interest from securities and savings, social security benefits, pensions, and welfare payments. To this sum, we add, where pertinent, imputed value of fuel and food raised and consumed on farms. We subtract from the total the estimate for direct taxes--federal, state, and local [36, p. c-6].

4. Retail Sales--These were "updated from the 1963 Census by statistical analysis of several economic series: employment, earnings, department store sales, sales taxes, collections, bank debits, etc" [36, p. c-6].

III. INPUT-OUTPUT SPECIFICATIONS

Plant Characteristics

A complete model plant consists of four operational stages: beef slaughter (BS), beef boning (BB), hog slaughter (HS), and hog cutting and boning (HC). Complete cost budgets were synthesized in three different scales for each of the four operating stages. The activities in each operation are described in Appendix A.

Each complete model plant was assumed to operate on both a full shift and a half shift operating schedule. The full shift plants operate for eight hours per day. Each of its four component operations has a separate work crew which is responsible for slaughtering or cutting and boning for the entire eight-hour shift,

The half shift plants also operate for eight hours per day; however, the slaughter operations and the cutting and boning operations each use the same work crew. Slaughter takes place during one four-hour shift; the work crew then changes over and is responsible for cutting and boning during another four-hour shift. Activities such as clean-up, yard work, cooler, and maintenance, however, take place for the full eight hours in both full and half shift operations.

In both the full and half shift plants, the cutting and boning crew processes the previous day's slaughter. The carcasses are kept in the cooler over night.

Although the full shift plants operate on an eight-hour a day basis, the effective operating time² is seven hours and 30 minutes due to two 15-minute rest breaks. Lunch breaks are not taken on plant operating time and the workers are not paid for this period.

The effective operating time in the half shift operations is three hours, 35 minutes per shift. Two 15-minute rest breaks and a 20-minute period necessary for changing over from slaughtering to cutting and boning bring the daily effective operating time to seven hours and ten minutes per day in a combined slaughter, cutting and boning operation.

All plants are in operation five days per week for 52 weeks per year, with the exception of holidays. The total number of days worked per year then is 252.

² Effective operating time is that time during which the work crews are at their stations and not on lunch or rest breaks.

Beef slaughter capacity ranged from 750 to 2,250 head per week in the single shift operations and from 358 to 1,074 head per week in the half shift stages. Hog slaughter capacity ranged from 1,875 to 11,250 head per week on a single shift and from 895 to 5,370 head per week on the half shift stages. The beef boning and hog cutting and boning operations were each "constructed" in three successively larger sizes. Each was designed to process the maximum amount of raw product that the associated slaughter operation could supply. Table 16 shows the hourly, weekly, and annual output of all model operations at full capacity.

Slaughter Composition

It was assumed that the cattle slaughter operation would slaughter in the following composition: steers, 27 percent; heifers, 27 percent; cows, ten percent; bulls, three percent, cutters and canners, 33 percent. Ninety percent of the hogs slaughtered were barrows and gilts and the remaining ten percent was composed of sows. These percentages were based on 1968 average slaughter percentages for the South Central States, Eastern Region [47]. Weekly output for the beef and hog slaughter operations and the percentage slaughter in each market class is shown in Tables 17 and 18.

Slaughter Animal Characteristics

Average dressed weights of beef cattle by class in 1968 were taken from Livestock and Meat Statistics [46, p. 106]. It was assumed the entire yield of dressed steer and heifer carcasses would be sold

TABLE 16
OUTPUT OF THE MODEL OPERATIONS AT FULL CAPACITY

Operation	Output per hour	Output per week		Output per year	
		Single shift ^a	Half shift ^b	Single shift ^a	Half shift ^b
		-----Number of head-----			
<u>Beef Slaughter</u>					
BS-I	20	750	358	37,800	18,043
BS-II	40	1,500	716	75,600	36,086
BS-III	60	2,250	1,074	113,400	54,130
<u>Beef Boning</u>					
BB-I	10	375	179	18,900	9,022
BB-II	20	750	358	37,800	18,043
BB-III	30	1,125	537	56,700	27,065
<u>Hog Slaughter</u>					
HS-I	50	1,875	895	94,500	45,108
HS-II	125	4,688	2,238	236,250	112,770
HS-III	300	11,250	5,370	567,000	270,648
<u>Hog Cutting and Boning</u>					
HC-I	100	3,750	1,790	189,000	90,216
HC-II	125	4,688	2,238	236,250	112,770
HC-III	300	11,250	5,370	567,000	270,648

^aBased on seven hours and 30 minutes per day of effective operating time.

^bBased on three hours and 35 minutes per day of effective operating time.

TABLE 17

COMPOSITION OF SLAUGHTER BY MARKET CLASS IN THE MODEL BEEF SLAUGHTER OPERATIONS^a

Operation	Total head per weak at full capacity		Steers, ^c 27 percent		Heifers, ^d 27 percent		Cows, ^e 10 percent		Bulls, ^f 3 percent		Cutters and canners, ^g 33 percent	
	Full shift	Half shift	Full shift	Half shift	Full shift	Half shift	Full shift	Half shift	Full shift	Half shift	Full shift	Half shift
BS-I	750	358	203	97	203	97	75	36	23	11	248	118
BS-II	1,500	716	405	193	405	193	150	72	45	21	495	236
BS-III	2,250	1,074	608	290	608	290	225	107	68	32	743	354

^aThe market class slaughter composition was based on 1968 average slaughter percentages for the South Central States, Eastern Region, U.S.D.A., Livestock Div., C.M.S., Vol. 36, Nos. 1-53 (Wash.: G.P.O., 1968).

^bTable 16 (page 51).

^c27 percent of columns 1 and 2.

^d27 percent of columns 1 and 2.

^e10 percent of columns 1 and 2.

^f3 percent of columns 1 and 2.

^g33 percent of columns 1 and 2.

TABLE 18

COMPOSITION OF SLAUGHTER BY MARKET CLASS IN THE MODEL HOG SLAUGHTER OPERATIONS^a

Operation	Total head per week at full capacity ^b		Barrows and gilts, 90 percent ^c		Sows, 10 percent ^d	
	Full shift	Half shift	Full shift	Half shift	Full shift	Half shift
HS-I	1,875	895	1,688	806	188	90
HS-II	4,688	2,238	4,219	2,014	469	224
HS-III	11,250	5,370	10,125	4,833	1,125	537

^aThe market class slaughter composition was based on 1968 average slaughter percentages for the South Central States, Eastern Region, U.S.D.A., Livestock Div., C.M.S., Vol. 36, Nos. 1-53 (Wash. G.P.O., 1968).

^bTable 16 (page 51).

^c90 percent of columns 1 and 2.

^d10 percent of columns 1 and 2.

fresh. Cows, bulls, and cutters and canners would be boned out and sold as boneless beef. Carcass yields of boneless beef for cows, bulls, and cutters and canners are 73.5 percent, 72.4 percent, and 70.0 percent, respectively [14, p. 25]. The yields of fresh cuts and boneless beef are shown in Table 19.

The average live weight of barrows and gilts in 1968 was 233 pounds per head, and sows averaged 432 pounds [46, p. 99]. The average dressed weight of barrows and gilts used in this study was then 172 pounds (74.0 percent of 233 pounds per head). The disassembly characteristics of barrows and gilts were the standard yields utilized by the industry [28, p. 48]. Sows were all boned out and according to industry sources, the yield of boneless pork is 52 percent of the live weight (Table 20).

TABLE 19
DRESSED CARCASS YIELDS OF FRESH CUTS AND BONELESS BEEF

Slaughter class	Slaughter composition ^a	Average dressed weight per head ^b Pounds	Dressed weight yield of fresh cuts and boneless beef ^c -----Percent-----	Fresh cuts	Boneless beef
				---Pounds per head---	
Steers	27	667	97.0	647	
Heifers	27	558	97.0	541	
Cows	10	495	73.5		364
Bulls	3	706	72.4		511
Cutters and canners	33	315	70.0		221

^aTable 17 (page 52).

^bU. S. average dressed weights under Federal Inspection, 1968, U.S.D.A., Supplement for 1968 to Statistical Bulletin No. 333, E.R.S. (Washington: Government Printing Office, July, 1969), pp. 143-145.

^cCole, J. W., C. B. Ramsey, and A. R. Cavender, Tennessee A.E.S. Bulletin 345 (Knoxville: The University of Tennessee, July 1962), p. 25, including 3 percent shrinkage.

TABLE 20
PORK CARCASS YIELDS OF FRESH CUTS AND BONELESS PORK

Cuts of pork	Yield per head percent of dressed weight ^a	Yield per head percent of live weight ^b	Yield per head ^c Pounds
<u>Barrows and gilts</u>			
Hams	18.5		31.82
Picnics	8.5		14.62
Belly	17.5		30.10
Fat backs	18.0		30.96
Jowl	3.0		5.16
Loins	15.0		25.80
Boston butts	6.5		11.18
Ribs	3.0		5.16
Neckbones, feet, and tail	5.0		8.60
Sausage trimmings	5.0		8.60
			<u>172.00</u>
<u>Sows</u>			
Boneless pork		52	225.00

^aLessons on Meat (Chicago: N.L.M.B., 1966), p. 48.

^bA standard supplied by local industry sources. Average live weight of sows is 432 pounds.

^cAverage dressed weight of barrows and gilts is 172 pounds.

CHAPTER IV

MODEL PLANT SYNTHESIS

The model plants consisted of four operating stages: beef slaughter, beef boning, hog slaughter, and hog cutting and boning. The labor, building, equipment, and utilities requirements were taken from Logan and King [29] for the beef slaughter operations and from Cassell and West [12] for the hog slaughter operations. These studies were selected as data sources for these two operations after an extensive survey of equipment manufacturers and review of livestock processing, economic engineering studies. Both equipment manufacturers and industry sources indicated that the input requirements reported in these studies were consistent with efficient technology that is currently available. Since the input budgets and plant layouts reported for these studies were deemed applicable to conditions in the Tennessee Valley, there was no need to duplicate the assembly of input budgets for the beef slaughter and hog slaughter operations.

For the beef boning and hog cutting and boning stages, input budgets and plant layouts were synthesized from data and specifications provided by equipment manufacturers and from personal interviews with industry sources.

I. LABOR REQUIREMENTS AND COSTS

Plant labor costs were determined for each of the four operations: beef slaughter, hog slaughter, beef boning, and hog cutting and boning. Input budgets for these four operations were specified for three successively larger sizes. Labor costs were estimated for each of the model operations (or stages) for both full shift and half shift operating schedules.

The model operations were designed to be combined into complete plants that performed all four operations. The full shift slaughter operations for both cattle and hogs were designed to be combined with full shift cutting and boning operations of compatible sizes. Similarly, the half shift slaughter operations were designed to be combined with half shift cutting and boning operations. The beef slaughter, cutting, and boning combined operations were then merged with the combined hog slaughter, cutting, and boning operations to form complete diversified plants.

In a combined full shift slaughter, cutting and boning operation, there are two labor crews. One crew slaughters during the entire eight-hour day. The other crew also works on a eight-hour day and is responsible for cutting and boning the previous day's carcasses (which have been kept in the cooler overnight).

In a combined half shift slaughter, cutting and boning operation, there is only one crew. This crew kills in the morning during one four-hour shift. During the afternoon the crew cuts and bones

the previous day's carcasses during another four-hour shift. Activities such as clean-up, yard work, cooler, and maintenance, however, take place during the full eight hours in both the full and half shift operations.

Laborers in the full shift operations are paid for an eight-hour day, 40 hours per week for 50 weeks per year, and workers in each of the half shift operations are paid for a four-hour day, 20 hours per week for 50 weeks. But, when a half shift slaughter operation is combined with a half shift cutting and boning operation, in actuality the same crew is used for both operations. They are paid, however, on the basis of four hours per day for the slaughter operation and four hours per day in the cutting and boning operation.

According to an American Meat Institute survey of U. S. meat processing plants in 1966, employee benefits account for 15.4 percent of total wages and salaries. These benefits include: social security, 3.9 percent; retirement, 2.7 percent; insurance and hospitalization, 3.8 percent; and vacations and holidays, 5.0 percent [18, p. 10].

Beef Slaughter Labor Requirements and Costs

Labor requirements for 20, 40, and 60 head per hour on-the-rail slaughter operations were taken from Logan and King [29, Tables A-3, 4, 10, 11]. Wage rates for the Tennessee Valley in 1968 were supplied by the local representative of the Amalgamated Meat Cutters and Butchers Workmen of North American, AFL-CIO (Appendix B, Tables 60 and 61).

Total annual in-plant labor costs including benefits for the 20 head per hour beef slaughter operation (BS-I) were \$91,516. The half shift stage totaled \$45,758. The annual in-plant labor cost for BS-II was \$172,364 for the full shift and \$86,182 for the half shift. Beef slaughter operation III totaled \$240,217 and \$120,109 for the full and half shifts, respectively. Cooler, dock maintenance, yard and clean-up employee requirements and wage rates are shown in Table 21, and are the same for both the full and half shift beef slaughter operations,

Outlays for office, managerial, and buying and selling labor cannot be associated directly with any particular operating stage of a complete plant. Therefore outlays for these labor categories were estimated to be a constant percent of the in-plant labor costs for each operation. On the basis of reports of earlier research on costs of beef slaughter [29, p. 53] and hog slaughter [12, p. 21], costs for office, managerial, and buying and selling labor were assumed to be 60.41 percent of the in-plant labor cost for each model operation.¹ Total beef slaughter labor costs are summarized in Table 21.

Hog Slaughter Labor Requirements and Costs

Labor requirements for 50, 125, and 300 head per hour hog slaughter operations were taken from a study by Cassell and West [12, p. 23]. The number of laborers required and the average wage rates

¹The figure used is the average of the ratios of office, managerial, and buying and selling labor costs to in-plant labor costs reported by Logan and King [29, p. 53] and Cassell and West [12, p. 21].

TABLE 21

ANNUAL IN-PLANT, COOLER, DOCK, MAINTENANCE, YARD, CLEAN-UP, OFFICE, BUYING AND SELLING, AND MANAGERIAL LABOR COST FOR THE BEEF SLAUGHTER OPERATIONS

Operation	In-plant ^a		Cooler, dock, maintenance, and yard ^b		Clean-up ^b		Office, managerial ^c buying and selling		Total	
	Full shift	Half shift	Both shifts		Both shifts		Full shift	Half shift	Full shift	Half shift
BS-I	91,516	45,758	43,240		2,487		55,285	27,642	192,528	119,127
BS-II	172,364	86,182	85,442		4,974		104,125	52,063	366,905	228,661
BS-III	240,217	120,109	106,895		7,461		145,115	72,559	499,688	307,024

^aCalculated from Tables 60 and 61, Appendix B.

^bCalculated from Table 62, Appendix B.

^c60.41 percent of in-plant labor cost.

for the Tennessee Valley are given in Table 22 and the plant, office, managerial, buying and selling, and total annual cost for full and half shift operating schedules are found in Table 23.

Beef Boning Labor Requirements and Costs

Labor requirements for beef boning operations of 10, 20, and 30 head per hour capacities were synthesized from equipment company data and specification [27] and personal interviews with industry sources. Wage rates for the Tennessee Valley in 1968 were supplied by the local representative of the Amalgamated Meat Cutters and Butchers Workmen of North America, AFL-CIO.

Labor requirements and hourly wage rates are in Table 24 and total labor costs of beef boning operations are shown in Table 25.

Hog Cutting and Boning Labor Requirements and Costs

Labor requirements for hog cutting and boning operations of 100, 125, and 300 head per hour were synthesized from equipment company specifications [1, pp. 11-13]. The plant wage rates were supplied by the local representative of the Amalgamated Meat Cutters and Butchers Workmen of North America, AFL-CIO (Appendix B, Tables 63, 64, and 65). Total labor costs for hog cutting and boning operations are found in Table 26.

Total Labor Cost

The total annual labor costs for all model operations is summarized in Table 27.

TABLE 22

LABOR REQUIREMENTS AND HOURLY WAGE RATES FOR THE
HOG SLAUGHTER OPERATIONS

Worker classification	Number of workers ^a			Hourly wage rate ^b
	HS-I	HS-II	HS-III	
				--Dollars--
In-Plant	9	23	52	2.253
Clean-up	1	2	3	2.155
Yard	1	2	4	2.155

^aTaken from Cassell, G. R., and West, D. A., N. C. State E.R.R. No. 3 (Raleigh: N. C. State, June, 1967), p. 23.

^bHourly wage rates are 1968 Tennessee Union wage rates, supplied by the local representative of the Amalgamated Meat Cutters and Butchers Workmen of North America, AFL-CIO.

TABLE 23

ANNUAL IN-PLANT, YARD, CLEAN-UP, OFFICE, MANAGERIAL, AND BUYING AND SELLING LABOR
AND TOTAL LABOR COST FOR THE HOG SLAUGHTER OPERATIONS.

Operation	In-Plant ^a		Yard ^a		Clean-up ^a		Office, managerial ^b buying and selling		Total	
	Full shift	Half shift	Beth shifts	Beth shifts	Beth shifts	Full shift	Full shift	Half shift	Full shift	Half shift
-----Dollars-----										
HS-I	46,799	23,400		4,974	4,974	28,271	28,271	14,136	85,018	47,484
HS-II	119,598	59,799		9,947	9,947	72,249	72,249	36,125	211,741	112,818
HS-III	270,396	135,198		19,895	14,921	163,346	163,346	81,673	468,558	251,687

^aCalculated from Table 22.

^b60.41 percent of in-plant labor cost (column 1).

TABLE 24
LABOR REQUIREMENTS AND HOURLY WAGE RATES FOR THE
BEEF BONING OPERATIONS

Worker classification	Number of workers ^a			Hourly wage rate ^b --Dollars--
	BB-I	BB-II	BB-III	
Boners	5	9	11	2.755
Break-up men	-	3	4	2.230
Handlers	2	-	1	2.155

^aThese requirements were synthesized from equipment company specifications, Koch Supplies, Inc. (Kansas City, Missouri: Koch Supplies, Inc., 1968), and interviews with industry sources.

^bTennessee Union wage rates for 1968 were supplied by the local representative of the Amalgamated Meat Cutters and Butchers Workmen of North America, AFL-CIO.

TABLE 25

ANNUAL PLANT, OFFICE, MANAGERIAL, BUYING AND SELLING, AND
TOTAL LABOR COST FOR THE BEEF BONING OPERATIONS

Operation	Plant labor ^a		Office, managerial, buying and selling ^b		Total	
	Full shift	Half shift	Full shift	Half shift	Full shift	Half shift
	-----Dollars-----					
BB-I	41,741	20,871	25,216	12,608	66,957	33,479
BB-II	72,668	36,335	43,899	21,950	116,567	58,285
BB-III	95,505	47,754	57,695	28,848	153,200	76,602

^aCalculated from Table 24 (page 65).

^b60.41 percent of plant labor.



TABLE 26

ANNUAL PLANT, OFFICE, MANAGERIAL, BUYING AND SELLING, AND TOTAL
LABOR COST FOR THE HOG CUTTING AND BONING OPERATIONS

Operation	Plant labor ^a		Office, managerial, buying and selling ^b		Total	
	Full shift	Half shift	Full shift	Half shift	Full shift	Half shift
	-----Dollars-----					
HC-I	79,771	39,886	48,190	24,095	127,961	63,981
HC-II	89,833	44,917	54,268	27,134	144,101	72,051
HC-III	219,930	109,965	132,860	166,430	352,790	176,395

^aCalculated from Tables 63 (page 169), 64 (page 170), and 65 (page 171).

^b60.41 percent of plant labor.

TABLE 27
TOTAL ANNUAL LABOR COSTS FOR ALL MODEL OPERATIONS

Operation	Total annual labor cost	
	Full shift	Half shift
	-----Dollars-----	
<u>Beef Slaughter</u> ^a		
BS-I	192,528	119,127
BS-II	366,905	228,661
BS-III	499,688	307,024
<u>Beef Boning</u> ^b		
BB-I	66,957	33,479
BB-II	116,567	58,285
BB-III	153,200	76,602
<u>Hog Slaughter</u> ^c		
HS-I	85,018	47,484
HS-II	211,741	112,818
HS-III	468,558	251,687
<u>Hog Cutting and Boning</u> ^d		
HC-I	127,961	63,981
HC-II	144,101	72,051
HC-III	352,790	176,395

^aTable 21 (page 61).

^bTable 25 (page 66).

^cTable 23 (page 64).

^dTable 26 (page 67).

II. BUILDING REQUIREMENTS AND COSTS

It was assumed that buildings utilized in this study would comply with federal standards and guidelines for construction. [49, pp. 7-8].

Beef Slaughter Building Requirements and Costs

The building requirements in square feet for the three beef slaughter operations were taken from Logan and King's [29, p. 62], three on-the-rail plants, killing 20, 40, and 60 head per hour, respectively. The costs per square foot in the Logan and King study were adjusted to approximate costs in the Tennessee Valley. Two adjustments were made: (1) the costs per square foot were adjusted for price level changes from 1962 to 1968; (2) the estimates were then adjusted for the geographic price differential between California and Tennessee. Logan and King used 1962 building costs for Los Angeles, California. The historical building cost index in The Architectural Record [42, p. 92] changed from 276.3 to 300.4 between 1962 and 1968. Or, according to this index, building costs in 1968 were 9 percent higher in 1968 than they were in 1962.

Geographic cost differentials were also taken from The Architectural Record [45, p. 92]. It was found that Los Angeles had a cost differential of 8.4. Since no differential is published for any city in Tennessee, the values for Atlanta and Birmingham were averaged to provide an estimated building cost differential for the Tennessee Valley. This figure was 7.4 percent. Dividing these two differentials

leads to the conclusion that Los Angeles building costs were 13.5 percent greater than those of Tennessee.

The adjustment then involved increasing the Logan and King building costs 9 percent for price level changes between 1962 and 1968 and then decreasing them 13.5 percent for the estimated geographic differential between California and Tennessee for 1968. Table 28 shows the adjusted building costs per square foot, the required number of square feet, and the estimated total building costs for the three beef slaughter operations.

Hog Slaughter Building Requirements and Costs

Cassell and West's [12, p. 14] building requirements were used for hog slaughter plants killing 50, 125, and 300 head per hour. For buildings, the estimated costs per square foot used for beef slaughter operations (Table 28) were used also for the hog slaughter operations. These costs and requirements are summarized in Table 29.

Beef Boning Building Requirements and Costs

Input budgets in the beef boning operations were synthesized from equipment company specifications [27], and personal interviews with industry sources. Appendix C shows the layouts of the model operations (Figures VIII, IX, and X). The areas required for each of the three different sizes of operation were 1,080, 1,080, and 1,180 square feet, respectively, for the plants boning 10, 20, and 30 head per hour.

TABLE 28

BEEF SLAUGHTER BUILDING REQUIREMENTS AND COSTS^a

Building area	Building cost per square foot	BS-I		BS-II		BS-III	
		Square feet	Cost	Square feet	cost	Square feet	Cost
Kill floor	23.88	1,230	29,372	3,219	76,870	5,142	122,791
Chill and offal cooler	19.10	1,513	28,898	2,672	51,035	3,645	69,620
Sales cooler	19.10	2,147	41,008	4,092	78,157	5,796	110,704
Equipment clean-up	9.55	224	2,139	224	2,139	224	2,139
Refrigerator	9.55	240	2,292	240	2,292	800	7,640
Boiler	9.55	200	1,910	372	3,553	442	4,221
Dry storage	9.55	150	1,433	229	2,187	344	3,285
Basement	9.55	618	5,902	1,237	11,813	1,855	17,715
Dock	19.10	430	8,213	990	18,909	1,350	25,785
Dock apron	3.82	860	3,285	1,320	5,042	1,800	6,876
Ramp	3.82	900	3,438	1,800	6,876	1,800	6,876
Areas in pens and alleys	2.63	9,313	24,493	17,813	46,848	26,313	69,203
Gates	42.98	34	1,461	68	2,923	102	4,384
Fencing (linear feet)	2.15	1,107	2,380	2,037	4,380	2,977	6,401
Total			156,224		313,024		457,640

^aBasic building costs and requirements were taken from Logan, S. H., and G. A. King, Cal. A.E.S. Gianinni Foundation R. R. No. 260 (Berkeley: Univ. of Cal., Dec., 1962), p. 62. The costs per square foot were adjusted for price level changes and geographic price differentials using procedures described on pages 69 and 70.

TABLE 29
HOG SLAUGHTER BUILDING REQUIREMENTS AND COSTS

Building area	Building cost ^a	HS-I		HS-II		HS-III	
		Square feet	Cost	Square feet	Cost	Square feet	Cost
Slaughter room	23.88	1,920	45,850	3,000	71,640	3,200	76,416
Chill cooler	19.10	1,820	34,762	4,200	80,220	8,632	164,871
Boiler room	9.55	300	2,865	427	4,078	552	5,272
Holding pens and alleyway	2.63	3,240	8,521	7,968	20,956	18,990	49,944
Total			91,998		176,894		296,503

^aBasic building costs per square foot were taken from Logan, S. H., and G. A. King, Cal. A.E.S. Gianinni Foundation R. R. No. 260 (Berkeley: Univ. of Cal., Dec., 1962), p. 62, and adjusted for price level changes and a geographic price differential using procedures described on pages 69 and 70.

^bTaken from Cassell, G. R., and D. A. West, N. C. State E.R.R. No. 3 (Raleigh: N. C. State, June, 1967), p. 14.

The costs per square foot of building space for the boning operations were based on data from a meat processing plant study in Oklahoma by Schnake [38, p. 37]. The cost differential for Kansas City in The Architectural Record [42, p. 92] was used to represent a cost differential appropriate for the Oklahoma area.

The cost differential of 8.3 for Kansas City was assumed to represent the Oklahoma area and was compared to the Atlanta-Birmingham average of 7.4 for 1968. Accordingly, it was estimated that building costs in Tennessee were 12.2 percent lower than in Oklahoma.

The Oklahoma study was based on 1967 data. The historical building cost index for Kansas City in The Architectural Record [42, p. 92] changed from 264.3 in 1967 to 273.6 in 1968 indicating a four percent rise in building costs from 1967 to 1968. Also, the building cost estimate for Oklahoma was decreased 12.2 percent to take account of the geographic price differential.

The basic building costs for cutting and boning facilities reported for Oklahoma was \$18.25 per square foot. The estimate for the Tennessee Valley in 1968 was \$16.75. The total cost of buildings for the three beef boning operations was \$18,090, \$18,090, and \$19,765 for operations BB-I, BB-II, and BB-III, respectively.

Hog Cutting and Boning Building Requirements and Costs

Equipment and building space requirements for the hog cutting and boning operations were synthesized from equipment manufacturers' specifications [1, pp. 11-13]. Building requirements in square feet

were 968, 1,085, and 1,470, respectively, for the three sizes of operation. At \$16.75 per square foot (the same estimate used for beef cutting and boning), the total cost for each operation was \$16,214, \$18,174, and \$24,623 for HC-I, HC-II, and HC-III, respectively.

Office and Employee Dressing Building Requirements and Costs

Building costs for office space and for employee dressing rooms were "overall costs," which could not be associated with a particular operation. (See Chapter II, Analytical Procedure.) Office building cost as a percent of total building cost was calculated from the figures in the Logan and King [29, p. 62], and Cassell and West [12, p. 14] studies, and the two were averaged to arrive at a figure of 5.2 percent. Similarly, the cost of the employee dressing building area was found to be 3.3 percent of the total building cost. Several other studies were examined and similar percentage figures were derived. For each of the model operations then, it was assumed that office costs were 5.2 percent of plant building costs and employee dressing room building costs were 3.3 percent of the total building cost.

Building Depreciation

Buildings were assumed to have a useful life of 25 years [29, p. 74]. They were depreciated by the straight line method at four percent per year. The total costs of plant and corral, office, and employee dressing buildings along with annual depreciation are summarized in Table 30.

TABLE 30

ANNUAL TOTAL BUILDING COST AND DEPRECIATION OF PLANT AND
CORRALS, OFFICE, AND EMPLOYEE DRESSING FACILITIES

Operation	Plant and corral	Office ^a	Employee dressing ^b	Total	Annual depreciation ^c
	-----Dollars-----				
BS-I	156,224 ^d	8,124	5,155	169,503	6,780
BS-II	313,024 ^d	16,277	10,330	339,631	13,585
BS-III	457,640 ^d	23,797	15,102	496,539	19,862
BB-I	18,090 ^e	941	597	19,628	785
BB-II	18,090 ^e	941	597	19,628	785
BB-III	19,765 ^e	1,028	652	21,445	858
HS-I	91,998 ^f	4,784	3,036	99,818	3,993
HS-II	176,894 ^f	9,198	5,838	191,930	7,677
HS-III	276,503 ^f	15,418	9,785	321,706	12,868
HC-I	16,214 ^g	843	535	17,592	704
HC-II	18,174 ^g	945	600	19,719	789
HC-III	24,623 ^g	1,280	813	26,716	1,069

^a5.2 percent of plant and corral cost.

^b3.3 percent of plant and corral cost.

^c4 percent of total building cost.

^dTable 28 (page 71).

^eSynthesized from equipment company specifications, Koch Supplies, Inc. (Kansas City, Missouri: Koch Supplies, Inc., 1968), and personal interviews with industry sources.

^fTable 29 (page 72).

^gSynthesized from equipment company specifications, Allbright-Nell Company (Chicago: Allbright-Nell Company, 1951), pp. 11-13.

III. EQUIPMENT REQUIREMENTS AND COSTS

It was assumed that all equipment utilized in the model plants would comply with federal guidelines on machinery and equipment installation and maintenance [49, p. 7].

Logan and King's beef slaughter equipment requirements were used for on-the-rail plants slaughtering 20, 40, and 60 head per hour [29, Appendix Table X-16]. The total in-plant equipment cost was inflated by the Bureau of Labor Statistics wholesale price index of machinery and equipment from 1962 to 1968 [52, p. A-64]. The 1962 index was 102.9 with 1957-59 = 100. The 1968 index was 114.7. It was assumed then, that Los Angeles f.o.b. prices of equipment rose 11.8 percent from 1962 to 1968.

The hog slaughter equipment requirements and costs were taken from the Cassell and West hog slaughter study for 50, 125, and 300 head per hour plants, respectively [12, p. 19]. The equipment costs were inflated from 1967 to 1968 by the Bureau of Labor Statistics wholesale price index for machinery and equipment. The index rose from 111.8 in 1967 to 114.7 in 1968, indicating a 3.0 percent rise in equipment costs from 1967 to 1968. Total equipment cost included slaughter room equipment, refrigeration equipment, and boilers.

The beef boning operations were synthesized from equipment specifications and costs of Koch Company in Kansas City [27]. Appendix C lists the equipment requirements and costs in Tables 66, 67, and 68. Layouts for these operations are also in Appendix C, Figures VIII, IX, and X.

Equipment specifications for the hog cutting and boning operations were supplied by the Allbright-Nell Company. Appendix C lists the equipment requirements and costs in Tables 69, 70, and 71.

Office and employee dressing room equipment costs are "overall costs," which cannot be associated with a particular operation. Office equipment includes file cabinets, typewriters, desks, chairs, calculators, drinking fountains, a safe, and several miscellaneous items. Employee dressing facilities include lockers, waste containers, drinking fountains, mirrors, etc. Percentage figures for these costs were derived in the same manner as were the figures for office and employee dressing building costs. It was found that office equipment cost involved an average of 5.2 percent of the plant equipment in the Logan and King [29, p. 72], and Cassell and West [12, p. 19] studies. Employee dressing equipment costs were 0.7 percent of the plant equipment costs. Several other studies were examined and employee dressing equipment costs varied from study to study. The figures of 5.2 and 0.7 percent were used because the Logan and King and Cassell and West studies are of similar size and technological configuration to the model operations of this study.

Calculation of Equipment Costs

The total f.o.b. equipment cost was the sum of the f.o.b. plant equipment cost, f.o.b. office equipment cost, and the f.o.b. employee dressing room equipment cost. Since the plant equipment costs were f.o.b. California, North Carolina, Missouri, and Chicago for the beef

slaughter, hog slaughter, beef boning, and hog cutting and boning operations, respectively, it was necessary to derive freight and installation costs.

In order to determine these costs, a survey was taken of packing plants in the Tennessee Valley. The results of the survey indicated that freight charges averaged five percent of the f.o.b. equipment cost and installation charges averaged 25 percent. The f.o.b. equipment costs were therefore increased by 30 percent to account for freight and installation.² The state of Tennessee has a one percent sales tax on industrial equipment so this one percent was added to the f.o.b. equipment cost plus freight and installation.³

In order to arrive at a balance for depreciation, salvage values of all plant equipment must be subtracted from the total equipment cost. The only study which listed these salvage values for compatible plant sizes with the model operations in this study was Logan and King [32, p. 72]. The average salvage value of all equipment in the Logan and King study was 7.3 percent of the total equipment bill. This figure

²The Logan and King beef slaughter equipment costs included installation charges, so only a five percent freight charge was added. The costs of refrigeration equipment and boilers in the Cassell and West study also included installation so only the five percent freight charge was added to this component of hog slaughter equipment costs. All other equipment costs were net of freight and installation charges and the figure of 30 percent was added, accordingly.

³Sales taxes on industrial machinery and equipment in other states in the Tennessee Valley include: Mississippi, 1.0 percent; North Carolina, 1.0 percent; Alabama, 1.5 percent; Kentucky, 5 percent; and Georgia, 3 percent. Industrial machinery and equipment is tax exempt in Virginia [44, pp. 216-217].

was subtracted from the equipment costs in each of the model operations to arrive at a balance for depreciation. Depreciation was based on an average expected use life of 12.5 years. The annual rate was therefore eight percent.

Table 31 contains f.o.b. equipment costs for the four operations including office and employee dressing. Table 32 contains the f.o.b. equipment cost plus freight, installation, sales tax, salvage values, the balance for depreciation, and the actual depreciation for the four model operations.

IV. LAND REQUIREMENTS AND COSTS

The total land area for each plant included space required for buildings, parking for plant personnel, visitor parking, and additional area for future expansion and landscaping. The parking area requirements were calculated on the basis of nine by 30 feet for each employee. It was assumed that the visitors parking area added ten percent to the regular employee parking area. The miscellaneous land area (for future expansion and landscaping) was assumed to be ten percent of the combined building and parking area for the full shift operations and ten percent of the total parking area for the half shift operations [28, p. 46].

The per acre land cost was assumed to be \$2,000. This figure was the median or expected price per acre reported for the Tennessee Valley by the East Tennessee Industrial Development Division in Knoxville. Accordingly, the cost per square foot of all land was assumed to be \$.046.

TABLE 31

IN-PLANT, OFFICE, EMPLOYEE DRESSING, AND TOTAL F.O.B.
EQUIPMENT COSTS FOR THE MODEL OPERATIONS

Operation	In-Plant	Office ^a	Employee ^b dressing	Total
	-----Dollars-----			
BS-I	119,724 ^c	6,226	838	126,788
BS-II	173,032 ^c	8,998	1,211	183,241
BS-III	278,151 ^c	14,464	1,947	294,562
BB-I	12,642 ^d	657	88	13,387
BB-II	13,428 ^d	698	94	14,220
BB-III	16,453 ^d	856	115	17,424
HS-I	37,393 ^e	1,944	262	39,599
HS-II	89,646 ^e	4,662	628	94,936
HS-III	163,497 ^e	8,502	1,144	173,143
HC-I	14,051 ^f	731	98	14,880
HC-II	22,585 ^f	1,174	158	23,917
HC-III	46,001 ^f	2,392	322	48,715

^a5.2 percent of in-plant.

^b0.7 percent of in-plant.

^cLogan, S. H., and G. A. King, Cal. A.E.S. Gianinni Foundation R. R. No. 260 (Berkeley: Univ. of Cal., Dec., 1962), Appendix Table x-16, and adjusted for price level changes (see page 76). These figures include installation costs.

^dAppendix C, Tables 66, 67, and 68.

^eCassell, G. R., and D. A. West, N. C. State E.R.R. No. 3 (Raleigh: N. C. State, June, 1967), pp. 15-19, and adjusted for a price level increase of 2.9 percent (see page 76).

^fAppendix C, Tables 69, 70, and 71.

TABLE 32

CALCULATION OF EQUIPMENT DEPRECIATION FOR THE MODEL OPERATIONS

Operation	Equipment cost plus freight and installation ^a	Total equipment cost including sales tax ^b	Salvage value ^c	Balance for depreciation ^d	Depreciation ^e
-----Dollars-----					
BS-I	133,127 ^f	134,458	9,256	125,202	10,016
BS-II	192,403 ^f	194,327	13,377	180,950	14,476
BS-III	309,290 ^f	312,383	21,503	290,880	23,270
BB-I	17,403	17,577	977	16,600	1,328
BB-II	18,406	18,671	1,038	17,633	1,411
BB-III	22,651	22,877	1,272	21,605	1,728
HS-I	43,183 ^g	43,615	2,890	40,725	3,258
HS-II	105,119 ^g	106,170	6,930	99,240	7,939
HS-III	191,164 ^g	193,076	12,639	180,437	14,435
HC-I	19,344	19,537	1,086	18,451	1,476
HC-II	31,092	31,403	1,746	29,657	2,373
HC-III	63,330	63,963	3,556	60,407	4,833

^aFreight charge is 5 percent of total cost and installation is 25 percent.

^bSales tax adds 1 percent to column (1).

^cSalvage value is 7.3 percent of total f. o. b. cost.

^dColumn (2) minus column (3).

^eEight percent of column (4).

^fSince installation is included in the total cost figure (Table 33), only a 5 percent freight charge was added.

^gThe in-plant equipment cost in the hog slaughter operations (Table 31) is made up of three components: slaughter room equipment, refrigeration equipment, and boilers. The figure in Table 31, however, included an installation charge for refrigeration and boilers, so only a 5 percent freight charge was added to these two components. The entire 30 percent for freight and installation was then added to the slaughter room equipment component of total f. o. b. cost.

Several paving contractors in the Knoxville area were contacted and according to these sources paving costs vary throughout the Tennessee Valley. The figure of \$0.35 per square foot was reported to be a realistic estimate of the average paving cost for all the site locations in the Tennessee Valley.

Interest was calculated at six percent per year.⁴ Land requirements, costs, and interest on the land investment are summarized in Tables 33, 34, and 35.

V. UTILITIES

Electricity Requirements and Costs

The electricity requirements in kilowatts and kilowatt hours for the beef slaughter and hog slaughter operations were taken from Logan and King [29, p. 84] and Cassell and West [12, p. 25], respectively.

The requirements for the beef boning and hog cutting and boning operations were synthesized as follows: For electric motors, the horsepower was multiplied by the running time in hours and the product was divided by 1,000 (1,000 watts per hour equals one kilowatt hour) to determine the required number of kilowatt hours [38, pp. 145-146].

The lighting requirements were synthesized by the Lumen method [23, Section 9]. This method involved six steps: "(1) determine the level of illumination, (2) select the lighting and luminaries, (3)

⁴The figure of six percent is low by current standards (1969). The bank prime rate was seven percent as of January 7, 1969 [52, p. A-31].

TABLE 33

BUILDING, PARKING AND MISCELLANEOUS LAND AREA REQUIREMENTS
FOR THE SINGLE SHIFT OPERATIONS

Operation	Building area	Employees parking area ^a	Visitors parking area ^b	Miscellaneous land area ^c	Total area
-----Square feet-----					
BS-I	19,424 ^d	6,480	648	2,655	29,207
BS-II	37,180 ^d	12,150	1,215	5,055	55,600
BS-III	53,608 ^d	17,820	1,782	7,321	80,531
BB-I	1,080 ^e	1,620	162	286	3,148
BB-II	1,080 ^e	2,700	270	405	4,455
BB-III	1,180 ^e	3,510	351	494	5,535
HS-I	7,280 ^f	2,970	297	1,055	11,602
HS-II	15,595 ^f	7,290	729	2,361	25,975
HS-III	31,374 ^f	15,930	1,593	4,890	53,787
HC-I	968 ^g	4,050	405	542	5,963
HC-II	1,085 ^g	4,590	459	613	6,747
HC-III	1,470 ^g	11,340	1,134	1,394	15,338

^aAn area of 270 square feet per employee.

^bTen percent of the employee parking area.

^cTen percent of the combined building, employee and visitors parking area.

^dTable 28 (page 71).

^eThese figures were synthesized from equipment company specifications, Koch Supplies, Inc. (Kansas City, Missouri: Koch Supplies, Inc., 1968), and interviews with industry sources.

^fTable 29 (page 72).

^gThese figures were synthesized from equipment company specifications, Allbright-Nell Company (Chicago: Allbright-Nell Company, 1951), pp. 11-13.

TABLE 34

BUILDING, PARKING AND MISCELLANEOUS LAND AREA REQUIREMENTS
FOR THE HALF SHIFT OPERATIONS

Operation	Building area ^a	Employees parking area ^b	Visitors parking area ^c	Miscellaneous land area ^d	Total area
-----Square feet-----					
BS-I	19,424	3,240	324	356	23,344
BS-II	37,180	6,210	621	683	44,694
BS-III	53,608	8,910	891	980	64,389
BB-I	1,080	810	81	89	2,060
BB-II	1,080	1,350	135	149	2,714
BB-III	1,180	1,890	189	208	3,467
HS-I	7,280	1,620	162	178	9,240
HS-II	15,595	3,780	378	416	20,169
HS-III	31,374	8,100	810	891	41,175
HC-I	968	2,160	216	238	3,582
HC-II	1,085	2,430	243	267	4,025
HC-III	1,470	5,670	567	624	8,331

^aColumn 1 Table 33 (page 83).

^bAn area of 270 square feet per employee.

^cTen percent of the employee parking area.

^dTen percent of the combined employee and visitor parking area.

TABLE 35

LAND COSTS AND ANNUAL INTEREST FOR THE MODEL OPERATIONS

Operation	Total land cost ^a		Annual interest ^b	
	Single shift	Half shift	Single shift	Half shift
-----Dollars-----				
BS-I	3,839	2,321	230	139
BS-II	7,236	4,447	434	267
BS-III	10,565	6,392	634	385
BB-I	769	407	46	24
BB-II	1,245	645	75	39
BB-III	1,606	887	96	53
HS-I	1,677	1,049	101	63
HS-II	4,002	2,383	240	143
HS-III	8,607	5,013	516	301
HC-I	1,833	997	110	60
HC-II	2,077	1,121	125	67
HC-III	5,072	2,566	304	154

^a\$0.046 per square foot of the total land area plus \$0.35 per square foot of parking area.

^bCalculated at 6 percent per year.

determine the coefficient of utilization, (4) estimate the maintenance factor, (5) calculate the number of lamps, and (6) determine the location of luminaries" [38, p. 146]. For a more complete discussion of the Lumen method, See Appendix D.

The required level of illumination was 50 foot candles per square foot [38, p. 24]. The lighting system was assumed to use fluorescent lamp fixtures with dual 40 watt standard cool white luminaries [38, p. 146]. The coefficient of utilization⁵ used was 0.52 [38, p. 146]. The maintenance factor⁶ was estimated to be 0.7 [38, p. 146].

The Lumen method was used to estimate annual consumption in kilowatt hours. However, there is also a billing demand charge for plants in the Tennessee Valley. This demand charge is based on the maximum load used during any 30-minute period of the month. This figure, however, varies from plant to plant and it varies from month to month within the same plant. Therefore, the demand charge was based on a rule of thumb used by electrical concerns. The billing demand was assumed to be four kilowatts for every 1,000 kilowatt hours consumed [29, p. 83].

Electricity rates for the Tennessee Valley were taken from the Tennessee Valley Authority Standard Rate Schedule for commercial service [51, p. 3]. Table 36 summarizes the electricity requirements and costs for the model operations.

⁵"... the ratio of the lumens received on the work plane to the lumens emitted by the lamps" [23, pp. 3-13].

⁶"The maintenance factor provides a depreciation allowance for design purposes relating the initial illumination and the illumination at the time at which it is anticipated that maintenance procedures will be instituted" [23, pp. 9-20].

TABLE 36

ELECTRICITY REQUIREMENTS AND COSTS FOR THE MODEL OPERATIONS

Operation	Kilowatt hours per month.	Kilowatts per month ^a	Demand charges per month ^b	Energy charges per month ^b	Annual electricity cost
-----Dollars-----					
BS-I	61,760 ^c	247	247	357	7,248
BS-II	110,421 ^c	442	442	541	11,796
BS-III	159,082 ^c	636	636	687	15,876
BB-I	478 ^d	2	--	11	132
BB-II	478 ^d	2	--	11	132
BB-III	518 ^d	2	--	12	144
HS-I	20,000 ^e	56	56	150	2,472
HS-II	43,719 ^e	137	137	285	5,064
HS-III	88,439 ^e	260	260	464	8,688
HC-I	423 ^d	2	--	10	120
HC-II	480 ^d	2	--	11	132
HC-III	2,215 ^d	9	--	28	336

^aFour kilowatts for every 1,000 kilowatt hours consumed.

^bElectricity rates for the Tennessee Valley were taken from the Tennessee Valley Authority Standard Rate Schedule for commercial service, U.S. Fed. Power Comm., Vol. 55, No. 1 (Wash.: G.P.O., Jan., 1969), p. 3.

I. Rate I for demands less than 50 kw: II. Rate II for demands of at least 50 kw but not more than 5,000 kw:

A. Demand charge

1. No charge for first 10 kw of demand or less.
2. \$1.00 per kw for all over 10.

B. Energy charge

1. 3.0¢ per kw--first 150 kwh
2. 2.0¢ per kw--next 350 kwh
3. 1.0¢ per kw--next 1,250 kwh
4. 0.8¢ per kw--next 1,325 kwh
5. 0.6¢ per kw--all additional

A. Demand charge

1. \$1.00 per kw demand

B. Energy charge

1. 0.800¢ per kwh--first 15,000 kwh
2. 0.600¢ per kwh--next 25,000 kwh
3. 0.400¢ per kwh--next 60,000 kwh
4. 0.300¢ per kwh--next 400,000 kwh
5. 0.275¢ per kwh--all additional

^cLogan, S. H., and G. A. King, Cal. A.E.S. Gianinni Found. R. R. No. 260 (Berkeley: Univ. of Cal., Dec., 1962), p. 84.

^dSynthesized by means of the Lumen method.

^eCassell, G. R., and D. A. West, N. C. State E.R.R. No. 3 (Raleigh: N. C. State, June, 1967), p. 25.

Water Requirements and Costs

Water requirements for the beef slaughter and hog slaughter operations were taken from Logan and King [29, p. 86] and Cassell and West [12, p. 26]. No water is used in the cutting and boning rooms except for clean-up and it was assumed that water required for these operations was included with cleaning water requirements of the slaughter operations.

The rates used were those charged by the Knoxville Utilities Board. Schedule E was the contract rate for large industrial, commercial, or other users. Two charges were involved: (1) a demand charge was based on five percent of the monthly usage. The rate for the first 75,000 cubic feet or less was \$630, and any excess over 75,000 cubic feet cost \$.84 per 100 cubic feet; (2) a commodity charge was placed on all water used per month at the rate of 8.4 cents per 100 cubic feet. Water requirements are summarized in Table 37.

Natural Gas Requirements and Costs

The monthly requirements of natural gas for the beef slaughter operations were taken from Logan and King [29, p. 88]. The natural gas requirements in the hog slaughter operations were synthesized from boiler horsepower requirements in Cassell and West [12, p. 27]. The hourly horsepower requirements for the model plants killing 50, 125, and 300 hogs per hour were 80, 150, and 250, respectively. "Approximately 33,500 B.T.U.'s of heat--the equivalent of 33.5 cubic feet of gas--are required hourly per horsepower of boiler" [29, p. 87]. Efficiency was

TABLE 37

WATER REQUIREMENTS AND COSTS OF THE MODEL OPERATIONS

Operation	Total monthly usage	Monthly demand ^a	Total monthly demand charges	Total monthly commodity charges	Annual water ^b costs
	-----Cubic feet-----			-----Dollars-----	
BS-I	114,000 ^c	5,700	630	96	8,712
BS-II	228,100 ^c	11,405	630	192	9,864
BS-III	342,100 ^c	17,105	630	287	11,004
HS-I	29,300 ^d	1,465	630	25	7,860
HS-II	64,000 ^d	3,200	630	54	8,208
HS-III	121,600 ^d	6,080	630	102	8,784

^aFive percent of total monthly usage.

^bCosts for sewage disposal were not included in water costs. Sewage disposal rates in Tennessee for cities are approximately 75 percent of the water costs. However, industrial complexes located outside city limits usually construct their own septic tanks or small processing or "package plants."

^cLogan, S. H., and G. A. King, Cal. A.E.S. Gianinni Found. R. R., No. 260 (Berkeley: Univ. of Cal., Dec., 1962), p. 86.

^dCassell, G. R., and D. A. West, N. C. State E.R.R. No. 3 (Raleigh: N. C. State, June, 1967), p. 26.

found to be 70 percent in boilers with greater than 60 horsepower [29, p. 87]. So, dividing 33.5 cubic feet per horsepower by the efficiency percentage of 70 percent resulted in the figure of 47.9 cubic feet of natural gas required per horsepower of boiler during a one hour period. The boilers were in operation eight hours per day for 21 days per month.

Since the equipment used in the cutting and boning operations was all electric, there were no requirements of natural gas in these operations.

The rates for natural gas were taken from the American Gas Association Rate Service [2, p. 5]. Requirements and costs of natural gas are summarized in Table 38 and the annual costs of all utilities are summarized in Table 39 for each operation.

VI. MISCELLANEOUS OPERATING COSTS

Miscellaneous operating costs were estimated for the beef and hog slaughter operations. They included repair and maintenance, killing supply costs, office costs, taxes and licenses, telephone, delivery and selling costs, feed and corral costs, and buying costs. These costs were an average of 64 percent of the in-plant labor cost for plants slaughtering 20, 40, and 60 head per hour in the Logan and King study [29, p. 92]. Other studies provide similar estimates of miscellaneous operating costs but the Logan and King study [29, p. 92] more closely approximates the sizes and technological configurations of the model operations of this study. The figure of 64 percent was used to

TABLE 38
NATURAL GAS REQUIREMENTS AND COSTS FOR BEEF AND HOG
SLAUGHTER OPERATIONS

Operation	Natural gas		Annual cost
	Cubic feet per month	Cost per month ^a	
BS-I	222,600 ^b	225	2,702
BS-II	342,720 ^b	331	3,974
BS-III	443,520 ^b	417	5,002
HS-I	643,776 ^c	585	7,021
HS-II	1,207,080 ^c	1,064	12,766
HS-III	2,011,800 ^c	1,748	20,974

^aRate C-I of the Chattanooga Gas Company for commercial and industrial service, American Gas Assoc., Vol. II, Tennessee, Department of Statistics (New York: A.G.A., May, 1968), p. 5, was used as follows:

1. First 500 cubic feet or less--\$2.00.
2. Next 4,500 cubic feet or less--13.5¢ per 100 cubic feet.
3. Next 45,000 cubic feet or less--11.5¢ per 100 cubic feet.
4. Next 50,000 cubic feet or less--10.0¢ per 100 cubic feet.
5. Next 100,000 cubic feet or less--9.5¢ per 100 cubic feet.
6. Next 100,000 cubic feet or less--9.0¢ per 100 cubic feet.
7. All additional--8.5¢ per 100 cubic feet.

^bLogan, S. H., and G. A. King, Cal. A.E.S. Gianinni Foundation R. R. No. 260 (Berkeley: Univ. of Cal., Dec., 1962), p. 88.

^cSynthesized from boiler horsepower requirements in Cassell, G. R., and D. A. West, N. C. State E.R.R. No. 3 (Raleigh: N. C. State, June, 1967), p. 27.

TABLE 39
TOTAL ANNUAL UTILITIES COSTS FOR THE MODEL OPERATIONS

Operation	Electricity ^a	Water ^b	Natural gas ^c	Total
-----Annual cost in dollars-----				
BS-I	7,248	8,712	2,702	18,662
BS-II	11,796	9,864	3,974	25,634
BS-III	15,876	11,004	5,002	31,882
BB-I	132	--	--	132
BB-II	132	--	--	132
BB-III	144	--	--	144
HS-I	2,472	7,860	7,021	17,353
HS-II	5,064	8,208	12,766	26,038
HS-III	8,688	8,784	20,974	38,446
HC-I	120	--	--	120
HC-II	132	--	--	132
HC-III	336	--	--	336

^aTable 36 (page 87).

^bTable 37 (page 89).

^cTable 38 (page 91).



derive the miscellaneous operating costs in both the full and half shift slaughter operations.

The miscellaneous operating costs specified were associated with complete slaughter plants. The cutting and boning operations, however, do not realize all of these miscellaneous operating costs so only a repair and maintenance cost was assigned to these operations. Repair and maintenance costs were based on one percent of the initial building cost and five percent of the initial equipment cost [11, p. 22].

Miscellaneous operating costs for the slaughter operations and repair and maintenance costs for the cutting and boning operations are summarized in Table 40.

VII. ANNUAL INVESTMENT COSTS

Building and Equipment Depreciation

Building and equipment depreciation were calculated and discussed in Sections II and III, Tables 30 and 32, pages 80 and 81.

Insurance

Costs of fire insurance vary depending upon the location of the plant with regard to its proximity to fire fighting services. There is also variability due to the nature of the plant's building material and fire prevention devices and precautions. It was, therefore, assumed that fire fighting services were available and the plant building was constructed in a safe manner complying with Federal guidelines. Rates are usually based on individual evaluations of building and equipment

TABLE 40

MISCELLANEOUS OPERATING COSTS AND REPAIR AND MAINTENANCE
COSTS FOR THE MODEL OPERATIONS

Operation	Annual miscellaneous operating costs ^a		Annual repair and maintenance costs ^b
	Full shift	Half shift	Both shifts
	-----Dollars-----		
BS-I	58,570	29,285	--
BS-II	110,313	55,156	--
BS-III	153,739	76,870	--
BB-I	--	--	1,075
BB-II	--	--	1,130
BB-III	--	--	1,358
HS-I	29,951	14,976	--
HS-II	76,543	38,271	--
HS-III	173,053	86,527	--
HC-I	--	--	1,153
HC-II	--	--	1,767
HC-III	--	--	3,465

^a 64 percent of the in-plant labor cost (Tables 21 and 23, pages 61 and 64, respectively).

^b One percent of the initial cost of buildings plus five percent of the initial equipment cost.

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safety. Several insurance companies were contacted and it was reported that the rate of \$.20 per \$100 of investment in buildings and \$.35 per \$100 of equipment cost [11, p. 23] can be expected for packing plants in the Tennessee Valley.

Personal Property Tax

Personal property taxes vary from county to county and from state to state. The Knox County Tax Assessor's office was contacted and it was reported that the rates in Knox County closely approximate the rates in similar locations in the Tennessee Valley. The standard assessment is based on 30 percent of the market value of land, buildings, and equipment. The rate is \$3.80 per \$100.

Interest on Land, Buildings, and Equipment

Interest on the land investment was discussed in Section IV and summarized in Table 35, page 85. Interest on buildings and equipment was based on 50 percent of the original investment assuming the value would be zero at the end of the depreciation period. The interest rate was six percent⁷ per year [11, p. 22].

Total Annual Investment Cost

Annual investment costs are summarized in Table 41.

⁷The figure of six percent is low by current standards (1969). The bank prime rate was seven percent as of January 7, 1969 [51, p. A-31].

TABLE 41

ANNUAL INVESTMENT COSTS

Operation	Depreciation ^a	Insurance ^b	Taxes ^c		Interest ^d		Total	
			Full shift	Half shift	Full shift	Half shift	Full shift	Half shift
			Dollars					
BS-I	16,796	810	3,509	3,492	9,348	9,257	30,463	30,355
BS-II	28,061	1,359	6,166	6,138	16,453	16,285	52,039	51,843
BS-III	43,132	2,086	9,342	9,295	24,902	24,652	79,462	79,165
BB-I	2,113	101	433	429	1,162	1,140	3,809	3,783
BB-II	2,196	104	452	445	1,224	1,188	3,976	3,933
BB-III	2,586	123	524	517	1,426	1,383	4,659	4,609
HS-I	7,251	353	1,654	1,647	4,404	4,366	13,662	13,617
HS-II	15,616	755	3,444	3,426	9,183	9,086	28,998	28,883
HS-III	27,303	1,319	5,967	5,926	15,959	15,744	50,548	50,292
HC-I	2,180	103	445	433	1,224	1,174	3,952	3,890
HC-II	3,160	149	608	597	1,659	1,601	5,576	5,507
HC-III	5,902	277	1,087	1,064	3,025	2,875	10,291	10,118

^aTables 30 (page 75) and 32 (page 81).^b\$.20 per \$100 of investment on buildings and \$.35 per \$100 of investment in equipment.^cBased on 30 percent of the market value of land, buildings, and equipment at a rate of \$.38 per \$100.^dIncludes interest on land (Table 25, page 66), buildings, and equipment.

VIII. TOTAL ANNUAL COST

Total annual cost for each of the model operations was calculated by summing the following costs: total annual labor cost, total annual cost of utilities, annual investment cost, miscellaneous operating, and repair and maintenance costs. Cost per animal processed was derived by dividing the total cost per annum by the capacity output of the model operations (Tables 42-45).



TABLE 42

ANNUAL TOTAL COST AND COST PER HEAD PROCESSED FOR THE BEEF SLAUGHTER OPERATIONS

Annual cost.	Operation					
	BS-I	BS-II	BS-III	BS-I	BS-II	BS-III
	Full shift			Half shift		
	-----Dollars-----					
Labor ^a	192,528	366,905	499,688	119,127	228,661	307,024
Utilities ^b	18,662	25,634	31,882	18,662	25,634	31,882
Investment ^c	30,463	52,039	79,462	30,355	51,843	79,165
Miscellaneous ^d						
operating	58,570	110,313	153,739	29,285	55,156	76,870
Total	300,223	554,891	764,771	197,429	361,294	494,941
Annual production ^e	37,800	75,600	113,400	18,043	36,086	54,130
Cost per head	7.94	7.34	6.74	10.94	10.01	9.14

^aTable 27 (page 68).^bTable 39 (page 92).^cTable 41 (page 96).^dTable 40 (page 94).^eTable 16 (page 51).

TABLE 43

ANNUAL TOTAL COST AND COST PER HEAD PROCESSED FOR THE BEEF BONING OPERATIONS

Annual cost	Operation			
	BB-I	BB-II	BB-III	BB-II
		Full shift		Half shift
		Dollars		
Labor ^a	66,957	116,567	153,200	33,479
Utilities ^b	132	132	144	132
Investment ^c	3,809	3,976	4,659	3,783
Repair and maintenance ^d	1,075	1,130	1,358	1,130
Total	71,793	121,805	159,361	63,480
Annual production ^e	18,900	37,800	56,700	18,043
Cost per head	3.80	3.22	2.81	3.52
				3.06

^aTable 27 (page 68).^bTable 39 (page 92).^cTable 41 (page 96).^dTable 40 (page 94).^eTable 16 (page 51).

TABLE 45

ANNUAL COST AND COST PER HEAD PROCESSED FOR THE HOG CUTTING AND BONING OPERATIONS

Annual cost	Operation			
	HC-I	HC-II Full shift	HC-III	HC-I Half shift
	-----Dollars-----			
Labor ^a	127,961	144,101	352,790	63,981
Utilities ^b	120	132	336	120
Investment ^c	3,952	5,576	10,291	3,890
Repair and maintenance ^d	1,153	1,767	3,465	1,153
Total	133,186	151,576	366,882	69,144
Annual production ^e	189,000	236,250	567,000	90,216
Cost per head	0.70	0.64	0.65	0.77
				0.70
				0.70

^aTable 27 (page 68).^bTable 39 (page 92).^cTable 41 (page 96).^dTable 40 (page 94).^eTable 16 (page 51).

CHAPTER V

COST ANALYSIS

I. AVERAGE COST OF THE MODEL OPERATIONS

Figures II through V show graphically the average costs per unit of output derived from the plant stages whose synthesis was presented in Chapter IV. In the beef and pork slaughter operations (Figures II and IV, respectively), costs per unit of output decrease as output increases for both full shift and half shift operating schedules. Unit costs for half shift operations are higher than for full shift operations.

These higher unit costs in the half shift slaughter operations were due to the influence of the fixed costs, which--in the aggregate--are common to both the full and half shift operations and independent of output. For example, total costs in the half shift beef slaughter operations are an average of 60 percent of the total costs in the full shift beef slaughter operations. Half shift hog slaughter total costs average 65 percent of the full shift total costs. Output, however, in the half shift operations is only 48 percent of the output in the corresponding full shift operations. Since the ratio of total cost to output is greater in the half shift operations than in the full shift stages, average costs are necessarily higher in the half shift slaughter operations.

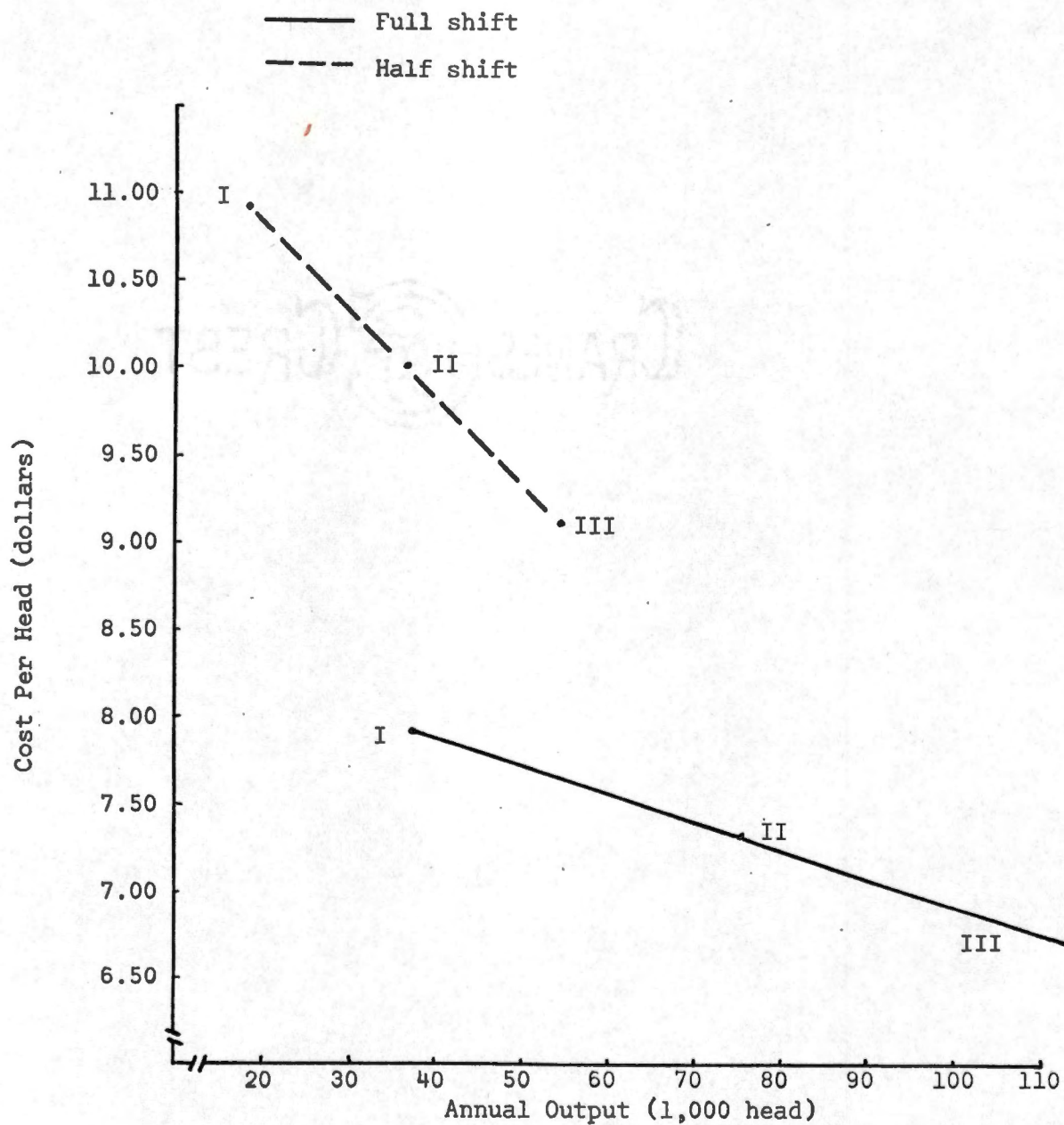


Figure II, Average cost of beef slaughter at full capacity,

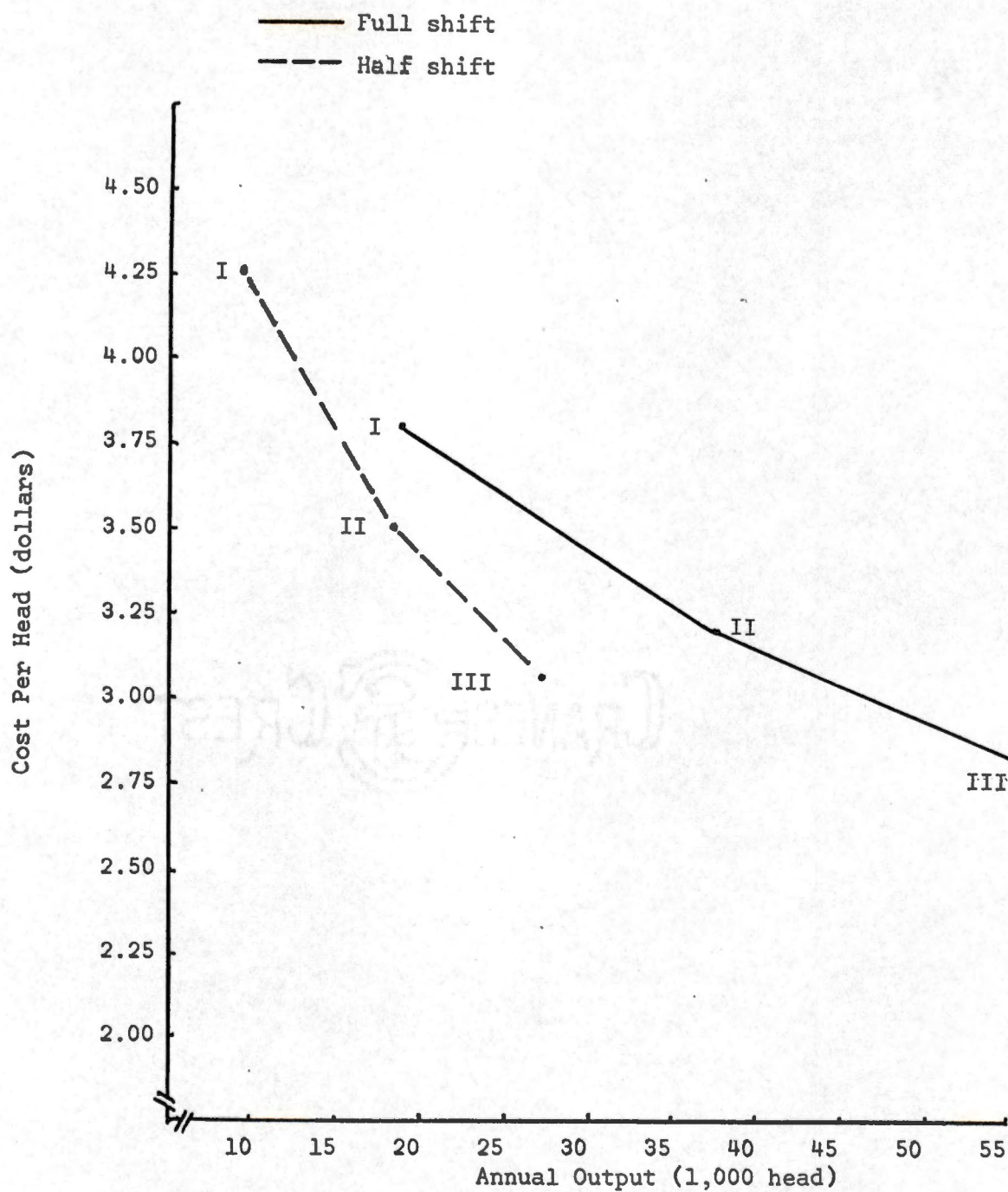


Figure III. Average cost of beef boning at full capacity.

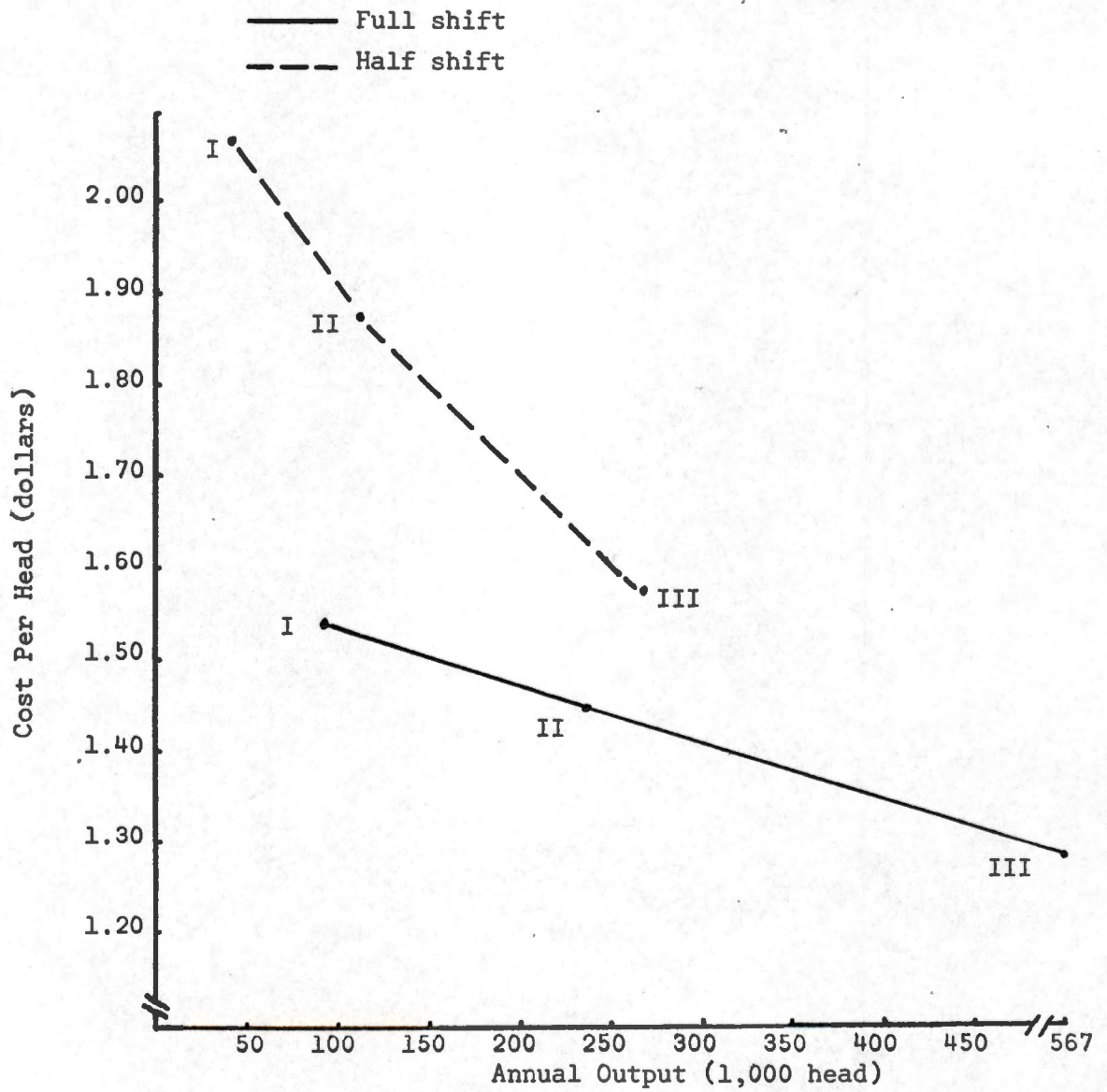


Figure IV. Average cost of hog slaughter at full capacity.

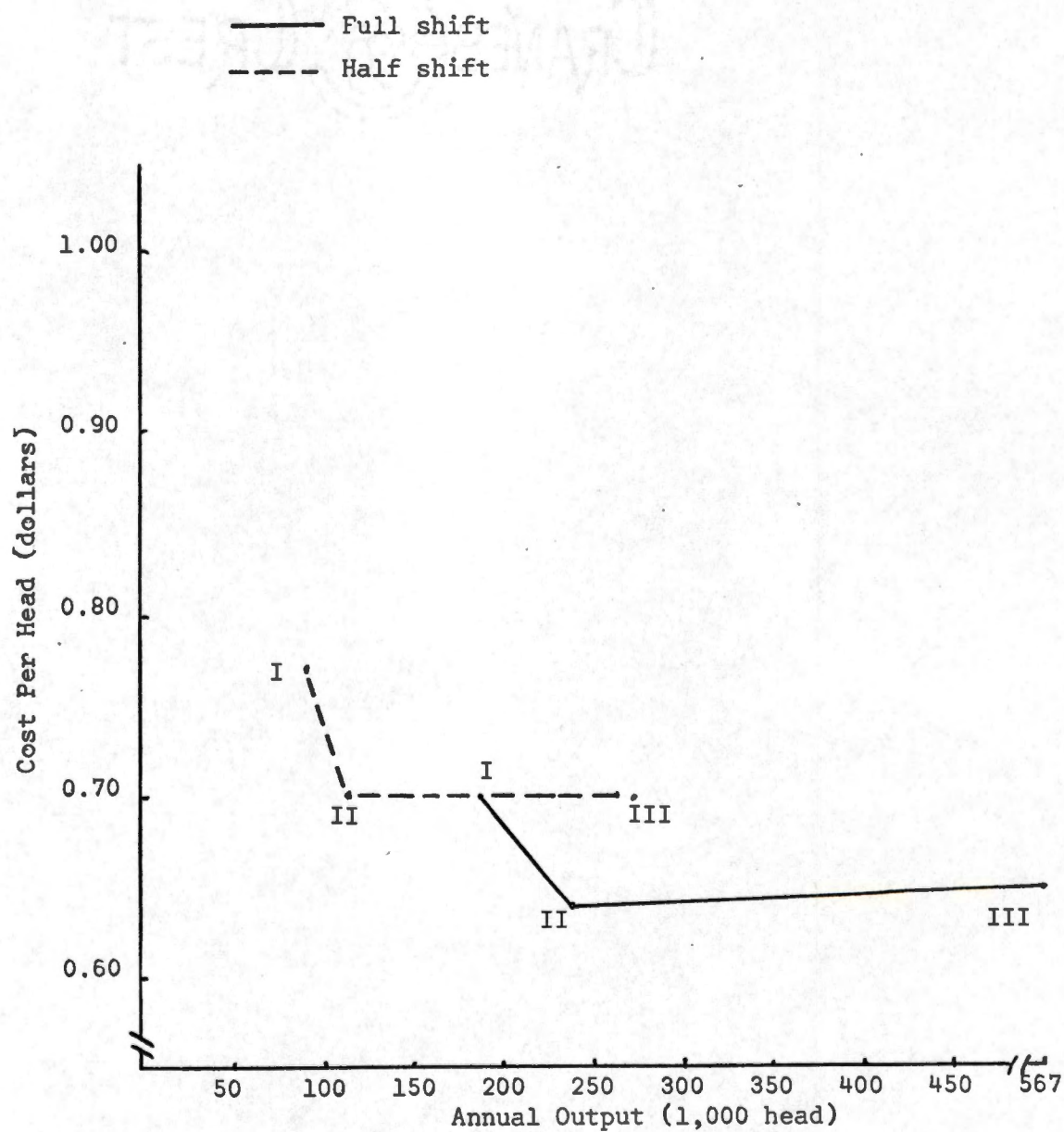


Figure V. Average cost of hog cutting and boning at full capacity.

In the beef boning operations (Figure III, page 104), the half shift average cost curve is below the full shift average cost curve for two of the three model operations. Cost per unit of output in half shift operations BB-II (capacity = 18,043 head per year) and BB-III (capacity = 27,065 head per year) is less than the average costs in full shift operations BB-I (capacity = 18,900 head per year) and BB-II (capacity = 37,800 head per year). Three factors may explain this: (1) there is almost no difference between the investment costs required for the half shift plant BB-II and the full shift operation BB-I; (2) annual output, in number of head, is almost the same for both of these operations; and (3) the work crew in the lower cost half shift operation BB-II is apparently more efficiently organized than the work crew in the full shift operation BB-I.

Both of these operations (half shift, BB-II and full shift, BB-I) require the same building area in square feet (1,080). The equipment requirements are also very similar (Appendix C), so the annual investment costs for the half shift operation BB-II (\$3,933) and for full shift operation BB-I (\$3,809) are almost the same. Also, both of these operations produce almost the same total output (18,043 head for half shift, BB-II and 18,900 for full shift, BB-I). However, the work crew in half shift operation BB-II, consisting of nine hours and three break-up men is more productive than that of the full shift operation BB-I with five boners and two handlers (Appendix C). Therefore, the half shift operation BB-II has a lower cost per unit of output than full shift operation BB-I.

In the hog cutting and boning operations (Figure V), costs per unit of output in the half shift operations are greater than those of the full shift stages. However, as output increased between full shift operations HC-II and HC-III, cost per unit of output increased \$0.01 per head. Between half shift operations HC-II and HC-III, cost per unit of output remained the same.

Annual total cost increases 142 percent between full shift operations HC-II and HC-III (Table 45, page 101). Output, however, only increases 140 percent indicating an increase in average total unit cost as output increases. Labor costs account for an average of 95.88 percent of total costs in the full shift hog cutting and boning operations and 92.18 percent of total cost in the half shift operations, indicating a high degree of labor intensity. Since labor is a variable cost which increases as output increases, total cost of an operation which is highly labor intensive may increase as output increases.

II. LESS THAN FULL CAPACITY UTILIZATION

A seasonal index of commercial slaughter was computed to determine the effects of seasonal changes in rates of plant utilization. A moving average of quarterly slaughter rates in Tennessee was the basis of this index on cattle slaughter for 1960-67 and on hog slaughter for 1964-67 in both cases to eliminate cyclical influences.

The following seasonal indexes¹ were computed:

<u>Quarter</u>	<u>Cattle Slaughter Index</u>	<u>Hog Slaughter Index</u>
1	88.6	105.6
2	94.4	98.4
3	114.0	92.8
4	104.9	100.9

A seasonal index for a particular period can be used by comparing the index number for a particular quarter to some base period figure to determine the percentage difference in slaughter animal availability due to seasonal variation in the supply of slaughter animals [31, pp. 669-671]. However, some of the quarterly index numbers are greater than 100, indicating a supply of slaughter animals which is greater than the capacities of the model plants.

Since the model operations of this study were not designed to produce over their capacity, the highest quarterly figure in each seasonal index was assumed to be the maximum or capacity slaughter. The values for other quarters were then expressed as a percentage of the value for capacity slaughter. The four resulting quarterly figures were then averaged to determine the seasonal supply of slaughter animals as a percent of capacity on an annual basis. The seasonal supply of slaughter

¹The moving average was computed by first taking a four quarter moving average and then a two quarter moving average to arrive at seasonal relatives. These indicate for each quarter the cattle and hog slaughter as a percent of the average of the four quarter period centered at that quarter. The seasonal relatives were then averaged for each quarter to derive a seasonal index [31, pp. 676-687].

cattle was 88.13 percent of capacity and hog slaughter under seasonal conditions was 94.15 percent of capacity.

Figures of 80, 70, and 60 percent for both beef and hog slaughter were then arbitrarily chosen in order to examine situations of less than seasonal utilization of capacity. Implications of these less than full capacity figures shall be discussed in the next chapter.

The cost functions for beef slaughter operations were then combined with those of the beef boning operations to determine average cost per head of beef processed. Data pertaining to beef slaughter operation I (BS-I), for example, were combined with cost data for beef boning operation I (BB-I) to derive a cost function for combined operation BSBB-I. In effect, 37,800 animals were disassembled; 54 percent of these animals (21,168 steers and heifers) were sold as fresh cuts, while 44 percent (16,632 cows, bulls, cutters, and canners) were slaughtered, boned, and sold as boneless beef (Table 19, page 55). Average cost per head was calculated by summing the total costs of both operations and dividing by the total number of head slaughtered (37,800). This was repeated for BS-II and BB-II, BS-III and BB-III, and similarly for the hog slaughter and hog cutting and boning operations.

Tables 46 and 47 show the annual production and the average costs for combined slaughter, cutting, and boning operations for five annual utilization patterns: (1) full capacity; (2) seasonal

TABLE 46

NUMBER OF ANIMALS SLAUGHTERED ANNUALLY AT FULL CAPACITY, SEASONAL UTILIZATION OF CAPACITY, EIGHTY, SEVENTY, AND SIXTY PERCENT OF CAPACITY IN THE COMBINED MODEL OPERATIONS

Operation	Full capacity ^a	Seasonal utilization ^b of capacity	Annual Production		
			80 percent capacity utilization ^c	70 percent capacity utilization ^d	60 percent capacity utilization ^e
			Number of head		
			Full shift		
BSBB-I	37,800	33,313	30,240	26,460	22,680
BSBB-II	75,600	66,626	60,480	52,920	45,360
BSBB-III	113,400	99,939	90,720	79,380	68,040
			Half shift		
BSBB-I	18,043	15,901	14,434	12,630	10,826
BSBB-II	36,086	31,803	28,869	25,260	21,652
BSBB-III	54,130	47,705	43,304	37,891	32,478
			Full shift		
HSBC-I	94,500	88,972	75,600	66,150	56,700
HSBC-II	236,250	222,429	189,000	165,375	141,750
HSBC-III	567,000	533,831	453,600	396,900	340,200
			Half shift		
HSBC-I	45,108	42,469	36,086	31,576	27,065
HSBC-II	112,770	106,173	90,216	78,939	67,662
HSBC-III	270,648	254,815	216,518	189,454	162,388

^aTable 16 (page 51).

^b88.13 percent of column 1 for beef animals and 94.15 percent of column 1 for hogs.

^c80 percent of column 1. ^d70 percent of column 1. ^e60 percent of column 1.

TABLE 47

AVERAGE TOTAL UNIT COST OF THE COMBINED MODEL OPERATIONS AT FULL CAPACITY, SEASONAL
UTILIZATION OF CAPACITY, EIGHTY, SEVENTY, AND SIXTY PERCENT OF CAPACITY

Operation	Total annual cost ^a	Average total unit cost				
		Full capacity ^b	Seasonal utilization ^c of capacity	80 percent capacity utilization ^d	70 percent capacity utilization ^e	60 percent capacity utilization ^f
-----Dollars-----						
				Full shift		
BSBB-I	372,016	9.84	11.17	12.30	14.06	16.40
BSBB-II	676,696	8.95	10.16	11.19	12.79	14.92
BSBB-III	924,132	8.15	9.25	10.19	11.64	13.58
				Half shift		
BSBB-I	235,898	13.07	14.84	16.34	18.68	21.79
BSBB-II	424,774	11.77	13.36	14.71	16.82	19.62
BSBB-III	577,654	10.67	12.11	13.34	15.25	17.79
				Full shift		
HSHC-I	279,097	2.95	3.14	3.69	4.22	4.92
HSHC-II	494,817	2.09	2.22	2.62	2.99	3.49
HSHC-III	1,097,487	1.94	2.06	2.42	2.77	3.23
				Half shift		
HSHC-I	162,574	3.60	3.82	4.51	5.15	6.01
HSHC-II	285,467	2.53	2.69	3.16	3.62	4.22
HSHC-III	617,266	2.28	2.42	2.85	3.26	3.80

^aTables 42 through 45 (pages 98 through 101).

^bColumn 1 divided by column 1 in Table 48 (page 121).

^cColumn 1 divided by column 2 in Table 48 (page 121).

^dColumn 1 divided by column 3 in Table 48 (page 121).

^eColumn 1 divided by column 4 in Table 48 (page 121).

^fColumn 1 divided by column 5 in Table 48 (page 121).

utilization of capacity as indicated; (3) 80 percent of capacity slaughter; (4) 70 percent; and (5) 60 percent of capacity slaughter.²

Figures VI and VII show the average costs for the combined operations at full capacity. The unit costs for the full shift beef slaughter combined operations were lower than the unit costs for the half shift stages (Figure VI), but costs per unit of output under both operating schedules decreased as plant capacity increased.

Figure VII shows the half shift combined hog slaughter, cutting and boning cost function overlapping the full shift cost function. Over the range of output of 75,000 to 175,000 head per year, the full shift unit cost was greater than the half shift unit cost. This was due primarily to the physical design of the smallest hog cutting and boning operation, HC-I. The cutting and boning model operations were designed to process the maximum amount of dressed carcasses the respective slaughter operations could supply. Hog cutting and boning operation HC-I was designed to process 100 head per hour (Table 16, page 51). The smallest hog slaughter operation HS-I, on the other hand, only kills 50 head per hour, so the cutting and boning operation HC-I is operating at 50 percent of capacity when combined with the hog slaughter operation HS-I. This increases cost per unit of output in the combined operation HSHC-I on both full and half shift schedules.

²According to Williams and Stout [55, p. 365], existing U. S. packing plants from 1950 to 1960 utilized an average of 73 percent of capacity for cattle and 65 percent of capacity for hogs. This was the basis for examining rates of utilization of 80, 70, and 60 percent.

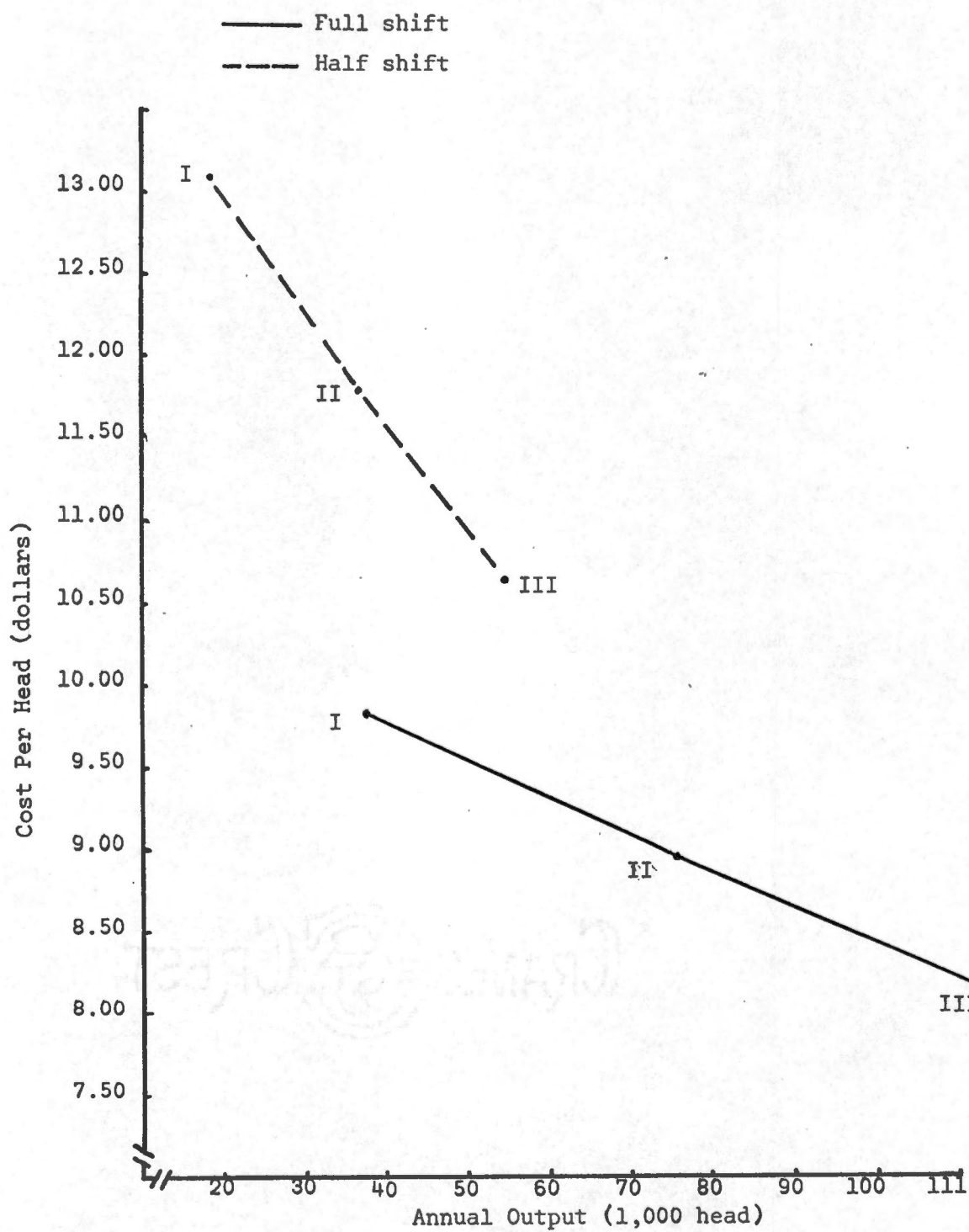


Figure VI. Average cost of beef slaughter and boning at full capacity.

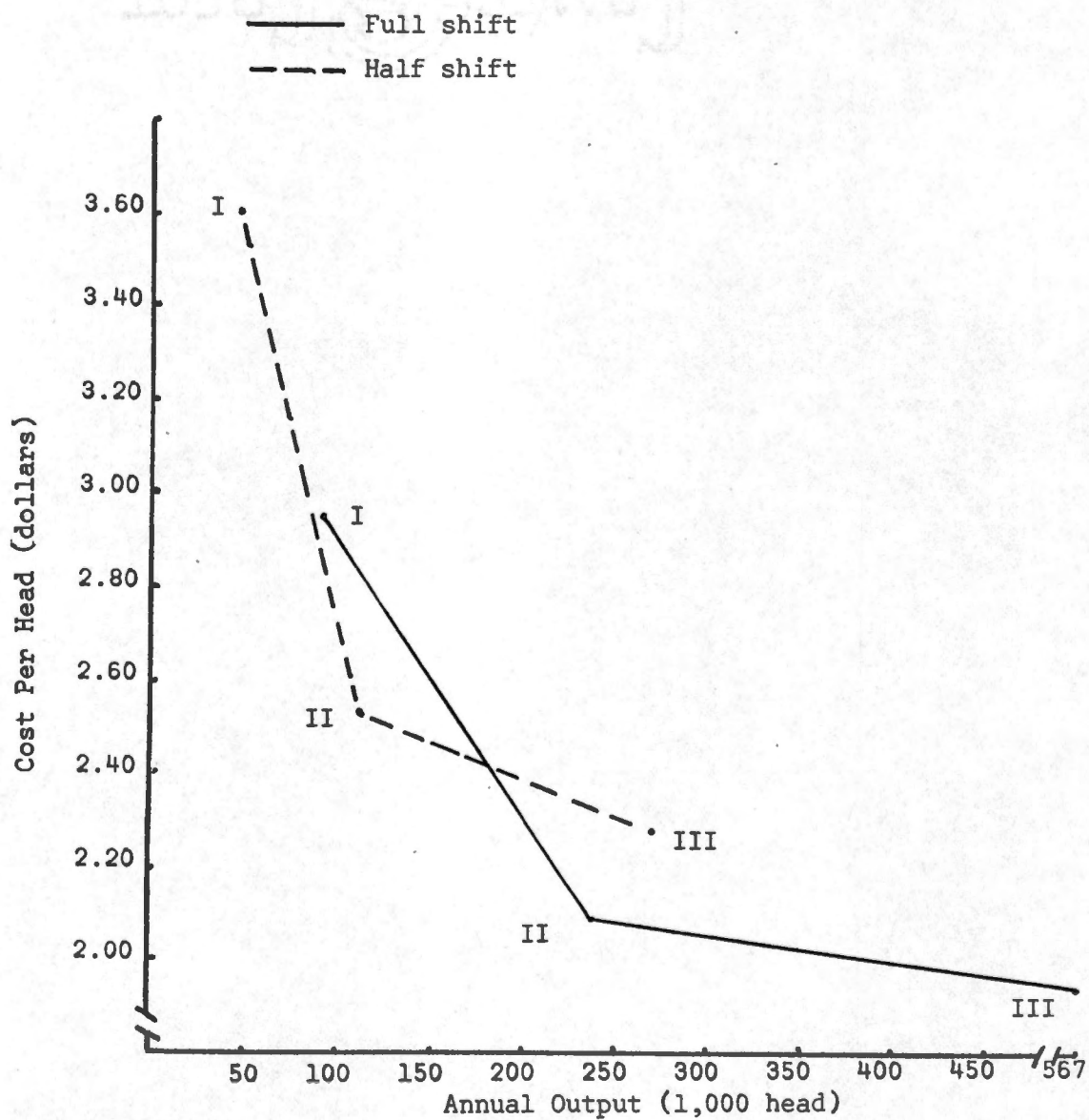


Figure VII. Average cost of hog slaughter, cutting and boning at full capacity.

However, the slaughter and cutting and boning components of the subsequent combined operations, HSHC-II and HSHC-III, are each operating at full capacity,

III. LABOR COMPONENT OF TOTAL COST

There has been a trend in the meat packing industry, as in other agricultural processing industries, towards more automation. However, even in highly automated meat packing plants, labor costs account for the major share of total costs. In this study, labor costs accounted for an average of 65.2 percent of total cost in the full shift beef slaughter operations at full capacity. The average labor cost in the full shift hog slaughter operations at full capacity was 61.3 percent of total cost. The more labor intensive cutting and boning operations showed a higher percentage. The full shift hog cutting and boning labor costs were 95.9 percent and beef boning labor costs were 95.0 percent of total cost at full capacity.

This dominant role of labor costs has implications in regard to any cost reductions due to economies of size. In the model operations of this study, cost per head processed by the slaughter operations decreased as output increased. The same was found in the more labor intensive beef boning operations. However, in the hog cutting and boning operations at full capacity, cost per head began to increase as the size of the operation increased (Figure V, page 106).

Although the increase was only \$0.01 per head between HC-II and HC-III, the appearance of a cost increase with an increasing size of

operation may suggest a need for development of labor saving devices in these operations. It is possible, however, that larger sizes of operation than those of this study will not suffer from similar losses, especially if the technological design of the various operations are modified.



CHAPTER VI

REVENUE ANALYSIS

I. INTRODUCTION

In order to estimate potential net revenues that would have been realized from operating the model plants described in this study under specified conditions, it was necessary to use prices that would be received for plant output for some appropriate period--in this case, the year 1968.¹ A net value per head processed during 1968 (for both species) was determined as follows:

1. An estimate was made of the weighted average gross value per head slaughtered.
2. From the above figure the following items were subtracted:
(a) the weighted average cost per slaughter animal; (b) the weighted average cost of delivery (from the plant to the wholesaler) for products derived from one slaughter animal; and (c) the estimated annual plant operating cost per slaughter animal. This weighted average net value

¹Since the costs estimated for the model plants were based on 1968 conditions, 1968 slaughter animal and processed product prices were used in estimating annual net revenues to the model plants. It should be noted, however, that 1968 slaughter beef animal prices were approximately 6.5 percent greater than the 1962-1968 average, and 1968 slaughter hog prices were 3.5 percent greater than the 1962-1968 average. Wholesale prices of processed beef cuts in 1968 were 7.5 percent greater than the 1962-1968 average and processed pork was 4.6 percent greater than the 1962-1968 average [46, pp. 141-142].

per head processed (for each species) in each combined model operation was multiplied by the number of head (of each species) processed in each combined operation to estimate the annual net revenue to the plant from each combined operation in alternative sized plants and at alternative rates of plant utilization. The estimated annual net revenue for all operations was then divided by the annual total plant operating cost to determine the percent return on annual operating cost for each model plant at different rates of plant utilization.

Processed Animal Gross Revenue

Daily carlot beef and pork prices reported by The National Provisioner [43] for Chicago were averaged to arrive at annual figures for the different fresh cuts in 1968. The price formation process for processed meat in Tennessee is based on day to day bargaining (between packing plants and the various buyers) where the forces of supply and demand interact to arrive at the selling price. It was reported by industry sources and university animal science specialists that packers, in most areas where there is a deficit in the production of slaughter animals, add 1.5 cents per pound to the Chicago quoted price. This is done in order to compensate for the extra cost of procuring live slaughter animals and the processed product price differential between surplus and deficit areas due to transportation costs. This adjusted selling price then varies from day to day depending on the relative bargaining positions of the buyers and sellers.

Weighted average gross values per head of beef were estimated as follows:

1. Given the supplies of slaughter animals that would be available to the model plants in the areas in which they would operate, there would be a certain "mix" of market classes of slaughter animals that the model plants would process. Table 17, page 52, shows this "raw product mix" for beef operations that would be located in Tennessee.

2. The expected yields of fresh cuts or boneless beef for the average of all grades in each market class were multiplied by the percentages of the market class "raw product mix" in order to obtain the expected yield in pounds of what may be called a "weighted average composite market class" slaughter animal.

3. Finally, the expected yields of fresh cuts or boneless beef from the weighted average composite market class slaughter animal were multiplied by their respective prices to obtain the estimated weighted average gross value per slaughter animal in the combined (slaughter and boning) beef operation (Table 48).

Using this approach, the weighted average gross value per beef animal slaughtered was estimated at \$207.28 using 1968 prices.

A weighted average gross value per hog was computed by the same technique that was used for beef animals. The weighted average gross value per hog of \$51.97 was calculated by multiplying the market class percentage raw product mix by the yields of the two market classes (butcher hogs and sows) in fresh cuts and/or boned out pork by the weighted

TABLE 48

DATA PERTAINING TO CALCULATION OF WEIGHTED AVERAGE GROSS
VALUES OF BEEF CATTLE AND HOGS

Animal Class	Market class percentage raw product mix ^a ---percent---	Yield of fresh ^b cuts ---pounds per head---	Yield of boneless ^b beef ---pounds per head---	Price per pound ^c ---cents---
<u>Beef Animals</u>				
Steers	27	647		43.290
Heifers	27	541		42.520
Cows	10		364	55.790
Bulls	3		511	55.790
Cutters and canners	33		221	55.790
<u>Hogs</u>				
Barrows and gilts	90	172		29.925 ^d
Sows	10		225	25.080

^aTables 17 (page 52) and 18 (page 53).

^bTables 19 (page 55) and 20 (page 56).

^cDaily carlot beef and pork prices were taken from The National Provisioner [43] and averaged to arrive at annual figures in 1968. The Chicago prices were adjusted for deficit area conditions by adding 1.5 cents per pound. Carlot beef and pork prices were those of the following grades and weight classes: (1) steers, the average of (a) good, 5/600 and (b) choice, 5/600; (2) heifers, the average of (a) good, 4/500 and (b) choice, 4/500; (3) fresh boneless beef prices were based on the Northern cutter and canner cow meat price; (4) fresh pork cut prices included: (a) skinned hams, 14/16; (b) picnics, 6/8; (c) bellies, 25/30; (d) fat backs, 18/20; (e) loins, 14/17. Other fresh pork cuts included skinned jowls, Boston butts, ribs, neckbones, and 80 percent lean sausage trimmings.

^dTable 49 (page 123).

average price per pound of fresh cuts (Table 49) and/or boned out pork (Table 48).

Slaughter Animal Cost

Slaughter animal prices in Tennessee for different market classes were taken from weekly quotations reported by the Nashville Union Stockyards and averaged for 1968.²

Weighted average prices (Table 50) per hundred pounds of live slaughter beef animals that could be used in the model plants were derived by multiplying the prices of the slaughter animal market classes reported for Nashville³ by the percentages of each market class that would be expected to be slaughtered in the model plants (Table 17, page 52). Since the average live weight of all cattle slaughtered in Tennessee in 1968 was 940 pounds [46, p. 89], the weighted average price per hundred-weight of animals slaughtered in the model operations was multiplied by 9.4. The weighted average beef slaughter animal cost for all model operations was therefore assumed to be \$188.94 per head.

The live weight price per hundred pounds of barrows and gilts in 1968 was \$19.03 and for sows was \$15.01. These prices were

²It should be noted that, in cases where slaughter animals are purchased from outside the Tennessee Valley, the estimated price structure may be affected due to price as well as transportation cost differentials between the Tennessee Valley and other areas.

³Slaughter animal prices were those of the following grades and weight classes: (1) steers, good, 900-1,100 pound; (2) heifers, good, 600-800 pound; (3) cows, commercial and cutter and canner; (4) bulls, commercial; (5) barrows and gilts, U. S. 1 and 2, 220-240 pound; and (6) sows, U. S. 2 and 3, 400-550 pound.

TABLE 49

DATA PERTAINING TO THE CALCULATION OF A WEIGHTED AVERAGE
PRICE PER POUND OF FRESH PORK CUTS

Fresh pork cuts	Yield ^a percent	Price per pound ^b --cents--
Hams	18.5	43.030
Picnics	8.5	27.730
Belly	17.5	21.350
Fat back	18.0	15.360
Jowl	3.0	17.750
Loins	15.0	46.670
Boston butts	6.5	34.490
Ribs	3.0	48.330
Neckbones, feet and tail	5.0	9.250
Sausage trimmings	5.0	<u>28.280</u>
Weighted average price per pound of whole carcass		29.925

^aLessons on Meat (Chicago: National Livestock and Meat Board, 1966).

^bDaily carlot pork prices were taken from The National Provisioner, Vol. 158, No. 1 through Vol. 159, No. 23 (Chicago: The National Provisioner, 1968), p. 48, and averaged for 1968. The Chicago prices were adjusted for deficit area conditions by adding 1.5 cents per pound.

TABLE 50

DATA PERTAINING TO THE CALCULATION OF WEIGHTED AVERAGE OF BEEF
SLAUGHTER ANIMAL PRICE PER HUNDRED POUNDS OF LIVE WEIGHT

Market class	Market class percentage raw product mix ^a ---percent---	Price per hundred pounds ^b -dollars-
Steers	27	24.29
Heifers	27	22.74
Cows	10	17.18
Bulls	3	21.94
Cutters and canners	33	<u>15.24</u>
Weighted average price per 100 pounds		20.10

^aTable 17 (page 52).

^bAverage of weekly quotations reported by the Nashville Union Stockyards in 1968. Slaughter animal prices were those of the following grades and weight classes: (1) steers, good, 900-1,100 pound; (2) heifers, good, 600-800 pound; (3) cows, commercial and cutter and canner; (4) bulls, commercial.

similarly averaged from weekly quotations of the Nashville Union Stockyards. The average live weight of barrows and gilts in 1968 was 233 pounds per head and sows averaged 432 pounds (Chapter III, Section IV). Ninety percent of the slaughter hogs were barrows and gilts while ten percent were sows (Table 18, page 53). The weighted average composite slaughter hog cost for the model operations was estimated at \$46.39 per head by multiplying the percentages of each market class used in the model operations by the respective live weights (in hundred-weight) by the prices per hundred-weight of the two animal classes.

Delivery Cost Per Processed Animal

Meat packing plants usually deliver their output to buyers. Therefore, a freight or delivery cost must be subtracted from the gross value of each processed animal. A survey of freight agencies in Knoxville indicated a rate of \$1.32 per hundred pounds of beef or pork carload lots as the standard charge for a 400 mile radius within the Tennessee Valley. The weighted average yield of beef per slaughter animal was assumed to be 177 pounds per head (Table 20, page 56) based on standard yields utilized by the industry. The average processed weight (fresh cuts and boned meat) per animal slaughtered was determined by multiplying the weighted average composite market class slaughter animal by the yield in pounds per head of fresh cuts or boned meat of each market class and summing the products. The average delivery cost per processed animal was estimated at \$5.87 per beef animal and \$2.34 per hog.

II. NET REVENUE FOR COMBINED SLAUGHTER, CUTTING, AND BONING OPERATIONS

In order to determine net value per head processed in the model operations, the following figures were derived in the previous section:

	<u>Beef</u>	<u>Hogs</u>
1. Weighted average gross value per head slaughtered	\$207.28	\$51.97
2. Weighted average cost per slaughter animal	\$188.94	\$46.39
3. Weighted average delivery cost per slaughter animal	\$ 5.87	\$ 2.34
4. Annual plant operating cost per head slaughtered	Tables 48 and 49, pages 121 and 123.	

The net value per head processed in the combined operations (for both species) is determined by subtracting items 2, 3, and 4 from item 1. This net value per head processed in each combined operation was multiplied by the number of head processed in each combined operation to estimate an annual net revenue for each combined operation. The annual net revenue for each combined operation was then divided by the annual total operating cost attributed to that combined operation to estimate the return on annual operating cost for each combined model operation. (Table 51).

TABLE 51
ANNUAL RETURNS OF COMBINED OPERATIONS AT FULL CAPACITY

Operation ^a	Annual total operating cost ^b	Annual total sales ^c	Annual net revenue ^d	Dollars	
				Full shift	Half shift
BSBB-I	372,016	7,835,184	99,350	26.7	1.3
BSBB-II	676,696	15,670,368	266,036	39.3	1.7
BSBB-III	924,132	23,505,552	489,966	53.0	2.1
BSBB-I	235,898	3,739,953	-10,902	-4.6	-0.3
BSBB-II	424,774	7,479,906	25,218	5.9	0.3
BSBB-III	577,654	11,220,066	97,347	16.9	0.9
HSHC-I	279,097	4,911,165	27,010	9.7	0.5
HSHC-II	494,817	12,277,913	270,554	54.7	2.2
HSHC-III	1,097,487	29,466,990	739,593	67.4	2.2
HSHC-I	162,574	2,344,263	-16,424	-10.1	-0.7
HSHC-II	285,467	5,860,657	79,908	28.0	1.4
HSHC-III	617,266	14,065,577	259,634	42.1	1.5

^aTable 46 (page 111).

^bTable 47 (page 112).

^cWeighted average gross value per head slaughtered times the number of head slaughtered in each combined operation.

^dColumn 1, Table 46 (page 111), times the net value per head processed.

^eColumn 3 divided by column 1 times 100. ^fColumn 3 divided by column 2 times 100.

Net revenue as a percent of annual operating cost ranged from -4.6 percent to 53.0 percent in beef slaughter and boning, and from -10.1 to 67.4 percent in hog slaughter, cutting, and boning. The smallest half shift combined operation for both beef and hog processing suffered losses. Net revenue as a percent of estimated total value of sales ranged from -0.3 percent to 2.1 percent in beef slaughter and boning, and from -0.7 to 2.2 percent in the hog slaughter, cutting, and boning operations.⁴

The data for combined beef slaughter and boning operations were next added to those for the combined hog slaughter, cutting, and boning operations to examine annual net revenues in complete diversified plants.

III. RATES OF RETURN ON ANNUAL OPERATING COST FOR COMPLETE PLANTS

Cost behavior and rates of return on annual operating cost for 12 different combinations of plant capacity and operating schedules for both beef and hog processing were studied. These combinations

⁴The estimated rates of return on annual total operating costs in some of the larger model plants appear to be quite high. It should be emphasized, however, that these model plants were assumed to operate under ideal conditions. The model plants were assumed to operate at full capacity for an entire year. According to Williams and Stout, [55, p. 365], however, existing U. S. packing plants from 1950-1960 utilized an average of 73 percent of capacity for cattle and 65 percent for hogs. On the other hand, net revenues as a percent of total sales in the model plants are consistent with those reported for existing plants in the industry. Net income of meat packing plants in 1967 and 1968 averaged one percent of total sales [48, p. 9]. Net revenue of the combined model operations of this study averaged 1.09 percent of total sales at full capacity (Table 51).

included three plants with both operations on full shift schedules; six plants, each with one operation on full shift and the other on a half shift schedule; and three plants with both operations on a half shift schedule. The configurations are summarized in Table 52.

There are many more possible combinations than the 12 examined in this study. For example, BSBB-I (full shift) could be combined with HSHC-II (full shift) or BSBB-III (full shift) could be combined with HSHC-I (half shift). The largest operations in terms of annual output), however, realize the lowest costs and, with constant raw and processed product prices, the highest annual net revenues. Model plants C, F, I, and L are the largest plants in each of the four main categories: (1) full shift beef slaughter--full shift hog slaughter; (2) full shift beef slaughter--half shift hog slaughter; (3) half shift beef slaughter--full shift hog slaughter; and (4) half shift beef slaughter--half shift hog slaughter. These categories were selected so that different plant configurations could be compared on the basis of labor as well as capacity utilization.

Table 53 lists the rates of return on annual operating cost for complete plants operating at full capacity. Net revenue as a percent of annual operating cost ranged from -6.9 to 60.8 percent. The 6.9 percent loss was incurred in model plant J, the smallest plant with have shift operating schedules for both species. This plant would have processed 18,043 cattle and 45,108 hogs per annum. Table 51 shows its component half shift combined operations BSBB-I and HSHC-I having 4.6 and 10.1 percent losses, respectively.

TABLE 52

COMPLETE PLANT CONFIGURATIONS OF BEEF SLAUGHTER, BEEF BONING,
HOG SLAUGHTER, AND HOG CUTTING AND BONING OPERATIONS^a

Plant	Annual cattle production number of head	Combined operation	Shift	Annual hog production number of head	Combined operation	Shift
A	37,800	BSBB-I	Full	94,500	SHSC-I	Full
B	75,600	BSBB-II	Full	236,250	SHSC-II	Full
C	113,400	BSBB-III	Full	567,000	SHSC-III	Full
D	37,800	BSBB-I	Full	45,108	SHSC-I	Half
E	75,600	BSBB-II	Full	112,770	SHSC-II	Half
F	113,400	BSBB-III	Full	270,648	SHSC-III	Half
G	18,043	BSBB-I	Half	94,500	SHSC-I	Full
H	36,086	BSBB-II	Half	236,250	SHSC-II	Full
I	54,130	BSBB-III	Half	567,000	SHSC-III	Full
J	18,043	BSBB-I	Half	45,108	SHSC-I	Half
K	36,086	BSBB-II	Half	112,770	SHSC-II	Half
L	54,130	BSBB-III	Half	270,648	SHSC-III	Half

^aTable 16 (page 51).

TABLE 53

ANNUAL NET REVENUES AND TOTAL SALES OF COMPLETE PLANTS AT FULL CAPACITY

Plant ^a	Annual total operating cost ^b	Annual total sales ^c	Annual net revenue ^d	Annual net revenue as a percent of operating cost ^e	Annual net revenue as a percent of total sales ^f
			Dollars		
A	651,186	12,746,349	126,360	19.4	1.0
B	1,171,592	27,948,281	536,590	45.8	1.9
C	2,021,619	52,972,542	1,229,559	60.8	2.3
D	534,590	10,179,447	82,926	15.5	0.8
E	962,163	21,531,025	345,944	36.0	1.6
F	1,541,398	37,571,129	749,600	48.6	2.0
G	515,068	8,651,118	16,108	3.1	0.2
H	919,670	19,757,819	295,772	32.2	1.5
I	1,675,141	40,687,056	836,940	50.0	2.1
J	398,472	6,084,216	-27,326	-6.9	-0.4
K	710,241	13,340,563	105,126	14.8	0.8
L	1,194,920	25,285,643	356,981	30.0	1.4

^aTable 52.^bColumn 1, Table 51 (page 127).^cWeighted average gross value per head processed times the number of head processed in each complete plant.^dNet value per head processed times the number of head processed in each complete plant.^eColumn 3 divided by column 1 times 100. ^fColumn 3 divided by column 2 times 100.

Plant C showed a 60.8 percent return on annual operating cost. This plant was designed to slaughter 113,400 beef animals and 567,000 hogs per year. Table 51 (page 127) shows its components, full shift BSBB-III and full shift HSHC-III, making rates of return on annual operating costs of 53.0 and 67.4 percent, respectively.

Less Than Full Utilization of Capacity

If seasonal utilization of capacity is considered, plant G would also incur a loss. Table 54 shows plants G and J having losses of 5.5 and 15.7 percent, respectively, when operated at rates that reflect seasonality in the supplies of slaughter animals. Plant G had a net return on annual operating cost of 3.1 percent when operating at full capacity, but when annual production decreased due to seasonality in the supply of slaughter animals, this marginal plant would suffer a loss. The 60.8 percent return of plant C would have decreased to 47.2 percent when the supply of slaughter animals decreased due to seasonality.

At a rate of plant utilization of 80 percent (Table 55), three more plants suffered losses. Plants A, D, and K incurred losses of 4.5, 7.6, and 8.2 percent, respectively. At 70 percent utilization of capacity (Table 56), three more plants (E, H, and L) exhibited negative annual net revenues. Only the two largest plants operating on completely full shift schedules (B and C) and the largest two plants operating on combined full and half shift schedules (F and I) incurred positive annual net returns at the 70 percent rate of plant utilization. Plant C had a 60.8 percent return on annual operating at full capacity

TABLE 54

ANNUAL NET REVENUES AND TOTAL SALES OF COMPLETE PLANTS AT SEASONAL UTILIZATION OF CAPACITY

Plant ^a	Annual total operating cost	Annual total ^c sales	Annual net ^d revenue	Annual net revenue as a percent of operating cost ^e	Annual net revenue as a percent of total sales ^f
			Dollars		
A	651,186	11,528,994	52,496	8.1	0.45
B	1,171,592	25,369,872	379,904	32.4	1.49
C	2,021,619	48,458,553	954,232	47.2	1.96
D	534,590	9,112,233	18,423	3.4	0.20
E	962,163	19,328,048	212,664	22.1	1.10
F	1,541,398	33,958,092	530,442	34.4	1.56
G	515,068	7,919,834	-28,514	-5.5	-0.36
H	919,670	18,151,761	197,583	21.5	1.08
I	1,675,141	37,631,489	649,352	38.8	1.72
J	398,472	5,503,073	-62,587	-15.7	-1.13
K	710,241	12,109,937	30,343	4.3	0.25
L	1,194,920	23,131,028	225,562	18.9	0.97

^aTable 52 (page 130).^bColumn 1, Table 51 (page 127).^cWeighted average gross value per head processed times the number of head processed in each complete plant.^dNet value per head processed times the number of head processed in each complete plant.^eColumn 3 divided by column 1 times 100. ^fColumn 3 divided by column 2 times 100.

TABLE 55

ANNUAL NET REVENUES AND TOTAL SALES OF COMPLETE PLANTS OPERATING AT EIGHTY PERCENT OF CAPACITY

Plant ^a	Annual total operating cost	Annual total ^c sales	Annual net revenue ^d	Annual net revenue as a percent of operating cost	Annual net revenue as a percent of total sales
			Dollars		
A	651,186	10,197,079	-29,149	-4.5	-0.28
B	1,171,592	22,358,624	194,954	16.6	0.87
C	2,021,619	42,378,034	577,379	28.6	1.36
D	534,590	8,143,536	-40,578	-7.6	-0.49
E	962,163	17,224,820	84,323	8.8	0.48
F	1,541,398	30,056,882	291,398	18.9	0.96
G	515,068	6,920,812	-90,132	-17.5	-1.30
H	919,670	15,806,296	52,686	5.7	0.33
I	1,675,141	32,549,645	332,580	19.9	1.02
J	398,472	4,867,269	-101,561	-25.5	-2.08
K	710,241	10,672,492	-57,945	-8.2	-0.54
L	1,192,920	20,228,493	46,599	3.9	0.23

^aTable 52 (page 130).^bColumn 1, Table 51 (page 127).^cWeighted average gross value per head processed times the number of head processed in each complete model plant.^dNet value per head processed times the number of head processed in each complete plant.^eColumn 3 divided by column 1 times 100. ^fColumn 3 divided by column 2 times 100.

TABLE 56

ANNUAL NET REVENUES AND TOTAL SALES OF COMPLETE PLANTS OPERATING AT SEVENTY PERCENT OF CAPACITY

Plant ^a	Annual total operating cost ^b	Annual total ^c sales	Annual net revenue ^d	Annual net revenue as a percent of operating cost ^e	Annual net revenue as a percent of total sales
				Dollars	
A	651,186	8,922,445	-106,904	-16.4	-1.19
B	1,171,592	19,563,797	24,135	2.1	0.12
C	2,021,619	37,080,779	254,206	12.6	0.68
D	534,590	7,125,634	-102,328	-19.1	-1.43
E	962,163	15,071,718	-46,489	-4.8	-0.30
F	1,541,398	26,299,810	62,302	4.0	0.23
G	515,068	5,999,797	-143,246	-27.8	-2.38
H	919,670	13,830,432	-68,863	-7.5	-0.49
I	1,675,141	28,480,939	83,316	5.0	0.29
J	398,472	4,202,986	-138,670	-34.8	-3.29
K	710,241	9,338,353	-139,487	-19.6	-1.49
L	1,194,920	17,699,970	-108,588	-9.1	-0.61

^aTable 52 (page 130).^bColumn 1, Table 51 (page 127).^cWeighted average gross value per head processed times the number of head processed in each complete model plant.^dNet value per head processed times the number of head processed in each complete plant.^eColumn 3 divided by column 1 times 100. ^fColumn 3 divided by column 2 times 100.

utilization and this figure decreased to 12.6 percent at the 70 percent rate of plant utilization. When operating at 60 percent of capacity (Table 57), all plants showed negative annual net revenues. Losses due to decreases in rates of plant utilization, in every case, were greatest in the smallest model plants.

It should be noted, however, that the rates of 80, 70, and 60 percent of capacity were selected⁵ to examine the effects on model plant revenues ceteris paribus. In an actual situation where a plant was producing at 80 percent of capacity or less, there might have been forces affecting the net values per head processed in the model operations. This could increase or decrease net revenue from one period to another depending on the relative price movements.

Another factor to be considered was labor utilization. The plant labor forces were assumed to be constant regardless of the rate of capacity utilization. Actual plants may be able to decrease the size of the labor force in a plant operating consistently at 80 percent of capacity or less. But, it is also possible that technological requirements (one man--one machine) and union restrictions may have prevented a reduction in the size of the labor force. Labor crews could have been diverted from processing activities to maintenance work.

In order to determine the feasibility of establishing a plant in a given area, another method was employed to estimate the ability of a proposed plant to repay its initial investment.

⁵See footnote 2, page 113.

TABLE 57

ANNUAL NET REVENUES AND TOTAL SALES OF COMPLETE PLANTS OPERATING AT SIXTY PERCENT OF CAPACITY

Plant ^a	Annual total operating cost	Annual total sales ^c	Annual net revenue ^d	Annual net revenue as a percent of operating cost ^e	Annual net revenue as a percent of total sales
			Dollars		
A	651,186	7,647,809	-184,658	-28.4	-2.41
B	1,171,592	16,768,969	-146,683	-12.5	-0.87
C	2,021,619	31,783,525	-70,912	-3.5	-0.22
D	534,590	6,107,678	-164,079	-30.7	-2.68
E	962,163	12,918,615	-177,299	-18.4	-1.37
F	1,541,398	22,542,635	-166,802	-10.8	-0.73
G	515,068	5,190,712	-196,360	-38.1	-3.78
H	919,670	11,854,775	-190,400	-20.7	-1.60
I	1,675,141	24,412,234	-167,892	-10.0	-0.68
J	398,472	3,650,581	-175,781	-44.1	-4.81
K	710,241	8,004,421	-221,016	-31.1	-2.76
L	1,194,920	15,171,344	-263,782	-22.1	-1.73

^aTable 52 (page 130).^bColumn 1, Table 51 (page 127).^cWeighted average gross value per head processed times the number of head processed in each complete model plant.^dNet value per head processed times the number of head processed in each complete plant.^eColumn 3 divided by column 1 times 100. ^fColumn 3 divided by column 2 times 100.

IV. THE FEASIBILITY CRITERION

Polopolus defines a feasibility criterion "as the ability of the processing industry to repay the initial investment in a limited time horizon plus a normal rate of return" [33, pp. 168-170].

Given M products, where M = 2, hogs and beef:

$$\Delta_t = \sum_{m=1}^M P_{mt} X_{mt} - \sum_{m=1}^M K_{mt} X_{mt}$$

where:

Δ_t = quasi rent in any given period t.

P_{mt} = market price of product M in period t

X_{mt} = number of units of product M sold in period t

K_{mt} = operating cost per unit of product M sold in period t.

An estimate of the capital value of the multiproduct plant is required. It involves the estimated capital value of a stream of quasi rents ($\Delta_1, \Delta_2, \dots, \Delta_t$). The estimate is obtained by the following formula:

$$V = \frac{\Delta_1}{1+r} + \frac{\Delta_2}{(1+r)^2} + \dots + \frac{\Delta_T + S}{(1+r)^T}$$

where:

V = estimated capital value

T = the planning horizon

r = the market rate of interest on long term loans

S = the expected scrap value of the plant in period t.

It was assumed the scrap value S was a zero.⁵ Δ_t was constant from period to period and equal to the net revenue figures for each of the complete plants.

The feasibility criterion was positive if $V - I \geq 0$ where V was the estimated capital value and I was the initial aggregate investment cost [33, pp. 168-170]. I was equal to the initial cost of land, buildings and equipment. The market rate of interest (r) used was six percent and the planning horizon (t) was ten years.

To facilitate calculations the equation for the estimated capital value (V) was simplified to the following equation:

$$V = \Delta_t \left[\frac{(1+r)^T - 1}{r(1+r)^T} \right]$$

The manipulation is explained in Appendix E.

Substituting $r = .06$ and $t = 10$

$$V = \Delta_t (7.3649)$$

Table 58 summarizes the initial aggregate investment costs (I) for model plants A through L and gives the values of V for full capacity, seasonal utilization of capacity, 80, 70, and 60 percent of capacity utilization of the model plants.

At full capacity plants G, J, and K were not capable of repaying their initial aggregate investment costs within ten years. The percent

⁵Scrap values of equipment were subtracted from the total equipment cost to arrive at a balance for equipment depreciation (Chapter IV, Section III). Therefore, scrap values are implicitly considered in the calculation of the estimated capital value equation above.

TABLE 58

FEASIBILITY CRITERION FOR FULL, SEASONAL, EIGHTY PERCENT, SEVENTY PERCENT, AND SIXTY PERCENT OF CAPACITY UTILIZATION OF COMPLETE PLANTS^a

Plant ^b	Initial aggregate investment cost (I) ^c	Estimated capital value in ten years (V) ^d				
		Full capacity	Seasonal utilization of capacity	80 percent of capacity	70 percent of capacity	60 percent of capacity
				Dollars		
A	529,846	930,629	386,628 ^e	Negative ^e	Negative ^e	Negative ^e
B	936,039	3,951,932	2,797,955	1,435,817	177,752 ^e	Negative ^e
C	1,484,555	9,055,579	7,027,823	4,252,339	1,872,202	Negative ^e
D	528,382	610,742	135,684 ^e	Negative ^e	Negative ^e	Negative ^e
E	933,464	2,547,843	1,566,249	621,030 ^e	Negative ^e	Negative ^e
F	1,478,455	5,520,729	3,906,652	2,146,117	458,848 ^e	Negative ^e
G	527,966	118,634 ^e	Negative ^e	Negative ^e	Negative ^e	Negative ^e
H	932,650	2,178,331	1,455,179	388,027 ^e	Negative ^e	Negative ^e
I	1,479,663	6,163,979	4,782,413	2,449,418	613,614 ^e	Negative ^e
J	526,502	Negative ^e	Negative ^e	Negative ^e	Negative ^e	Negative ^e
K	930,075	774,242	223,473 ^e	Negative ^e	Negative ^e	Negative ^e
L	1,473,563	2,629,129	1,661,241	343,197 ^e	Negative ^e	Negative ^e

^aV must be greater than I for a plant to be feasible. A negative estimated capital value is the result of negative annual net revenue in the plant.

^bTable 52 (page 130).

^cInitial cost of land, buildings, and equipment (Tables 35, 30, and 32, pages 85, 75, and 81, respectively).

^dEstimated capital value in ten years, $V = \Delta(7.3649)$ where Δ = annual net revenue.

^ePlant infeasible at given capacity.

returns on annual operating costs of the infeasible plants (Table 53, page 131) at full capacity ranged from -6.9 to 14.8 percent,

Less than Full Utilization at Capacity

At seasonal utilization of capacity, plants A, D, and L became infeasible in addition to those which were already infeasible at full capacity. Returns of the infeasible plants ranged from -15.7 to 8.1 percent at seasonal utilization of capacity. When operating at 80 percent of capacity, only plants B, C, F, and I remained feasible. These were the largest completely full shift plants and the largest of the plants operating under combined full shift and half shift schedules.

At 70 percent of capacity utilization, only plant C, the largest model plant (in terms of investment and annual output) in this study, remained feasible. When operating at 60 percent of capacity, the net revenue of every model plant in the study was negative, and accordingly none of the model plants studied was feasible in terms of repayment ability at 60 percent of capacity.

It appeared that full utilization of capacity by using a full shift operating schedule produced the greatest ability to withstand losses due to an inadequate supply of slaughter animals. These plants were also better able to pay for themselves than the plants utilizing only half shift labor crews.

These results can be compared to the feasibility of (1) specialized beef slaughter and boning operations and (2) specialized hog slaughter,

cutting, and boning operations (Table 59). At full capacity all of the half shift beef slaughter plants and the smallest half shift hog slaughter, cutting, and boning plant were feasible. At seasonal utilization of capacity, the two largest full shift beef slaughter operations, the two largest full shift hog slaughter, cutting, and boning plants, and the largest two half shift hog slaughter plants would have survived. When operating at 80 percent of capacity, only the largest full shift beef slaughter plant and the two largest full shift hog slaughter plants remained feasible. At 70 percent of capacity, only the largest hog slaughter plant remained feasible in terms of repayment capacity, and, when operating at 60 percent of capacity, none of the model combined operations was able to pay for itself plus a normal rate of return during a ten year period.

Thus, in terms of full capacity utilization, the larger specialized hog slaughter, cutting, and boning operations had higher estimated net revenues, and conversely, higher estimated losses in the smaller operations, than both the specialized beef slaughter combined operations and the complete diversified plants.⁶ The complete plants, however,

⁶Comparison of annual net revenues for specialized beef and specialized hog processing operations was based on similar initial aggregate investment costs for the two operations. It should be noted, however, that a prospective new plant owner would compare a diversified plant of a given size, in terms of initial aggregate investment costs, to a specialized plant with similar aggregate investment costs rather than to two specialized plants (one processing beef and the other processing hogs) with combined aggregate investment costs equivalent to the initial cost of the diversified plant under consideration.

TABLE 59
FEASIBILITY CRITERION FOR FULL, SEASONAL, EIGHTY PERCENT, SEVENTY PERCENT, AND SIXTY PERCENT OF
CAPACITY UTILIZATION OF COMBINED SLAUGHTER AND BONING OPERATIONS

Operation ^b	Initial aggregate investment cost (I) ^c	Estimated capital value in ten years (V) ^d				
		Full capacity	Seasonal utilization of capacity			
			60 percent of capacity	70 percent of capacity	80 percent of capacity	90 percent of capacity
-----Dollars-----						
			Full shift			
BSBB-I	345,774	731,703	319,615 ^e	37,391 ^e	Negative ^e	Negative ^e
BSBB-II	580,738	1,959,329	1,135,152	570,706 ^e	Negative ^e	Negative ^e
BSBB-III	865,415	3,608,551	2,372,286	1,525,610	484,146 ^e	Negative ^e
			Half shift			
BSBB-I	343,894	Negative ^e	Negative ^e	Negative ^e	Negative ^e	Negative ^e
BSBB-II	577,349	185,728 ^e	Negative ^e	Negative ^e	Negative ^e	Negative ^e
BSBB-III	860,523	716,951 ^e	126,875 ^e	Negative ^e	Negative ^e	Negative ^e
			Full shift			
HSHC-I	184,072	198,926	67,551 ^e	Negative ^e	Negative ^e	Negative ^e
HSHC-II	355,301	1,992,603	1,663,385	865,692	301,946 ^e	Negative ^e
HSHC-III	619,140	5,447,028	4,655,537	2,741,046	1,388,055	Negative ^e
			Half shift			
HSHC-I	182,608	Negative ^e	Negative ^e	Negative ^e	Negative ^e	Negative ^e
HSHC-II	352,726	588,514	431,097	50,324 ^e	Negative ^e	Negative ^e
HSHC-III	613,040	1,912,178	1,534,366	620,508	Negative ^e	Negative ^e

^aV must be greater than I for a plant to be feasible. A negative estimated capital value is the result of a negative annual net revenue in the combined operation.

^bTable 46 (page 111).

^cInitial cost of land, buildings, and equipment.

^dEstimated capital value in ten years, $V = \Delta_T(7.3649)$ where Δ_T = annual net revenue.

^ePlant infeasible at given capacity.

had the advantage of being able to offset low net revenue in one species by higher rates of return in the other species.

Specialized as well as diversified plants operating under full shift schedules would have realized greater estimated rates of return on annual operating costs than the smaller half shift operations. And, operating at less than full utilization of capacity had the effect of significantly reducing estimated net revenue as well as the ability to repay initial aggregate investment costs over a limited time horizon.



CHAPTER VII

SUMMARY AND CONCLUSIONS

I. REVIEW OF THE APPROACH

The objectives of the study were: (1) to develop budgets for resource requirements, performance rates, and costs per unit of output for beef and pork packing plants that would be feasible in the Tennessee Valley; (2) to determine least-cost combinations of activities required for the disassembly of slaughter animals according to differing plant sizes and levels of diversification; (3) to determine maximum profit production and marketing schedules for these plants under both existing and estimated demand and supply conditions; (4) to determine the effects of changes in slaughter animal availabilities on model plant operating costs and to specify the slaughter animal supply flows required to support different rates of utilization of capacity; and (5) to determine the effects on costs and efficiencies of differing levels of labor and capacity utilization.

The general approach used to accomplish the objectives of this study was synthetic cost analysis or economic engineering. This method of analysis involved the specification of a set of "building blocks" which were used for estimating plant cost functions.

The conventional economic engineering technique sums the cost functions of individual plant operating stages to form the total cost

curve for the complete plant. This process is then repeated for several different sized plants. This study, however, also focussed attention on the total costs of different sized operating stages (beef slaughter, beef boning, hog slaughter, and hog cutting and boning), and how they may be efficiently combined to form complete diversified plants. The conventional analysis was, in this sense, modified by designing the individual operating stages such that each could be considered as an autonomous plant. Each operation had its own total cost curve and was "constructed" in three different sizes. A complete beef and pork packing plant, therefore, was formed by summing the cost functions of the four operating stages and the plant capacity depended on the particular combination of different sized operating stages.

A series of least cost combined slaughter and boning operations was determined for different levels of slaughter animal availability and plant utilization. Estimated raw and processed product prices were used to determine net revenues for beef and pork packing plants at selected rates of plant utilization under both full and half shift operating schedules. A feasibility test was made of the ability of the model plants to repay their initial aggregate investment costs plus a normal rate of return over a limited planning horizon.

II. SUMMARY OF RESULTS AND THEIR IMPLICATIONS

The results of this study are of primary use as planning guides for both short and long range purposes. Resource requirements, performance rates, unit costs, and profit rates for different sizes and

configurations of plants should be of use to plants already in existence as well as to possible new entrants into the market.

Under 1968 conditions average total unit costs would have ranged from \$8.15 to \$13.07 in combined beef slaughter and boning operations, and from \$1.94 to \$3.60 per head in the combined hog slaughter, cutting, and boning operations at full utilization of capacity. The largest specialized beef slaughter operation, BSBB-III (capacity = 113,400 head per year under a full shift operating schedule), would have had an average total unit cost of \$8.15. If production decreased to 60 percent of capacity, average total unit cost would have increased from \$1.94 at full capacity to \$3.23 at 60 percent of capacity.

The net values per head processed (using 1968 prices) in the model operations (gross value minus slaughter animal cost minus processed animal delivery cost minus annual plant operating cost) were relatively low, in relation to gross value per head, for both cattle and hogs. The net values ranged from -\$0.60 to \$4.32 per head for beef and from -\$0.36 to \$1.30 per hog in the combined operations at full capacity. If the ratio between raw and processed product price changes from one period to another, or if average total unit costs increase due to less than full utilization of capacity, net revenues would also change. The specialized plants would have been more vulnerable to this variation than the diversified plants if a reduction in revenue from one species would be offset by an increase in revenue from the other species.

Specialized hog slaughter, cutting, and boning operations would have had higher estimated returns on annual operating costs in the

larger operations as well as higher estimated losses in the smaller sized operations than both the specialized beef slaughter and boning operations and the combined beef and pork packing plants. Plants slaughtering both species would be better able to withstand losses from one species when returns from slaughtering the other species would be high enough to offset the losses. Less than full utilization of capacity in the model operations had the effect of significantly reducing estimated returns as well as the ability to repay initial aggregate investment costs over a limited time horizon.

The model plants on full shift operating schedules would have had lower total unit costs and higher net revenues than plants operating on half shift schedules at all levels of utilization of capacity. And, in all cases, the largest plants would have had the lowest unit costs, the highest estimated returns, and the greater ability to repay their initial investments over a limited planning horizon.

The costs and efficiencies specified in this study were assumed to be those of advanced technological and organizational framework. They may be considered as optima with which both existing plants and prospective new entrants may compare their own levels of efficiency.

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LITERATURE CITED

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APPENDICES



APPENDIX A

PHYSICAL-FUNCTIONAL DESCRIPTION OF ACTIVITIES



PHYSICAL-FUNCTIONAL DESCRIPTION OF ACTIVITIES

The complete model plant consisted of four operational stages: (1) cattle slaughter, (2) beef boning, (3) hog slaughter, and (4) pork cutting.¹

Cattle Slaughter, On-the-Rail

Bring up cattle. From the holding pens, the cattle are driven to a restraining pen. This may be adjacent to the knocking area or it may converge into the knocking area. The job may require one or two men depending on the number of cattle and their temperament. The animals are driven with the aid of electronic prods to the stunning area.

Immobilizing. The number of animals driven into the knocking pen may vary from one to three or four depending on the size of the operation. In the knocking or stunning pen, there is just enough room for the animals to stand. There are several methods of immobilizing the animal. The operation usually takes one man who uses a captive bolt stunner, a .22 calibre rifle or revolver, or a four to five pound hammer. It is preferable to stun rather than kill the animal for better meat quality. From the knocking pen, the immobilized animal must be transported to the kill floor for bleeding. This may be done by allowing the weight of the stunned animal to tilt the floor of the knocking pen

¹The description of these activities was based on interviews with industry sources and published sources including Logan and King [29, pp. 22-26], Sanders, Frazier, and Padgett [27, pp. 7-24], and Pork Cutting and Curing Equipment Catalog 61-A [1, pp. 4-7].

downward into the kill floor area on a lower level. The side door of the knocking pen is then raised as part of the same weight force or by a hydraulic or power lift.

Bleeding. In the landing area below the knocking pen the stunned animal is raised up to the rail. This is done by attaching a chain to one or both hind legs and hoisting the animal to the bleeding rail. A "sticker" then bleeds the animal by severing the carotid artery in the neck and allowing the blood to drain before the next activity.

Head removal and work-up. After bleeding the head is either completely severed or allowed to remain attached by the trachea and esophagus. Another worker then completely removes the head from the animal and it is transported to the head work-up area. The animal is also dehorned at this station if it is not already polled.

The head work-up usually requires one man who removes the head from the carcass, transports it to the work-up area, skins the head, drops the tongue and removes the head and cheek meat. The jaws are separated and head bones are thrown into barrels for removal.

Primary skinning. Here, the skin of the carcass is first opened and the trachea and esophagus are separated from the rest of the neck tissue. The lower parts of the legs are skinned and removed as are the hoofs. Then the sides, flanks, shoulders and shanks are skinned with an electric or air-operated dehider. At this stage the udder is

removed and the breast and aitch bones are split. The hide is then transported from the kill floor.

Eviscerating. The viscera is removed from the carcass and placed on the viscera table. Here the heart, liver, lungs and trachea are removed, the paunch is opened with a hand knife and the contents washed into a hopper. The tripe is scraped and placed on an umbrella-type washer for further cleaning. It is then hung on a hook rack and packaged or shipped.

Splitting carcass. The carcass is split down the back from the rump to the neck with the use of a suspended electric carcass saw.

Washing. A worker on a stationary platform washes each side of the carcass with a high pressure water spray. The carcass is washed to remove blood, bone scraps and other foreign material.

Weighing and recording. After washing, the carcass is trimmed, scribed and weighed. The weight is then recorded on a tally sheet while the carcass is stamped and tagged.

Shrouding. The surface of the carcass is first wiped clean with warm cloths. A heavy muslin cloth soaked in brine solution is pinned on each carcass side by one worker. The cloth is first placed around the hind shank, then it is stretched and pinned at various places in order that the entire outside portion of each side is covered. The carcass, as a result, has a smoother appearance after cooling with less drying effects.

Positioning carcass in cooler. The shrouded carcass is then transported to a chill cooler over night. They are held at a temperature of 30° to 32° to remove the initial body heat. The shrouds are removed after the carcass has been chilled. The carcasses are then moved from the chill cooler to a holding cooler where they are cut or shipped directly.

Beef cutting. A side of beef is ribbed or quartered by splitting it into a fore and hind quarter. All but one rib is usually left on the fore quarter.

A fore quarter is divided into chuck, rib and plate. The plates are then divided into shank, brisket and short plate.

The wholesale cuts in the hind quarters are: (1) butcher's round (with or without rump), (2) rump, (3) loin (with flank, kidney and suet), (4) trimmed loin (flank off kidney and suet out), and (5) flank.

Beef Boning

Cutting. The sides of beef are transported to the boning area from the cooler. Cows, bulls and cutters and canners are completely boned out. The sides are broken into primal cuts with a band saw.

Boning. The primal cuts are then boned manually. The bones are trimmed and the boned out meat and trimmings are placed on a conveyor. The trimmed bones are placed on an overhead bone conveyor to be processed.

The boned out meat is then deposited on a lazy susan table to be shipped as boneless beef.

Hog Slaughter, On-the-Rail

Bring up hogs. The hogs are driven from unloading pens by one worker with the use of whips or electric prods. They are moved into shackling pens in a single line.

Stunning. The animals are immobilized with an electric stunner. The animal then slides down a ramp to the shackling area.

Shackling. In the shackling area, each animal is shackled by one of the rear legs just above the foot. The hog is then hoisted to the bleeding rail.

Bleeding. In the bleeding area, a "sticker" plunges a knife into the base of the throat puncturing the heart. During this operation, the rail moves the animal over the bleeding area.

Scalding and dehairing. Here the animal automatically drops from the bleeding rail into a scalding vat. The water in the scalding tub is heated to a temperature ranging from 150°F. to 160°F. The animal is then moved into a power operated dehairing device.

Hoist, scorch and scrape. The animal is then hoisted back onto the rail and gambrelled. The hog now hangs by both hind feet. The animal is then scorched by a large torch. It passes by several workers

on stationary platforms who scrape the animal with hand knives to remove residual hair. The hog is then passed through a washing area where a high powered water spray cleans the animal. Toenails are pulled and feet are cleaned in this area.

Primary head cut. The head is partially severed from the animal,

Eviscerating. First the bung is removed by an incision and the carcass opened on the ventral side. Here the sternum is opened and the bung is pulled out and tied. The abdominal viscera is removed and placed on an inspection table. The thoracic viscera is then removed and inspected.

Splitting carcass. The carcass is first trimmed to remove excess fat and is then split in half.

Remove head. The head is removed from the carcass and transported to the head work-up area. The head is skinned, detongued and debrained.

Weighing and positioning in cooler. The carcass is weighed, tagged and branded. The weight is recorded and the carcass is moved to the chill cooler overnight.

Pork Cutting

There are five main cuts to the hog carcass: (1) head, (2) shoulder, (3) loin, (4) belly, and (5) ham.

Head and jowl. The jowl is left attached to each side of the carcass whether or not the head is split. The jowls are squared and are then cured and smoked in the same manner as bacon. They are marketed as "jowl bacon." The jowls represent from 3 percent to 4 percent of the carcass weight and the bulk of them is used in fresh or cooked sausages and loaf meats.

Shoulder. The shoulder is skinned by first removing the rib and neck bone and the breast flap on the inside of the shoulder and cutting off the foot just above the knee. The skin and fat are then removed from the shoulder to within four inches of the base of the shank with not less than one-half inch of fat on any part. The Boston butt is separated from the picnic by cutting below the exposed blade bone across the shoulder where the neck bone was removed.

Ham. The ham is cut in either of three different lengths depending upon the carcass size or the amount of loin that is desired. The foot is cut off through or directly above the hock and the flank and tail bones are removed.

Loin. The loin is separated from the belly.

Belly. The spareribs are removed and their ends and sides are trimmed.



APPENDIX B

LABOR REQUIREMENTS AND COSTS

TABLE 60

NUMBER OF WORKERS REQUIRED AND HOURLY WAGE RATES FOR THE ACTIVITIES
OF THE BEEF SLAUGHTER OPERATIONS, HEAD PER HOUR

Activity	Number of workers required ^a		Hourly wage ^b rate Dollars
	BS-I	BS-II	
<u>Kill, remove head, and wash head:</u>			
Drive, pen, knock	.67	1.00	2,280
Shackle, hoist, stick, scalp, head	.67	2.00	2,525
Tag, cut off head, dehorn, wash head	.67	1.00	2,380
<u>Remove hide, eviscerate, split, and scribe:</u>			
Skin leg, punch gam, saw off, skin gam and punch, rip and point tail	.50	1.00	2,380
Transfer from bleeding to skinning rail, remove udder or pizzle, mark aitch bone	.50	1.00	2,380
Skin leg and saw off, split aitch bone	.50	.50	2,380
Drop bung	.50	.50	2,380
Turn round and flank both sides to naval	.50	1.00	2,380
Skin fell, rump and pull tail	.50	1.00	2,380
Skin and remove front feet, raise and tie weasand, clean neck both sides	.50	1.00	2,380
Mark and saw brisket, rim over right and left brisket	.50	1.00	2,380
Turn shank, clean rosette, neck & drop hide	1.00	2.00	2,230
Skin sides, high and low back	1.00	3.00	2,380
Transfer to flat rail	.50	.25	2,445
Eviscerate (paunch truck)	1.00	1.00	2,525
Split	.50	.75	2,525
Trim bruises	.50	1.00	2,230
Remove passed viscera	1.00	1.00	2,230
Scribe and trim neck	.50	1.00	2,525
<u>Carcass finishing:</u>			
Scale	.50	1.00	2,230
High and low wash	1.00	2.00	2,155
High and low shroud	.50	2.00	2,230

TABLE 60 (Continued)

Activity	Number of workers required ^a		Hourly wage ^b rate ^b Dollars
	BS-I	BS-II	
Other			
Utility and relief	1.00	1.00	2.155
Tripe work-up	1.00	2.00	2.230
Offal work-up	.50	1.00	2.230
Head work-up	.50	2.00	2.445
Total	17.00	32.00	

^aTaken from Logan, S. H., and G. A. King, Cal. A.E.S. Giannini Foundation R. R. No. 260 (Berkeley: Univ. of Cal., Dec., 1962), Table A-8.

^bHourly wage rates are 1968 Tennessee Union wage rates supplied by the local representative of the Amalgamated Meat Cutters and Butchers Workmen of North America, AFL-CIO.

TABLE 61

NUMBER OF WORKERS REQUIRED AND HOURLY WAGE RATES FOR THE ACTIVITIES
OF THE BEEF SLAUGHTER OPERATION, HEAD PER HOUR

Activity	Number of workers required ^a BS-III	Hourly wage ^b rate Dollars
<u>Kill, remove head, and wash head:</u>		
Drive, pen, knock cattle	1.00	2.280
Shackle, hoist, stick, scalp, head	3.00	2.525
Tag, cut off, dehorn, wash head	1.00	2.380
<u>Remove hide, eviscerate, split, and scribe:</u>		
Skin legs, punch gams, rip and point tail	2.00	2.380
Transfer from bleeding conveyor to skinning conveyor	1.00	2.380
Remove shackle, skin legs, cut off	1.00	2.380
Remove udder or pizzle, mark aitch bone	.50	2.380
Drop bung	1.00	2.380
Split aitch bone	.50	2.380
Turn round and flank both sides to naval	2.00	2.380
Skin fell, rump both sides, pull tail	2.00	2.380
Skin, remove front feet, raise and tie weasand	2.00	2.380
Open and turn shanks, clean necks	1.00	2.380
Mark and saw brisket	.50	2.380
Rim over brisket both sides	.50	2.380
Skin rosettes and neck	2.00	2.380
Operate hide puller	1.00	2.380
Low back	1.00	2.380
High back	1.00	2.380
Transfer from skinning to eviscerating and inspection conveyor (automatic)	--	--
Eviscerate	2.00	2.525
Split carcass	1.00	2.525
Scribe and trim bruises	1.00	2.525
<u>Carcass finishing:</u>		
Scale and tag	2.00	2.230
High and low wash	2.00	2.155
High and low shroud	2.00	2.230

TABLE 61 (Continued)

Activity	Number of workers required ^a	Hourly wage ^b rate
	BS-III	Dollars
Other:		
Utility and relief	2.00	2.155
Remove passed viscera	2.00	2.230
Head work-up	2.00	2.445
Tripe work-up	3.00	2.230
Offal work-up	1.00	2.230
Total	44.00	

^aTaken from Logan, S. H., and G. A. King, Cal. A.E.S. Gianinni Foundation R. R. No. 260 (Berkeley: Univ. of Cal., Dec., 1962), Table A-9.

^bHourly wage rates are 1968 Tennessee Union wage rates supplied by the local representative of the Amalgamated Meat Cutters and Butchers Workmen of North America, AFL-CIO.

TABLE 62

**BEEF SLAUGHTER COOLER, DOCK, MAINTENANCE, YARD, AND CLEAN-UP EMPLOYEE
REQUIREMENTS AND HOURLY WAGE RATES**

Worker classification	Number of workers ^a			Hourly wage rate ^b
	BS-I	BS-II	BS-III	
				--Dollars--
<u>Cooler and Dock:</u>				
Cooler men	4	5	8	2.350
Dock foreman	1	1	1	2.525
Order clerk	-	2	2	2.380
Dock checker	-	1	1	2.380
<u>Maintenance:</u>				
Maintenance men	1	4	5	2.155
Gang leader	1	-	-	2.380
Foreman	-	1	1	2.525
Yard men	1	2	2	2.155
Clean-up workers	1	2	3	2.155

^aTaken from Logan, S. H., and G. A. King, Cal. A.E.S. Giannini Foundation R. R. No. 260 (Berkeley: Univ. of Cal., Dec. 1962), Tables A-10-11.

^bHourly wage rates are 1968 Tennessee Union wage rates, supplied by the local representative of the Amalgamated Meat Cutters and Butchers Workmen of North America, AFL-CIO.

TABLE 63

LABOR REQUIREMENTS AND HOURLY WAGE RATES FOR HOG CUTTING AND
BONING OPERATION (HC-I), 100 HEAD PER HOUR

Activity ^a	Number of workers ^a	Hourly wage rate ^b
		--Dollars--
Feed carcass to cutting table	1	2.155
Cut down carcass, scribe hams	1	2.280
Cut off ham, saw hind foot, place carcass for shoulder cutter	1	2.230
Trim hams, trim trimmings	1	2.280
Skin hams	1	2.280
Scribe and pull loins	1	2.445
Trim loins and load truck	1	2.230
Trim bellies	2	2.445
Lift neckbones, saw shoulders	1	2.445
Pull butts and trim	1	2.230
Trim callies or shoulders	1	2.280
Trim shoulders, trim trimmings	1	2.280
Remove ribs, split sides	1	2.445
Trim fat backs, trim trimmings	1	2.180

^a Allbright-Nell Company specifications in Pork Cutting and Curing Equipment Catalog 61-A (Chicago: A.N.Co., 1951), p. 10.

^b Tennessee Union wage rates for 1968 were supplied by the local representative of the Amalgamated Meat Cutters and Butchers Workmen of North America, AFL-CIO.

TABLE 64

LABOR REQUIREMENTS AND HOURLY WAGE RATES FOR HOG CUTTING AND BONING
OPERATION (HC-II), 125 HEAD PER HOUR.

Activity ^a	Number of workers ^a	Hourly wage rate ^b --Dollars--
Feed carcass to cutting table	1	2.155
Cut down carcass, scribe hams	1	2.280
Cut off ham, saw hind foot, place carcass for shoulder cutter	1	2.230
Scribe and pull loins	1	2.445
Trim loins, load truck	1	2.230
Take sides from conveyor table, remove ribs	1	2.445
Split sides, trim fat backs	1	2.280
Trim bellies	2	2.445
Retrim belly trimmings	1	2.180
Trim hams	1	2.280
Skin hams	1	2.280
Retrim ham trimmings	1	2.180
Lift neckbones, saw shoulders	1	2.445
Pull and trim butts	1	2.230
Trim callies or shoulders	1	2.280
Retrim trimmings	1	2.180

^aAllbright-Nell Company specifications in Pork Cutting and Curing Equipment Catalog 61-A (Chicago: A.N.Co., 1951), p. 11.

^bTennessee Union wage rates for 1968 were supplied by the local representative of the Amalgamated Meat Cutters and Butchers Workmen of North America, AFL-CIO.

TABLE 65

LABOR REQUIREMENTS AND HOURLY WAGE RATES FOR HOG CUTTING
AND BONING OPERATION (HC-III), 300 HEAD PER HOUR

Activity ^a	Number of workers ^a	Hourly wage rate ^b --Dollars--
Feed conveyor	1	2.155
Place and bunch trolleys on rail	1	2.155
Cut off hams	1	2.230
Cut off hind foot	1	2.230
Place carcass for shoulder cutter	1	2.155
Scribe loins	1	2.280
Pull loins	2	2.445
Trim loins	2	2.230
Remove ribs	2	2.445
Trim bellies	3	2.445
Trim belly trimmings	3	2.180
Trim fat backs	2	2.280
Lift neckbones	2	2.445
Trim neckbones	3	2.180
Saw shoulders, cut off front feet	1	2.230
Pull butts	2	2.230
Skin shoulders or trim butts	2	2.280
Trim picnics	2	2.280
Trim trimmings	2	2.180
Set sides for splitter	1	2.155
Trim hams	2	2.280
Trim ham trimmings	2	2.180
Skin hams	3	2.280

^aAllbright-Nell Company specifications in Pork Cutting and Curing Equipment Catalog 61-A (Chicago: A.N.Co., 1951), p. 13.

^bTennessee Union wage rates for 1968 were supplied by the local representative of the Amalgamated Meat Cutters and Butchers Workmen of North America, AFL-CIO.



APPENDIX C

BEEF BONING AND HOG CUTTING AND BONING EQUIPMENT AND LAYOUTS

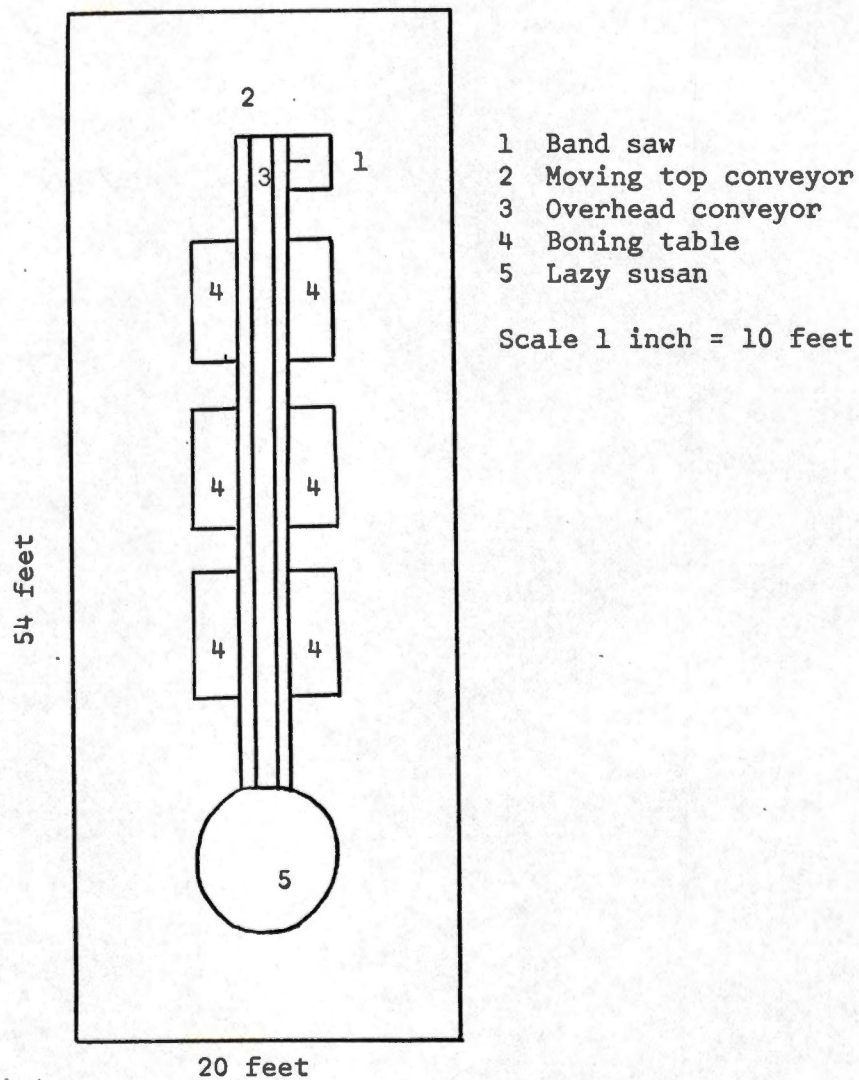


Figure VIII. Beef boning layout, ten head per hour.

TABLE 66

BEEF BONING OPERATION I, EQUIPMENT REQUIREMENTS
AND COSTS, TEN HEAD PER HOUR

Equipment	Unit Cost	Total Cost
	----Dollars----	
1 34 foot moving top boning table	6,870	6,870
1 32 foot S. S. overhead boning conveyor	3,450	3,450
1 Lazy susan table	995	995
6 Six foot cutting tables	72	432
1 18 inch band saw	895	895
Total cost		12,642

Source: Costs for the various items of equipment were taken from Koch General Catalog No. 186 (Kansas City, Missouri: Koch Supplies, Inc., 1968).

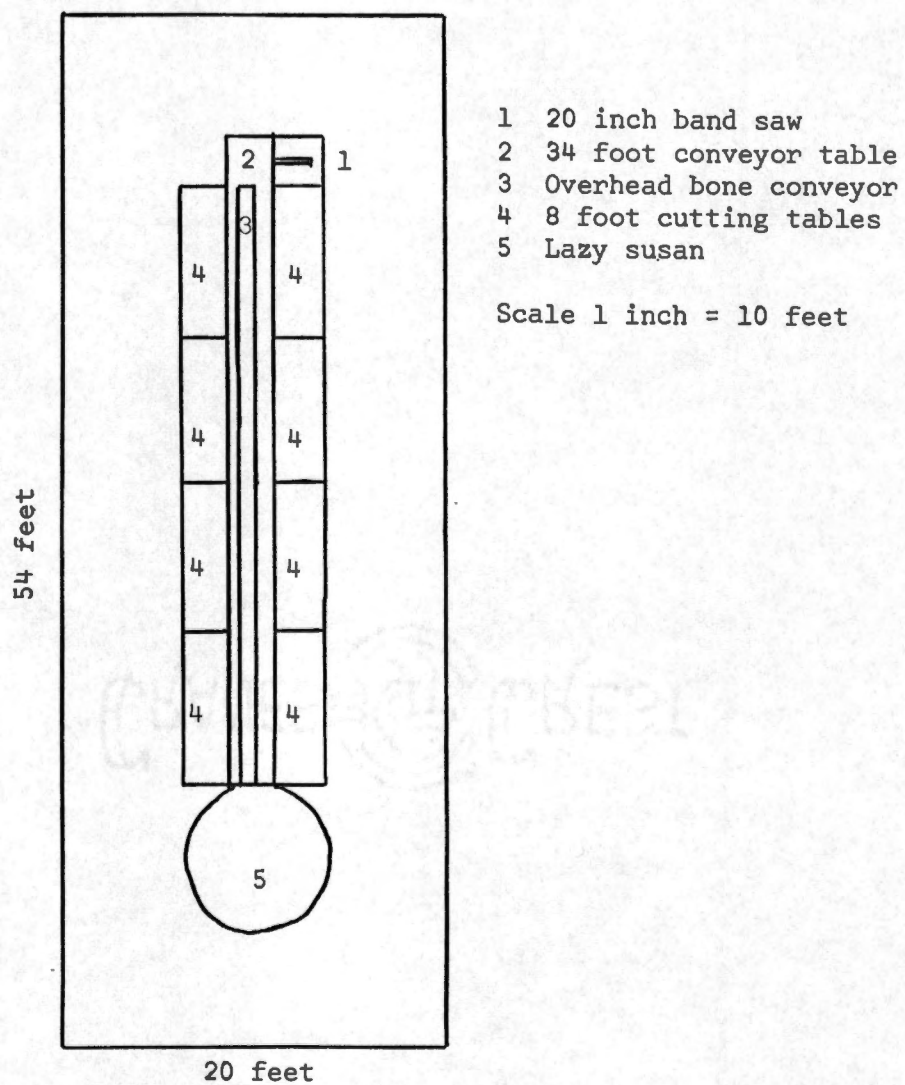


Figure IX. Beef boning layout, 20 head per hour.

TABLE 67

BEEF BONING OPERATION II, EQUIPMENT REQUIREMENTS
AND COSTS, 20 HEAD PER HOUR

Equipment	Unit cost	Total cost
	-----Dollars-----	
1 34 foot moving top boning table	6,870	6,870
1 32 foot S. S. overhead boning conveyor	3,450	3,450
1 Lazy susan table	995	995
8 Eight foot cutting tables	96	768
1 20 inch band saw	1,345	<u>1,345</u>
Total cost		<u>13,428</u>

Source: Costs for the various items of equipment were taken from Koch General Catalog No. 186 (Kansas City, Missouri: Koch Supplies, Inc., 1968).

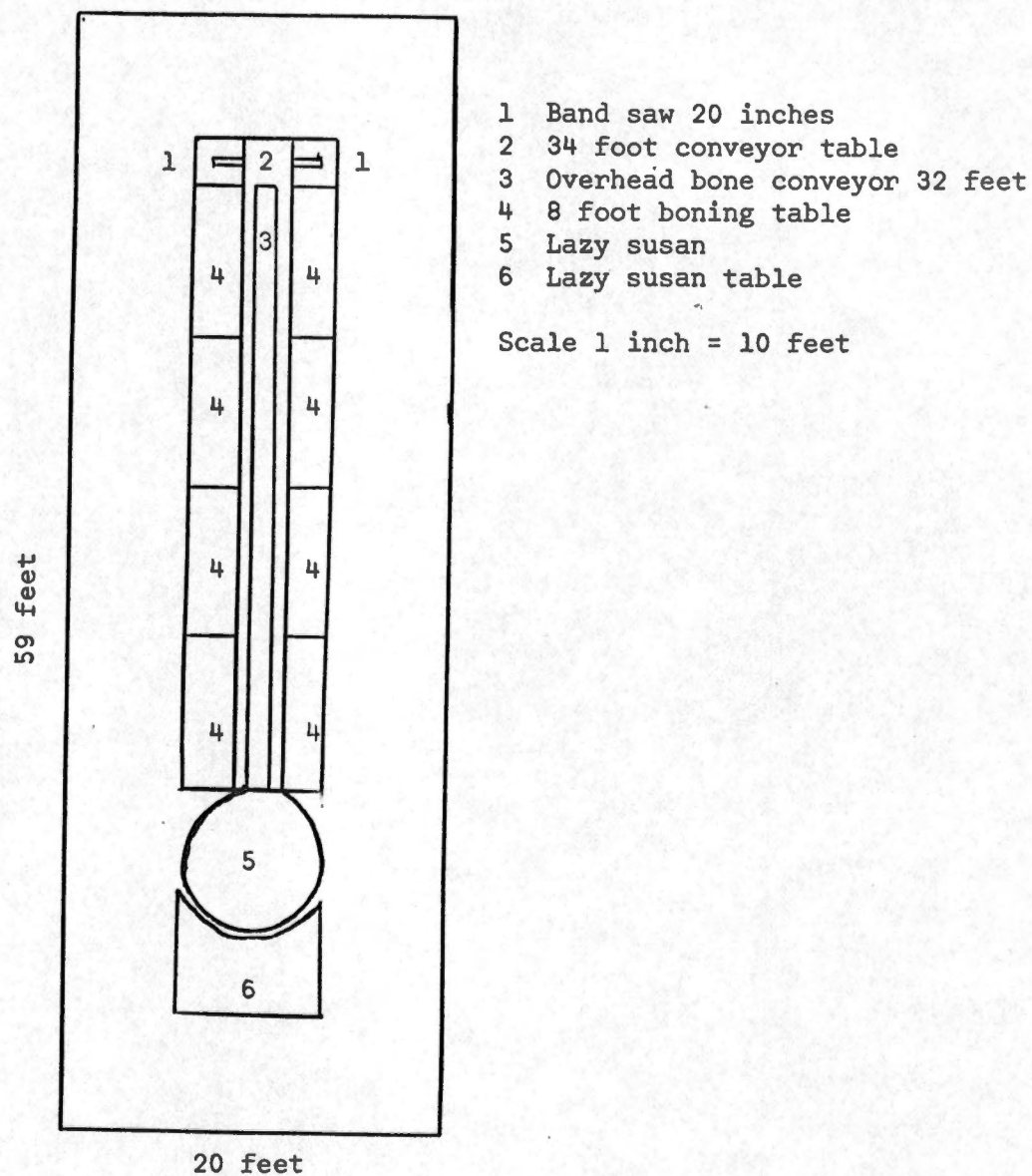


Figure X. Beef boning layout, 30 head per hour.

TABLE 68

BEEF BONING OPERATION III, EQUIPMENT REQUIREMENTS
AND COSTS, 30 HEAD PER HOUR

Equipment	Unit cost	Total cost
	----Dollars----	
1 34 foot moving top boning table	6,870	6,870
1 32 foot S. S. overhead boning conveyor	3,450	3,450
8 Eight foot boning tables	96	768
1 S. S. lazy susan table	1,950	1,950
1 Lazy susan packing table (curved)	725	725
2 20 inch band saws	1,345	<u>2,690</u>
Total cost		16,453

Source: Costs for the various items of equipment were taken from Koch General Catalog No. 186 (Kansas City, Missouri: Koch Supplies, Inc., 1968).

TABLE 69

PORK CUTTING AND BONING OPERATION 1, EQUIPMENT REQUIREMENTS
AND COSTS, 100 HEAD PER HOUR

Equipment	Total cost
	Dollars--
Hog cutting conveyer table	8,781
20 inch band saw	780
Shoulder cutter	2,010
20 inch band saw (special top).	880
Belly roller	<u>1,600</u>
Total cost	14,051

Source: Pork Cutting and Curing Equipment Catalog 61-A
(Chicago: Allbright-Nell Company, 1951), p. 10.

TABLE 70

PORK CUTTING AND BONING OPERATION II, EQUIPMENT REQUIREMENTS
AND COSTS, 125 HEAD PER HOUR

Equipment	Total Cost
	-Dollars--
Hog cutting conveyor table	8,781
Loin trimming table (3 feet 9 inches x 2 feet 6 inches)	1,610
Belly trimming table (8 feet x 3 feet)	2,200
20 inch band saw	780
Ham trimming table (6 feet x 3 feet)	360
2 h. p. shoulder cutter	2,010
36 inch band saw	880
Shoulder trimming table (10 feet x 2 feet 6 inches)	2,284
2 h. p. belly roller	1,600
Jowl and plate roller	<u>2,080</u>
Total cost	<u>22,585</u>

Source: Pork Cutting and Curing Equipment Catalog 61-A 137
(Chicago: Allbright-Neill Company, 1951), p. 11.

TABLE 71

PORK CUTTING AND BONING OPERATION III, EQUIPMENT REQUIREMENTS
AND COSTS, 300 HEAD PER HOUR

Equipment	Total Cost
	-Dollars--
Gambrel cord cutter	350
Hog cutting conveyor table (65 feet x 4 feet)	12,842
20 inch band saw	780
2 h. p. shoulder cutter	2,010
Neckboners table	446
Neckbone trimming table (8 feet 4 inches x 3 feet)	2,251
36 inch band saw	880
Shoulder conveyor table (45 feet x 4 feet)	8,265
Jowl and plate roller	2,080
Loin trimming table (5 feet 6 inches x 3 feet 9 inches)	2,538
2 h. p. belly roller	1,600
Side splitter	1,045
Trim belly trimmings table	2,200
S. S. utility table	299
Ham conveyor table (45 feet x 4 feet)	8,775
Total cost	46,001

Source: Pork Cutting and Curing Equipment Catalog 61-A
(Chicago: Allbright-Neil Company, 1951), p. 11.

APPENDIX D

DETERMINATION OF ANNUAL ELECTRICITY CONSUMPTION IN

KILOWATT HOURS: THE LUMEN METHOD

DETERMINATION OF ANNUAL ELECTRICITY CONSUMPTION IN
KILOWATT HOURS: THE LUMEN METHOD

The procedure for determining the annual consumption of kilowatt hours was taken from the I.E.S. Lighting Handbook [23, Section 9].

Two equations are involved:

$$1. \quad \frac{\text{Number of Lumens}}{\text{Foot candles of illumination} \times \text{floor area in sq. ft.}} = \frac{\text{Coefficient of utilization} \times \text{maintenance factor}}{\text{Coefficient of utilization} \times \text{maintenance factor}}$$

The number of lamps was determined by dividing the number of lumens computed in equation (1) by the number of lumens generated by the lamp used. In this case, the lamp generated 2,450 lumens [38, p. 147].

To compute the annual kilowatt hours used for lighting purposes [equation 2], the number of lamps was multiplied by the wattage (40) and the number of hours of operation. At 45 hours per week for 52 weeks, this came to 2,340 hours. This product was the annual wattage requirement and when divided by 1,000 gave the annual kilowatt requirements.

$$2. \quad \text{Annual kwh} = \frac{\text{Number of lamps} \times \text{watts (40)} \times \text{hours (2,340)}}{1,000 \text{ watts per kwh}}$$

APPENDIX E

SIMPLIFICATION OF THE ESTIMATED CAPITAL VALUE EQUATION (V)



To facilitate calculations, the estimated capital value equation V was simplified in the following manner;

$$V = \frac{\Delta}{1+r} + \frac{\Delta}{(1+r)^2} + \dots + \frac{\Delta}{(1+r)^T} \quad (1)$$

Multiplying both sides of the equation by $\frac{1}{1+r}$ the result is:

$$\frac{V}{1+r} = \frac{\Delta}{(1+r)} + \frac{\Delta}{(1+r)^2} + \dots + \frac{\Delta}{(1+r)^{T+1}} \quad (2)$$

Subtracting (1) from (2),

$$\frac{V}{1+r} - V = \frac{\Delta}{(1+r)^{T+1}} - \frac{\Delta}{1+r}$$

Then,

$$\frac{V - V(1+r)}{1+r} = \frac{\Delta}{(1+r)^{T+1}} - \frac{\Delta}{1+r}$$

Multiplying both sides by $1+r$

$$-Vr = \frac{\Delta}{(1+r)^T} - \Delta$$

Then multiply both sides by -1 and

$$Vr = \Delta - \frac{\Delta}{(1+r)^T}$$

Then,

$$Vr = \Delta \left[\frac{(1+r)^T - 1}{(1+r)^T} \right]$$

and

$$V = \Delta \left[\frac{(1+r)^T - 1}{r(1+r)^T} \right]$$

VITA

The author was born on September 24, 1942, in Cleveland, Ohio. From there, he moved to Milwaukee, Wisconsin, for two years and then to New Jersey where he graduated from Teaneck High School in 1960. He attended Rutgers University and graduated in 1964 with a B. S. degree in Agricultural Economics. He then went to the University of Vermont and received an M. S. degree in 1966. Since that time, he has been attending The University of Tennessee as a Ph. D. Research Assistant in Agricultural Economics.

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