COSTS AND EFFICIENCY OF DESIGNATED POULTRY PROCESSING PLANTS IN MICHIGAN

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By

KYU YAWP LEE

AN ABSTRACT

Submitted to the School for Advanced Graduate Studies
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ABSTRACT

Five poultry processing plants in Michigan were selected and studied to determine in-plant processing costs and efficiency of operation.

There are six major cost items in poultry processing. They are: labor, power, raw material, equipment, building, and management. Of these six factors of production, the first three are variable inputs and the last three are fixed. The cost of raw material (live poultry) is not included as an in-plant processing cost in this study.

In Michigan where a continuous supply of live poultry in large quantities is limited, investment in fixed input must be based on the live poultry supply in the area.

In a manual processing operation, the highest output per man-hour gives the minimum average unit cost. However, in mechanized plants, where labor and equipment are nearly perfectly complementary to each other, the speed of any one worker becomes insignificant. Furthermore, the lowest average unit cost per day becomes less important unless such a minimum unit cost continues everyday of the year.

For a given scale of plant and speed of conveyor line, the day-to-day maximum efficiency exists when waiting time between work segments is zero. In poultry processing operations where there are many work segments on the line, zero waiting time between work segments is attained with great difficulty.

When labor and equipment are arranged on the basis of the "most-time common denominator" on the line, there would be only one efficient hourly rate of operation in the plant. The hours of operation beyond regular working hours can be extended through overtime or multiple shift operations.

When output is a function of hours of operation the output is linear. Cost function is linear throughout regular working hours and becomes an upward step function after regular hours of operation due to overtime pay. Most plants in Michigan operate at only one-half of the potential plant capacity for a given day, and some of these plants operate only a few months out of the year. These practices can not be justified from an economic standpoint.

When output and total cost functions are linear the economies of large scale operation result from spreading the fixed costs over a larger volume of output. For this reason, if a continuous supply of live poultry is not available in the area, investments in fixed inputs should be kept as low as possible. One-half utilization of plant capacity in any given day and/or processing only a few months out of a year results in higher unit processing costs. This seems to be the case in Michigan poultry processing plants.

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CHAPTER I

INTRODUCTION

In 1958, 4,700,000 commercial broilers, 8,552,000 chickens, and 998,000 turkeys were produced in the State of Michigan. The producing units were scattered throughout the state and they were relatively small.

Poultry production is a supplementary enterprise on many farms. The inputs such as labor and feed used for poultry may be more productive if used in other enterprises but small scale poultry units exist throughout the state, though the number is declining.

Small scale poultry units create many problems in the processing enterprise. The major problem is the procurement of live poultry in sufficient quantities to facilitate continuous operations. This problem makes the selection of a plant location close to an adequate live poultry supply difficult. The small scale poultry producing unit also creates the problem of uniformity of the product in respect to size and quality.

The poultry processing operation involves transformation of live poultry into edible poultry. The entire processing operation can be performed by one person with simple tools, or the processing operation can be divided into many segments using specialized equipment.

Basically, the poultry processor performs three distinct functions: (1) procuring of live poultry, (2) processing poultry, and (3) distributing processed products.

A study of processing plants revealed a wide variation in the scale as well as methods of operation. Some plants had a large hourly processing capacity, but operated seasonally. Some plants had a small hourly capacity, but operated the entire year. Some were highly mechanized and some were partially mechanized.

In view of such variations in scale and duration of operation, there was need for a study to determine costs and efficiency associated with the degree of mechanization, scale of plant, and duration of operation.

This thesis is divided into three sections: (1) theoretical framework based on a static analysis, (2) investigation and analyses of selected plants, and (3) application of the theoretical framework to the processing operations.

CHAPTER II

REVIEW OF LITERATURE

Unfortunately, a comprehensive study of Michigan poultry processing plants is unavailable. Most of the available literature is from other states where the poultry processing industry is more commercialized and intense. Baum et al.(1952) synthesized five different model fryer processing plants in the State of Washington and attempted to determine economies of scale under static economic conditions. These workers pointed out the economic implications associated with the scale of the plant and the extent of plant utilization. The economies associated with plant capacity utilization were demonstrated by the higher per fryer processing cost, and the economies associated with scale of the plant were demonstrated by the higher unit cost in small plants. However, they found that per fryer processing cost increased most for smaller plants operating at less than capacity. The average per fryer processing cost for the model plants under assumed conditions was as follows:

Daily Processing Capacity	Processing Cost per Fryer
Bird	Dollar
500	$0.1663
1600	0.1479
3100	0.1351
4500	0.1283
9000	0.1178

Abbott (1954), in his study of the economic implications of recent technical developments, indicated that commercial plants handling 300 turkeys per hour failed to utilize full advantage of the specialization of labor associated with the conveyor line system. He concluded that the turkey processing industry should concentrate on 600 turkeys per hour capacity plants under the existing techniques and costs.

Eastwood and Scanlan (1954) made a study of fifteen cooperative poultry processing plants in eight eastern states. These workers reported that the total cost of New York dressed chickens (blood and feathers removed) ranged from 5.8 to 11.8 cents per pound. The average cost of New York dressed was 7.62 cents per pound. The cost of dressing shrinkage averaged 2.74 cents per pound or 31.0 percent of the total dressing costs. The average shrinkage in hauling live broilers and mixed types of chickens to processing plants was 2.8 percent for broilers and 3.2 percent for mixed chickens. Labor cost was 2.4 cents per pound or 26.9 percent of the cost of New York dressed.
Fulliove (1955) made a study of 28 Georgia commercial poultry processing plants and stated that most Georgia processing plants had efficient operations. Their large scale operation together with a highly integrated business in feed and poultry production enabled efficient processing operation. He indicated that there was opportunity for reductions in costs by increasing the rate of output per hour and

by operating additional hours. He also indicated that there was room for improving the efficiency in the area of rearranging workers in relation to the speed of the conveyor line, plant layout, and improvement in equipment.

French et al. (1956) studied the economic efficiency in California pear packing plants. Even though this study concerns the pear packing industry, the theoretical as well as modified approach was applicable to poultry processing plants. The authors recognized the inapplicability of conventional production function in line type operations for the following reasons:

1. The line type operation is different from the ordinary production function in that the line operation is composed of many stages. This would mean that efficiency in any one stage of operation does not necessarily mean efficiency in overall operations. Each stage must be integrated with all others so that simultaneous efficient operation will be possible.
2. In the short-run, equipment is not substitutable for labor after equipment is installed. Also, certain equipment requires a fixed number of workers. This would mean that the combination of inputs must be solved on the basis of fixed technical coefficients rather than prices of inputs.
3. Output is a function of rate as well as hours of operation.

As a result, the maximum profit does not necessarily occur at marginal cost is equal to marginal revenue.

4. When work is performed using labor and equipment they must be used in whole units. Service of labor and equipment are divisible in time such as certain hours per day, but they must be bought as a whole unit. This means that some stages of line operations are inefficient yet they may be economically justified from the overall operational standpoint.

King and Zwick (1950) studied the shrinkage of live poultry between farm and market and reported that the loss from shrinkage is an important cost of marketing. This study also reported that as time increases shrinkage cost increases at a decreasing rate. Zwick and King (1952) studied the economic advantages of location in marketing live poultry and showed that there was marked economic advantage for producers located near the live poultry market in spite of the fact that the shrinkage cost increases at a decreasing rate. They found the following linear equation for truck operation per pound of live poultry:

$$T = \$0.0014 + \frac{\$0.1060\,(D_2 + 30)}{13,200}$$

Where T is the truck costs per pound; \$0.0014 is fixed cost per pound; \$0.1060 is variable cost per mile; $(D_2 + 30)$ is the distance for a round trip to market in miles plus average trip involved in procuring poultry;

and 13, 200 is the weighted average capacity[1] of a truck in pounds.

Farrish and Seaver (1959) studied the cost and efficiency of different sizes of processing plants in southern New England and concluded that there were economies of scale in labor up to 7, 200 birds per hour processing capacity. Building costs showed returns to scale throughout the range of outputs tested (the range was from 2, 400 to 7, 200 birds per hour). Economies exist in using larger type equipment but were very small. Total processing costs per bird ranged from $0. 0872 for the smallest plant to $0. 0755 for the largest plant.

Hamann and Pond (1955) reported the importance of shrinkage cost in processing poultry. They emphasized that the price processors receive for the processed poultry should cover not only all the processing live poultry and packaging costs, but also the cost of shrinkage in transit and from processing by-products. The percentage of inedible portions from live to eviscerated broiler was reported as much as 35 percent of the live weight. Shrinkage in transit for hauling live poultry was reported between one-half of one percent to five percent.

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[1] In developing an average cost of operating the trucks used for hauling live poultry, costs were weighted by the percentage of poultry being handled by two truck types.

CHAPTER III

CLASSIFICATION OF POULTRY PROCESSING PLANTS ON THE BASIS OF ORGANIZATION

Processing plants can be classified in many ways, such as on the basis of: kind of poultry processed, scale of operation, processing procedures, duration of operation, organizational structure, and others.

When classified on the basis of organizational structure, the selected Michigan poultry processing plants fall into the following categories:

Category A. Single enterprise processing plant operating year around.

Category B. Processing enterprise combined with other poultry enterprises, during different months of the year but each dependent upon the other.

Category C. Processing enterprise as a part of an overall organization handling other commodities.

Plants in Category A operate the year around on a small-scale basis. They are small because live poultry can not be procured in sufficient quantities within economical distance. Their unit processing cost is high in comparison to such costs in large-scale plants. The majority of capital is invested in plant facilities and they tend to stay in business as long as the price of processed poultry covers average variable costs and facilities remain usable.

Category B is tye type of organization, used by turkey growers, where three different kinds of poultry enterprises exist in a year: such as a hatching enterprise in the spring, a turkey raising enterprise in the summer, and a processing enterprise in the fall. Each distinct enterprise has fixed inputs. For example, incubators for the hatching, brooder houses and poultry houses for the growing, and a processing plant for dressing enterprise. Each of these enterprises may be seasonal.

Plants in Category C are a combination of Category A and Category B in operation but differ in organization. A processing plant owned by a cooperative is an example. A cooperative may sell feed, fertilizer, seed, and/or many other farm supplies to its members. In turn, farm products such as eggs and poultry are bought from members. In some cases, processing is a service function supplementing the main enterprise. Plants in this category require year around operation. It may be necessary to build a large plant in order to meet the fluctuating live poultry supply from individual farms.

CHAPTER IV

THEORETICAL FRAMEWORK

The Nature of a Poultry Processing Operation

In order to accomplish a smooth operation, the processor coordinates the three basic functions: (1) procuring live poultry, (2) processing, and (3) distributing processed poultry.

Under competitive conditions where there are no special agreements or any form of discriminative actions between rivals, the price of live poultry at the plant would be the price at the producing center plus the cost of transfer[1] to the plant. Likewise, the price at the consuming center would be the price of the processed poultry at plant plus transfer cost to consuming center, and the prices would vary directly with distance and in-transit services. Under these conditions the selection of the plant location is of fundamental importance because it involves many functions affecting profit.

The in-plant operation involves the following six basic steps: (1) hanging live poultry on the line, (2) killing and bleeding, (3) scalding, (4) removing feathers, (5) removing viscera, and (6) packaging. Additional workers may be employed for specific assignments.

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[1] Transfer cost as used in this thesis includes cost with respect to distance and cost of in-transit services such as watering, meals for driver, etc., that are not directly proportional to distance.

With the conveyor line running at a constant speed with given equipment, some segments of work must allow a definite time to meet certain standards of quality. For example, with a given scalding temperature and a given class or weight of poultry the time required to scald is fixed. Also, some processing sequences can not be rearranged or reversed. For example, viscera can not be removed before the birds are killed, scalded, and feathers removed. The poultry moves continuously in one direction.

While poultry moves continuously on the conveyor line, the nature of each work segment and speed of each worker or piece of equipment varies. Unless the rates of output of all the segments on the line can be varied simultaneously the impact of changes in any segment will lessen the efficiency of the overall operation.

These limiting factors create two basic problems: (1) how fast should the maximum conveyor speed[1] be set? and (2) how should work segments be arranged with proper ratio of labor to equipment? These problems can be solved through time and motion studies.

The first problem can be solved by setting the maximum conveyor speed on the basis of the slowest work segment on the line (this will be referred to as the most-time common denominator). For example, if the scalding period requires the most time, the maximum conveyor speed should not exceed the minimum scalding time required.

[1]Conveyor speed is measured in terms of distance traveled per unit of time.

The second problem can be solved through time and motion studies by arranging work segments according to the required working and flow time. Such a time study is effective only after the maximum conveyor speed and the arrangement of working sequences are fixed. The proper arrangement of work segments on the basis of time and motion studies should make simultaneous operation of all work segments most efficient.

In the poultry processing operation in the long-run basis labor is substitutable for equipment in all segments of the operation. However, once the plant is designed and set up for conveyor line operation all the equipment becomes technically fixed; it is uneconomical to substitute labor for equipment; and, the addition or subtraction of equipment is not practical. This does not mean to imply that on a long-run basis one should not use equipment in place of labor when the productivity and price of labor is unfavorable to that of equipment.

Production Function

If one person performs all segments of the processing operation, the production function can be expressed as a continuous straight line with the number of available working hours as the limiting factor. Even in plants with some degree of mechanization, all inputs, such as equipment and labor could be considered as single fixed inputs since once the line type operation is set up, all the equipment becomes complementary to labor in fixed time proportions.

Operation of the conveyor line at a faster or slower rate than the optimum speed found by a time study would be undesirable. The only logical production adjustment then becomes the hours of operation rather than any other adjustment.[1] The production function can be expressed by the formula $Y = f(H \mid L, R, P, E, B, M)$ where Y is output, H is hours of operation, L is labor, R is live poultry, P is power, E is equipment, B is building, and M is management. The above production function with H=K, where K is the maximum available working hours, is given in Figure 1.

The above concept is based on the fact that every segment of operation including labor is an absolutely necessary component on the line. The absence of any one of the segments will result in zero[2] production or a proportional decrease in production with regard to time if any worker performs another job due to another worker's absence.

If rates of plant output are held constant, and output is a function of hours of operation per time period, the relationship between factor input and product output becomes linear up to the plant capacity or the available working hours K(K=24 hours). Since there is constant returns to variable factor the marginal and average product curves are identical, and they are horizontal line as shown in Figure 2.

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[1] This does not negate operation of multiple shifts or adjustment in shackle space as production adjustments.

[2] Zero production as used here implies that the product is not marketable in normal channels of trade.

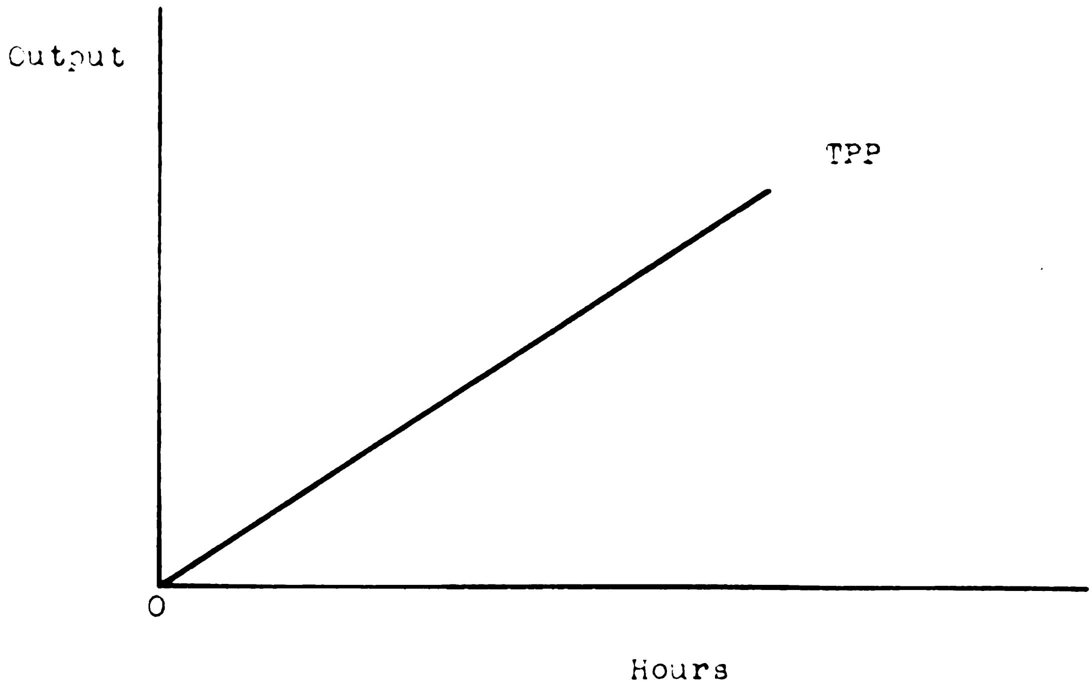

Figure 1. Output as a Function of Hours of Operation.

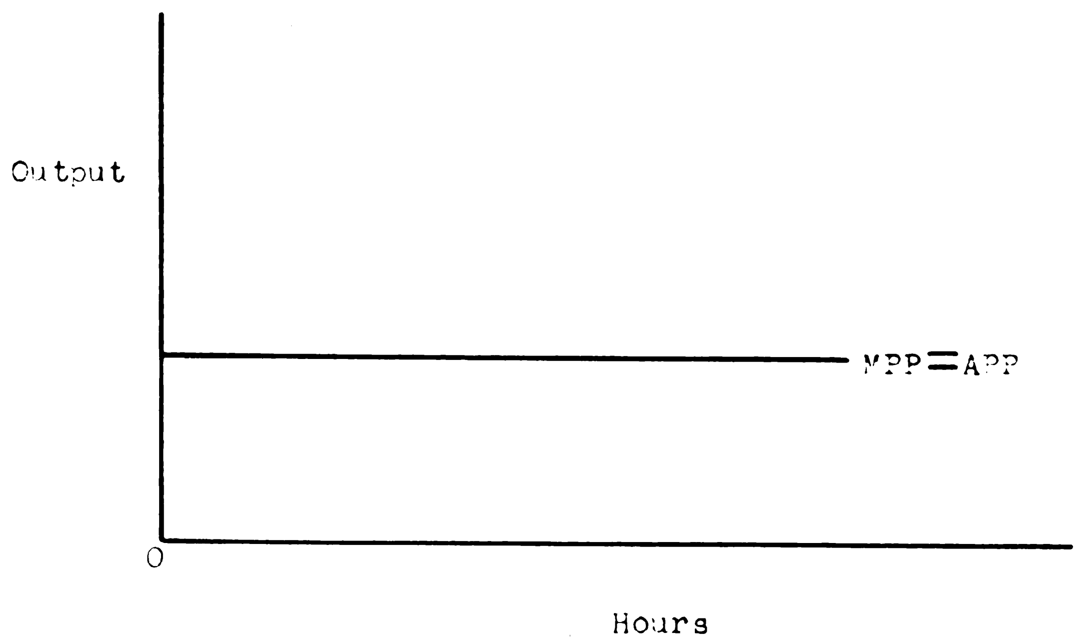

Figure 2. Average and Marginal Physical Product Curves Derived from Linear Production Function.

<u>Optimum Input Combination</u>

The ordinary production function states that inputs are optimally combined if the ratio between the marginal physical product (MPP) and the price of input bears the same relationship in all the inputs used for production. However, in the poultry processing operation where labor and equipment are used on the line, these services are technically fixed and they should be coordinated to other work segments on the line. This indicates that the main emphasis should be placed upon technical considerations rather than price of inputs, and must be given serious consideration by existing processors as well as future processors.

Before the processor makes the purchase of any equipment he must consider the fixity of the equipment. Most poultry processing equipment is highly specialized and is designed for a specific scale of poultry processing operations. This means that there is a limited opportunity to transfer the equipment between processors, or very little chance to sell to another industry. As a consequence, the purchase price is much higher than the salvage price, in comparison to equipment in some other industries.

The equipment should not only be technically proportional with other equipment on the line, but the plant must be capable of utilizing the labor equivalent of the equipment to its fullest extent. Employment of labor less than the capacity of equipment would result in overinvestment in equipment. The services of a single piece of equipment on the line operation is partial and inseparable from the overall operational point of view.

As a result of the above two complications some of the labor becomes fixed. The impact of any one segment of the line affects all segments on the line. In the poultry processing operation, therefore, there is an optimum input combination in each work segment considered independently but not necessarily the optimum when considered from the overall processing point of view. For this reason, some sacrifice in productive efficiency in some segments on the line would be justified from the overall operating point of view.

There are six major factors or inputs used in processing poultry:

1. labor
2. raw material--live poultry and packaging material
3. power
4. equipment
5. building
6. management

Of these six inputs the first three are variable and the last three are fixed. The inputs of live poultry and packaging material are nearly proportional to the output. Power also is nearly proportional but there is some variation due to changes in power rates and power used for other purposes than operating the conveyor line.

The relationships between input-input as well as those between input-output are important. For example, an increase in the speed of the conveyor line necessitates an increase in labor. The limiting factor with regard to the amount and proportion of inputs to use is the capacity of equipment. In some work segments of the line, an increase in one input must be in fixed ratio to another input. For example, the addition of one more packaging machine requires an additional operator. Furthermore, substitutions among these inputs are limited. There is no substitute for raw material. For a given plant substitutability between labor and power is very small. There is a possibility of substitution between labor and equipment in the long-run but it too becomes undesirable in the short-run.

Scale of Plant and Variation in Output

Variation in output can be adjusted in one or a combination of the following ways: (1) variation in scale of plant in the long-run, (2) variation in the rate of output,[1] and (3) variation in hours of operation.[2] If the supply of live poultry as well as the market for processed poultry is large, assuming prices of live as well as processed poultry are constant, construction of a large scale plant and intensified output in rate as well as in hours of operation would be desirable.

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[1] Rate can be varied by changing conveyor line speed or by changing shackle space.

[2] This includes multiple-shift operations.

In the long-run, increase in the output of a plant is accomplished by increasing scale of the plant. If an increase in scale of plant decreases average cost up to a certain scale, economies of scale exist and the larger plants are more efficient than the smaller plants. The long-run average cost curve is made up of all the minimum points of short-run average cost curves.

The concept of economies of scale is used somewhat loosely by some writers in the sense that they fail to distinguish between economies associated with changes in scale and changes in proportionality of variable and fixed inputs of a producing unit.

Heady (1957) clearly distinguishes between scale relationships and proportionality. He defines scale relationship as a long-run situation in which all factors vary by the same proportions; whereas, proportionality is defined as a short-run situation in which a variable factor is applied to some fixed factor.

Boulding (1955) also makes a clear distinction between scale changes and proportionality changes. He calls the former "the law of changes of scale" and the latter "the law of changes of marginal or average product." He states that, "the problem of constant, increasing, or decreasing returns to scale has nothing to do with the changes in the proportions of the input quantities."

The changes in scale problems return are whether (1) constant, (2) increasing, or (3) decreasing, as the scale increases.

Boulding (1955) confirms the existence of returns to scale on the ground that some inputs such as management capability and efficiencies are associated with scale as inputs increase.

In the case of proportional changes in scale the problems are whether the changes in inputs are (1) constant, (2) increasing, or (3) decreasing returns to the variable inputs to some fixed inputs. The law of diminishing returns applies very clearly in this case. The law states that as equal increment of one input is increased to the fixed inputs, the total output will first increase at an increasing rate, secondly increase at a decreasing rate, and then decline.

Stigler (1957) specifies three conditions to validate the law of diminishing returns. They are: (1) the state of technology is given, (2) the variable input is applied to some fixed input, and (3) the law premises the possibility of varying the proportions in which the various productive services are combined.

With these theoretical concepts in mind the following conditions are assumed: (1) Long-run scale relationship is one in which all inputs are changed in the same proportion in the long-run. Long-run is defined as a period long enough to change all variables. It is assumed that there are returns to scale due to physical impossibilities of increasing inputs in equal proportions, efficiencies of some inputs as a result of large scale, and inefficiencies of some inputs as a result of large scale. For these reasons, the long-run average cost curve is assumed to be U-shaped, however slight the curvature may be. (2) Short-run scale relationship is between variable input and fixed input. Short-run is defined as a period which is not long enough to vary all inputs. The shape and magnitude of total physical product (TPP) curve depends on the ratio between variable and fixed inputs. These scale relationships are given in Figure 3. In Figure 3, only five short-run scales of plants (SAC_1--SAC_5) are shown. Theoretically, there are infinite number of scales of plants represented by the long-run average cost curve (LAC). The long-run average cost curve is a series of the lowest possible average cost curves for each level of output.

To obtain maximum profit in Michigan, where the poultry population is sparse and scattered, the processor should build a plant in which the optimum output will coincide with live poultry supply in the area. After the plant has been built the concern of the processor is the least cost of a given output rather than the least processing cost of a given plant. If the scale of the plant is so large that it requires coverage of a wide live poultry supply area, profit will be squeezed because of higher procurement costs. On the other hand, if the scale of the plant is small and output is intensified by means of a higher rate of production or longer hours of operation, some operating costs such as overtime labor and extra workers would be higher. Furthermore, unless output is no more than equal to consumption in each operating period, there would be the problem of storing and marketing over a period of time.

Labor-Equipment Relationship

Assuming that management has precise knowledge about the supply of live poultry within the economic distance, the next problem would be: how to combine labor and equipment to achieve the desired level of output. Labor and equipment as used here, imply not only labor and equipment as such, but all the necessary inputs required to use one unit of labor or equipment.

Assuming a particular plant has an available supply of live poultry at the rate of 1,000 birds per hour, the management has two alternatives to process this amount. They are (1) use of labor alone, or (2) use of a combination of labor and equipment. If management chose to use labor alone the production function would be the same as the one person production function described on page 12.

The other alternative would be to combine labor and equipment in the least-cost combination. It must be emphasized that labor and equipment are complementary to each other, and at the same time, they are limiting factors since both inputs have to be used in somewhat fixed proportions.

In line type poultry processing plants two identical machines are usually not installed because each working segment has a specific assignment that has to be performed during a given period of time.

without stopping or reversing the line. Management's choice as to which input to use is not between equipment A and B of a similar type, but between labor and equipment.

In order to reach full utilization of efficiency of labor and equipment on the line the labor and equipment must have equal capacity. For example, if a scalding tank has a capacity of 800 birds per hour and a picker has a capacity of 1,000 birds per hour the picker would be underutilized relative to the scalder. This is an important point of which every manager must be aware prior to making an investment in equipment. The following are several possible reasons why underutilization in one or more pieces of equipment exists:

1. Equipment manufacturers do not have equipment to fit every scale of operation. In most cases, this results in installation of larger capacity equipment than required for scale of operation.
2. Some plants use equipment made by more than one manufacturer. This may result in differences in capacity as well as in processing procedures recommended by each manufacturer.
3. Some plants are located in structures converted from other business uses, and expanded by adding equipment piece by piece as business increases. In most cases this would lead to an initially inefficient plant layout and poor coordination of equipment.

Cost Functions

The concept of costs must be clarified before proceeding with an analysis of cost functions. Costs as used in economics are based on opportunity cost concept. Also costs include implicit costs such as owner's salary and normal returns on investment. In this study seven cost concepts are involved: total fixed cost (TFC), total variable cost (TVC), total cost (TC), marginal cost (MC), average fixed cost (AFC), average variable cost (AVC), and average total cost (ATC).

The nature of cost functions has a direct relationship with the nature of production function. The relationship between the production function and cost functions of one variable production function is given in Figure 4.

In Figure 4, it can be seen that when marginal physical product (MPP) is maximum, marginal cost (MC) is at a minimum and when average physical product (APP) is maximum, average cost (AC) is minimum. These are indicated by X_1A and X'_1A'; and X_2B and X'_2B'. Also it should be noted that when the average cost (AC) curve is decreasing, the MC curve is below the AC curve. When the AC curve is minimum, the MC curve is equal to the AC curve. These are fundamental relationships. From a physical production efficiency point of view the most efficient level of output is the operation of a given plant at the level at which short-run AC curve is at a

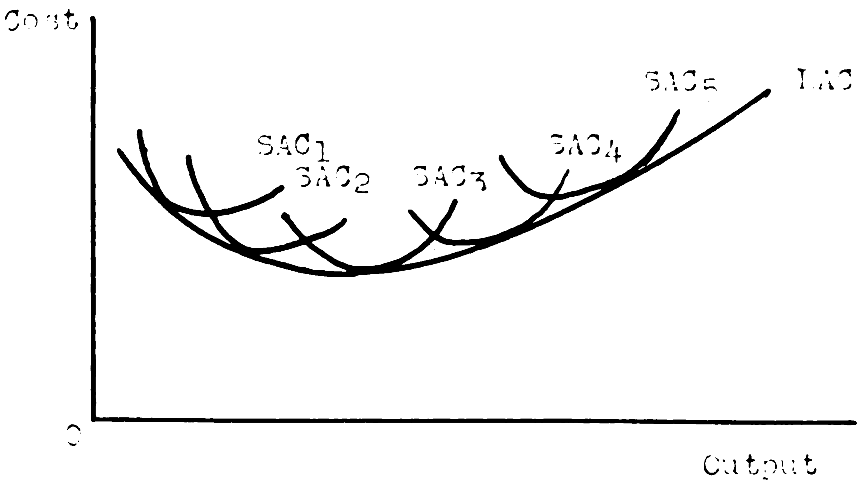

Figure 3. Economies of Scale Curves

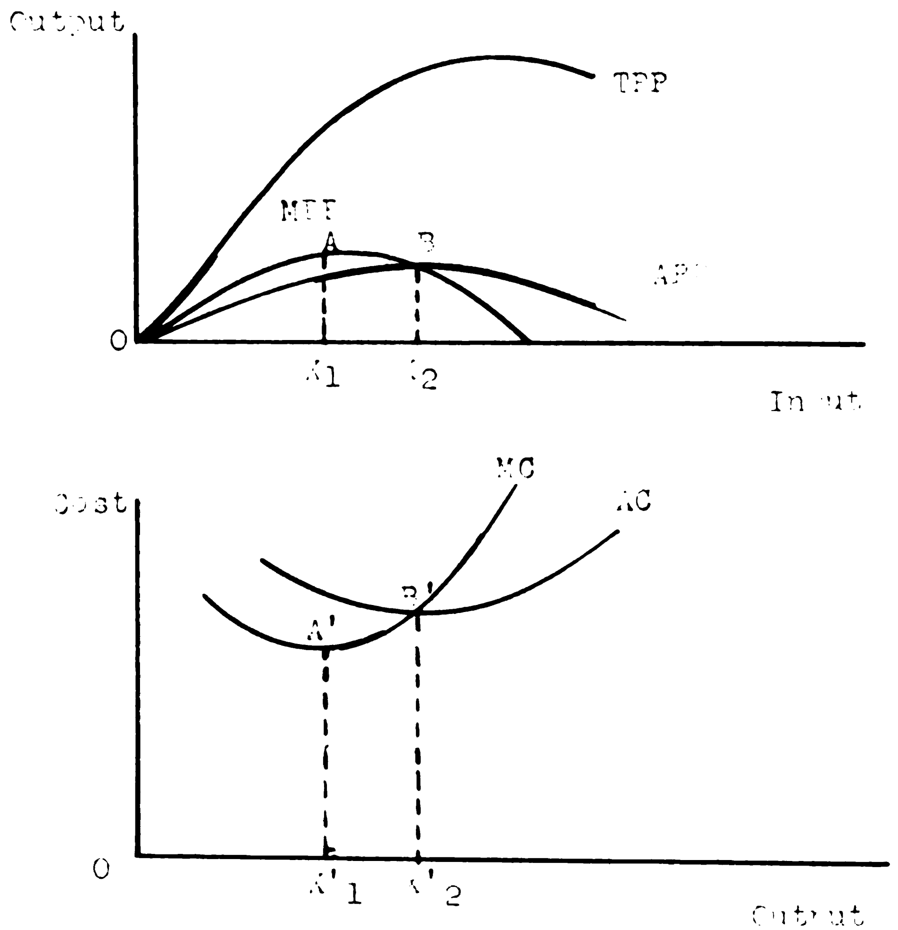

Figure 4. The Relationship Between Production Function and Cost Function.

minimum because at this level of output the unit cost of the product is minimum.[1]

With these short-run cost concepts in mind, plant managers must face several decision making situations. In short-run cost analysis, fixed cost has no importance in decision making because once the investment is made the fixed charge must be paid regardless of the level of output. Decision to produce or not to produce must be based on variable cost and the price of the product. Therefore, even though the price of the product is below ATC but above AVC, it would be economical to keep producing. If, however, the price of the product declines below AVC, loss can be minimized by not producing.

For these reasons any method with which the management can reduce AVC is desirable. The reduction in AVC could come about from internal economies such as improved production techniques or cost saving methods, or it could come about from external economies such as the decreased price of variable inputs. Internal diseconomies as well as external diseconomies are equally applicable.

At this point, one may hypothesize as to why all plants are not built and operated at an output which will give minimum average cost. First, management may not have sufficient knowledge about plant efficiency nor prices of input and output. Secondly, management

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[1] This does not necessarily mean that this point will insure maximum profit.

may have perfect knowledge about future prices so that they build the plant beyond current needs on the basis of the predicted future prices and try to average out the average cost over the years. Thirdly, management may have perfect knowledge about the future but its financial position does not permit it to expand.

Results from the above three situations have different effects on production and cost functions. The first case could result in any one of the following situations--all only by chance. In the first place, the management could have built a plant larger than optimum, which is similar to the second case. Secondly, the management could have built a plant smaller than optimum, which is similar to the third case. Finally, the management could have built a plant the optimum size by chance.

In the second case, initial investment in fixed input is higher; therefore, output is higher than current requirements but it will, in management's estimation, meet future requirements. Its ATC would be higher initially because its AFC is higher, but management hopes decreases in AVC will offset higher AFC as volume increases.

Case three is the reverse of case two in that initial ATC is low because AFC is low but AVC has very little force to pull AFC down. However, case three gives more flexibility when prices of inputs or product reverse. These cases are shown in Figure 5.

Suppose plant was built with cost structure such as AC_1 in Figure 5. The optimum level of output is at Y. However, the current need for product is only Y_2, but the management anticipates an increase in demand to Y_3 in the near future. The average of unit costs between Y_2 and Y_3 (Case II) is still lower than the average of unit costs between Y_1 and Y_4 (Case III).

Cost Functions with Regard to Procurement of Live Poultry

Cost functions for procurement of live poultry with plant equipment and personnel involve complicated accounting problems. In Michigan where the scale of the processing operation is small, procurement is done by workers who perform several other assignments in the plant. For example, two or three workers start out early in the morning and haul in the number of birds required for the day. These same workers join the rest of the crew and work on the processing line. How to allocate time and pay (including fringe benefits) is a difficult task. Plant managers identify workers as general plant workers rather than by specific jobs. Management does not keep a record of each worker for each job performed. Nevertheless, if the management is to compute reasonably accurate figures of labor and cost of live poultry, it has to give due consideration for these jobs. If labor used for procurement is not separated from processing, it would result in over priced labor for processing cost.

The portion of labor used for procurement should be deducted from processing costs and added to the live poultry price at the plant. The same reasoning and logic should be applied to the use of trucks and equipment. Failure to recognize these facts would result in lower live poultry cost at the plant. If such record keeping is not practiced, it would be appropriate to use a standard charge such as a commercial rate for trucking live poultry to the plant.

Cost Functions with Regard to Six Major Processing Costs in In-Plant Operations

Cost curves of six major inputs used in in-plant operations are shown in Figure 6.

When output is a function of hours of operation the costs of live poultry and packaging material are constant.[1] Labor cost is constant up to eight hours of operation, then has an upward step function indicating overtime pay. Cost of power has a downward step function because of reduced rates as consumption increases. Building and equipment costs as well as management costs decline sharply at first, then level off.

Efficiency and Role of Management

Efficiency as used in overall plant operations is the ratio between useful inputs to useful output; therefore, this ratio measures

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[1] This assumes there is no quantity discounts in purchasing.

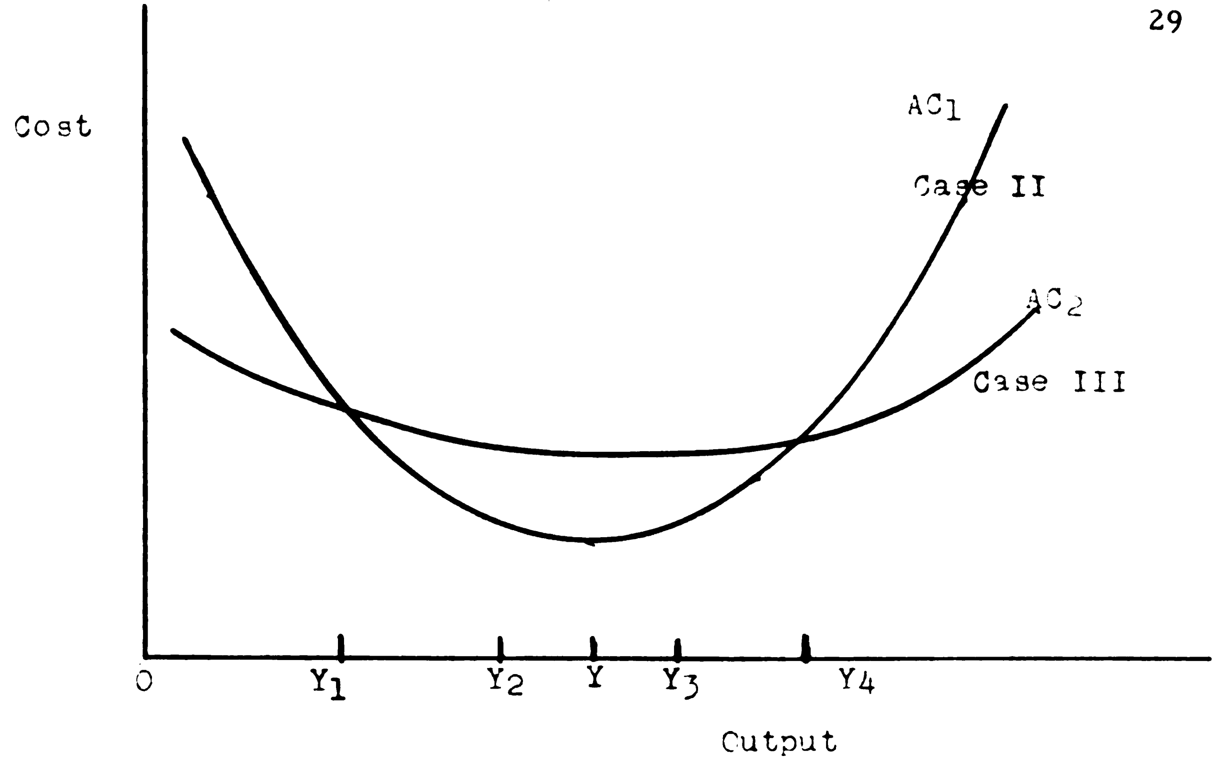

Figure 5. Cost Functions with Different Levels of Fixed Inputs.

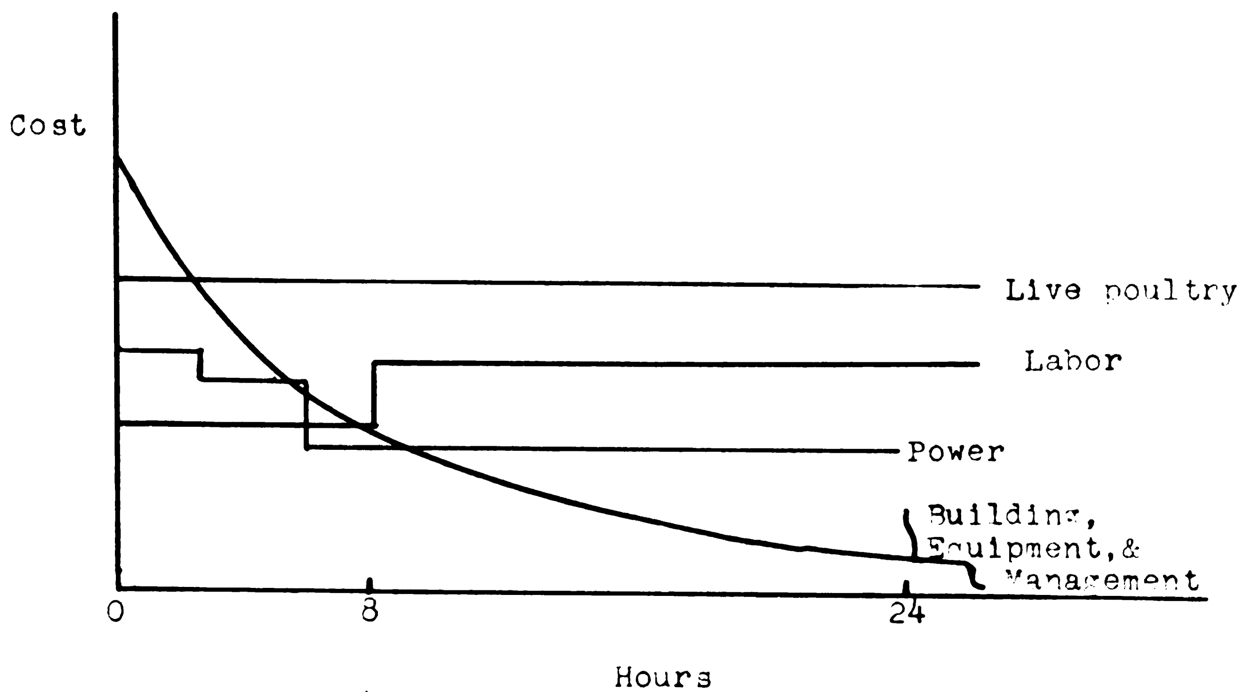

Figure 6. Six Major Cost Curves as a Function of Hours of Operation.

efficiency. This is a precise statement of efficiency yet it has many implications. In engineering, efficiency is the ratio of physical inputs to physical output. In human behavior, of which management is a part, efficiency could be measured in terms of "right actions" taken between "good" and "bad."

In processing plant operations, for example, if Plant A produces more output with the same amount of inputs or produces the same output with less inputs than Plant B, Plant A is more efficient than Plant B. To an engineer, a plant is most efficient when average physical product is equal to marginal physical product. In an enterprise such as a poultry processing operation where profit maximization is the goal, neither engineering efficiency nor management's action alone is sufficient to attain maximum profits since prices of inputs as well as output change. For these reasons, the author has used "useful inputs" to include management's action as an input in measuring efficiency.

Some elements of efficient management include quality, quantity, delivery costs, delivery scheduling, and terms of trade in procurement of live poultry; working schedule of workers, pre-processing and post-processing details, mechanical adjustments, human relations, in in-plant operations; and in marketing; the management should have knowledge about the processed poultry market and coordination between output and demand for the processed poultry.

In perfect competition, management's role would be confined to in-plant efficiency only because it has no control over the prices of the factor market or the product market.

CHAPTER V

STUDY PROCEDURE

Selection of Plants

For the purposes of collecting data the author visited nine commercial processing plants in Michigan. From these nine plants, four commercial processing plants and one manually operated plant were selected. The latter was composed of three graduate students majoring in poultry science at Michigan State University Poultry Science Department. Each of these four plants were visited four times during the processing season to observe plant operations and two times to interview plant managers.

Sources of Data

Time study data were collected by actual observations in each plant. The time recorded for a particular work segment was the mean of ten observations for the given speed for that day; the speed according to managers, was the "normal" speed at which the plants usually operated. Most of the plant cost data were collected from processors' accounting records. The degree of accuracy of figures furnished by plant managers, of course, will affect the final cost analysis.

Procurement Cost and Fixed Cost Computations

Procurement costs with plant truck and equipment depends on processing capacity, capacity of truck, and distance to travel.

The following formula is used for computation of procurement costs per bird:

$$\frac{\frac{\text{Daily requirement}}{\text{Volume of truck}} \times \text{Distance} \times 0.35^{1}}{\text{Daily requirement}}$$

If live poultry is delivered to the plant by a producer or some other agency, the procurement cost is simply $K+k$ where K is the price of poultry at the farm and k is the payment per unit for the transportation cost.

For computation of fixed costs the following formulas are used. Similar studies made in other states[2] confirm the rates used in this study.

Land:	$T \times 0.01 + I_n \times 0.06$	(1)
Building:	$D \times 0.025 + R \times 0.02 + I_n \times 0.06 +$	
	$I_{ns} \times 0.006 + T \times 0.01$	(2)
Equipment:	$D \times 0.20 + R \times 0.03 + I_n \times 0.06 +$	
	$I_{ns} \times 0.006 + T \times 0.01$	(3)
Administration:	From accounting record	(4)
Total fixed cost:	(1) + (2) + (3) + (4)	(5)
Averaged fixed cost:	$\frac{(5)}{Y}$	(6)

[1]This is per mile charge, according to Dr. Larzelere, is a reasonable figure for short haul, including driver's time.

[2]See Abbott and Farrish.

Where T is the tax rate based on current value; I_n is the interest rate; D is the depreciation rate based on the purchase price; R is the cost of repairs based on replacement value; I_{ns} is the insurance rate; and Y is the total output.

Other Cost Items

In this study, cost of live poultry, shrinkage cost, cost of holding live poultry at the plant, and charges for special fees such as inspection and auditing are not included in the in-plant processing cost computations.

CHAPTER VI

ANALYSES OF PLANT OPERATIONS

The Problem Areas in In-Plant Operation

The basic problems of in-plant operation involve two sets of three factors each. They are: (1) speed of dressing line, (2) speed of work segments on the line, and (3) distance between work segments. There is a similar set for the eviscerating line. The relationship among these three factors, given shackle space, can be simplified as follows:

Set I[1]

1. Speed of dressing line depends on the slowest work segment.
2. Speed of worker varies, within limits, with the speed of the line, but the speed of the worker determines the speed of the conveyor line.
3. Distance between work segments is determined by the required working time between work segments. If the speed of the line is increased beyond the speed of the work segment, the distance must be increased, or additional worker(s) must be added. On the other hand, if the speed of the line is decreased, the distance between the workers could be reduced or, in some cases, worker(s) could be

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[1]Set I refers to dressing line and Set II refers to eviscerating line.

eliminated from the line. However, the distance between work segments could be adjusted by shackle space.

A similar relationship holds true in the eviscerating line as shown in Set II.

Set II

1. Speed of the eviscerating line depends on the speed of the dressing line, or the speed of the slowest work segment of the eviscerating line, which ever is slowest.
2. Speed of the worker varies, within limits, with the speed of dressing line and eviscerating line, but the speed of the worker determines the speed of the conveyor line.
3. Distance between work segments is determined by the required working time between work segments. If the speed of the line is increased beyond the speed of the work segment, the distance must be increased, or additional worker(s) must be added. Again, rate of output can be varied by the shackle space adjustment.

It is clear that the "most-time common denominator" in Set I, must be based on the slowest work segment of dressing line, and the "most-time common denominator" in Set II, must be based on the slowest work segment of dressing line or eviscerating line, whichever is slowest. Since Set II depends on Set I, any changes in Set I must affect Set II. These relationships will become clear as analysis of actual plant operations progresses.

Bases for Modification of Plant Operations

The importance of variations in the size of plants, methods of operation, and the extent of the use of labor and equipment associated with costs have been pointed out. The point must be emphasized that plant size, the degree of mechanization or speed of each worker, taken alone as such, are not too relevant. This will be discussed in a later analysis. The in-plant operation is primarily physical and is a fairly simple task that any engineer could do better perhaps than a plant manager who is not trained in engineering.

If the scale of plant, labor, equipment, and prices are given, any permissible technique that increases output will lower the cost of the product and therefore increase revenue. Some of the techniques might be: (1) exploitation of labor up to the point just before physical exhaustion or the point just before labor strikes (Technique 1A and Technique 1B), (2) longer hours of operation by way of overtime or multiple shifts (Technique 2A and Technique 2B), (3) rearrangement of labor and equipment to find the least time combination (Technique 3), or (4) combination of work segments by a single worker for full utilization of time (Technique 4). These techniques may be explained with the following model.

Suppose Plant X is organized to process a maximum hourly output of 1, 000 birds but it is operating at only one-half of its maximum capacity [1] (which seems to be the case in Michigan by actual observation), and labor (L) and equipment (M) are arranged in the following manner:

Labor or equipment	L	M	L	M	L	L	L
Time in seconds	20	20	10	10	20	10	10
Work segments	(1)	(2)	(3)	(4)	(5)	(6)	(7)

By using the labor exploitation technique (Technique 1A), the output could be nearly doubled[2] by increasing the speed up to the maximum capacity, hence, lowering costs to nearly one-half. On the other hand, management could operate the plant at maximum capacity and reduce the hours of operation by one-half, in which case savings in variable costs but not in fixed costs would result (Technique 1B). Under competitive economic conditions the best alternative would be doubling the speed to reach the maximum output. The results from the above two techniques would be as follows:

Technique 1A

Output is nearly doubled,

AFC is decreased nearly one-half, and

AVC is decreased nearly one-half.

Technique 1B

Output is the same,

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[1] Maximum capacity found by the time and motion studies.

[2] Due to technical reasons output is not exactly doubled.

AFC is the same, and

AVC is decreased nearly one-half.

If management decided to use the longer hours of operation technique, output could be increased and would be further increased by combining Technique 1A and longer hours (Technique 2A). The cost structure will differ. If management decided to operate on the overtime technique (Technique 2A), the output would become a function of hours of operation up to 24 hours a day and reach a maximum. Variable costs would be increased by the amount paid out in overtime pay after regular working hours. Average fixed cost would decline by spreading the cost over a larger output. These relationships are shown in Figures 7A and 7B.

If the management decided to use the two shifts operation technique (Technique 2B), output as well as variable costs would nearly double, but average fixed cost will be reduced to nearly one-half, assuming there is no pay difference between shifts. These relationships are shown in Figure 8.

Results from the above two techniques are as follows:

Technique 2A

Output is increased by the amount of hourly output times the hours of overtime,

Variable costs are increased by the amount paid out in overtime, and

Fixed costs are declined by spreading over the increased output.

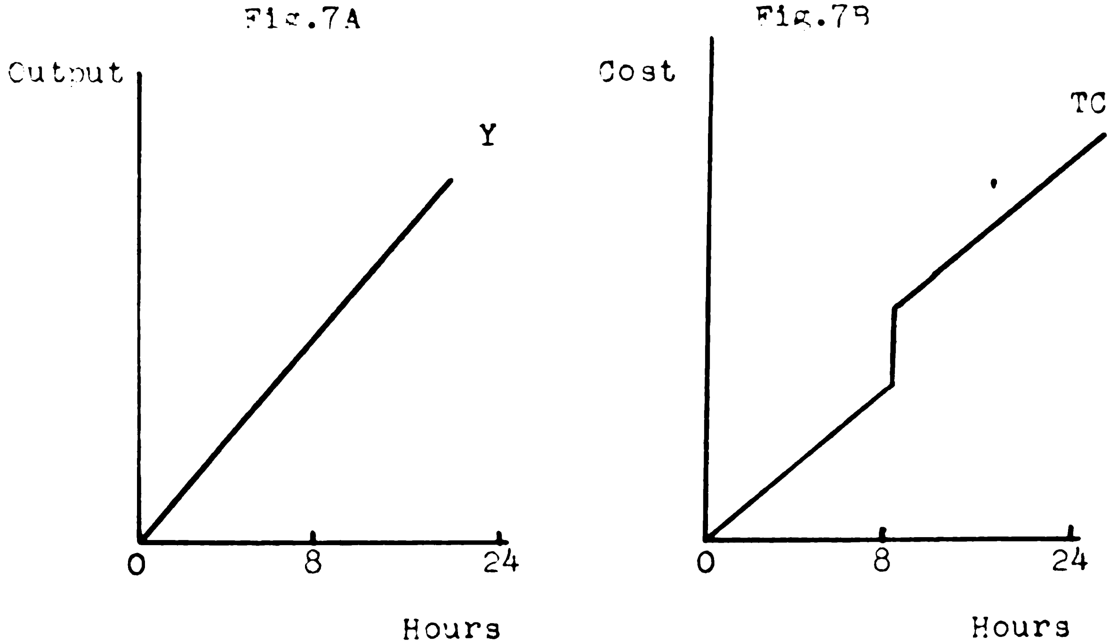

Figure 7A & 7B. Production and Cost Functions Beyond 8-Hour Working Day.

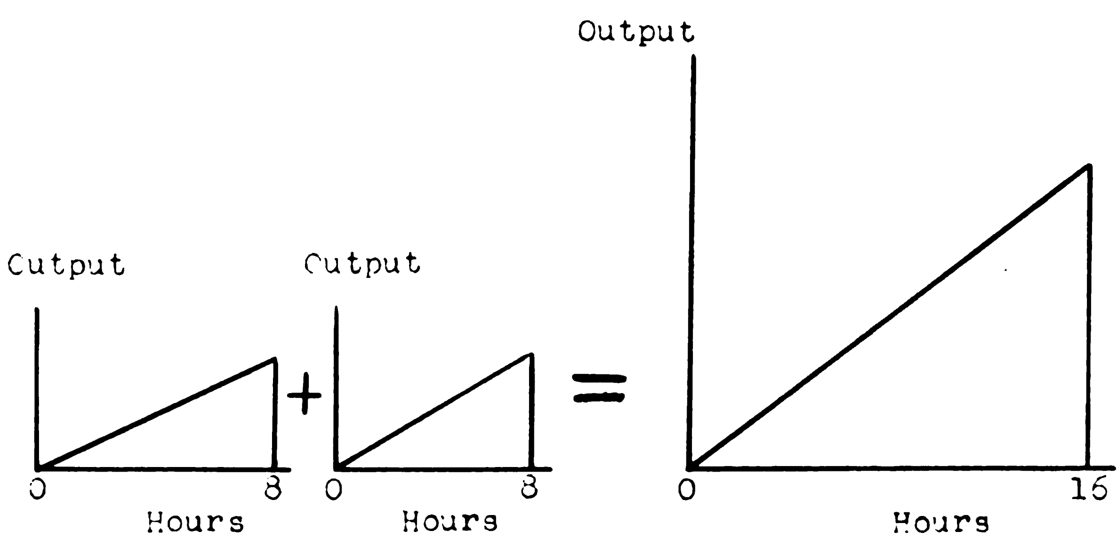

Figure 8. Output Resulting from Two Shifts.

Technique 2B

Output is nearly doubled,

Variable costs are nearly doubled, and

Fixed costs are decreased by nearly one-half.

If, rearrangement of labor and equipment is possible (Technique 3) it will result in reduced hours of operation or increased output with the same input. This rearrangement will reduce waiting time between work segments to nearly zero.

Finally, there may be a possibility of combining two or more work segments by one worker (Technique 4). If a particular work segment takes twice as long as the work segment next to it, management has a choice between adding another worker to the segment which takes only one-half the time.

The above modifications are available to management. However, management might not apply the available modification. The reason may be among the following:

1. The management is unable to recognize profitable modification possibilities.
2. The fact that profit maximization is not the only goal of management, particularly in the case of the self-owned plants. Maximization of family satisfaction is also important. For these reasons Techniques 1A and 1B are not practiced in plants in which family labor[1] is used.

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[1]Family labor may include not only members of the immediate family, but also relatives.

3. The uncertainty of the live poultry market as well as the processed market restricts the operation of the plant output at the level of least cost combination. Furthermore, if labor and live poultry are not readily available in the area, or predicted price of the product is not favorable the management would not use Techniques 2A or 2B.

4. The unavailability of cash reserve and credit plus uncertainty of the future prevents the management from doing what it would like to do.

The greatest possibility in plant reorganization without major changes in physical structure lies in the area of Technique 3 and Technique 4.

Description, Operation, Analysis, and Modification of the Five Selected Plants

Plant No. 1

A. Description of plant. Personnel of this plant was composed of three graduate students from the Poultry Science Department of Michigan State University. These students were asked to dress ten fryers manually at their normal speed. Their performance was timed and then averaged. This performance should represent the speed of an average poultry processing worker dressing poultry, all by himself, with simple tools and equipment. The equipment would consist of a knife, water pail, table, crate, and a container for dressed poultry.

Even though the operation was conducted at the Poultry Science laboratory, an operation of this size could be established and operated in almost any rural area. The main objective of this operation, was to establish the manual processing time to compare with line type operations.

B. Procurement of live poultry. Plant No. 1 was a simulated plant, therefore, there were no actual procurement figures. The broilers dressed were from the university poultry farm.

C. Operation of plant.

Segment 1. Hanging--Worker removed a bird from the crate and hung it on a hook by the feet at a rate of 10.8 seconds per bird. Extra time would be required for moving the empty crate and replacing it with a full crate.

Segment 2. Killing--Birds were killed at a rate of 4.5 seconds per bird. The worker killed a group of three birds in order to provide time for bleeding.

Segment 3. Scalding--Birds were submerged in a hot water tank for 41 seconds. Water temperature was 128^{o} F.

Segment 4. Picking--Picking birds by hand took 189.0 seconds per bird to complete.

Segment 5. Pinning--This job took 155.2 seconds per bird to complete. Pinning time depends on the condition of the bird with respect to pins.

Segment 6. Cropping--Crops were pulled at a rate of 53.0 seconds per bird.

Segment 7. Drawing viscera--Viscera were pulled out of the body cavity at a rate of 102.5 seconds per bird.

Segment 8. Separating giblets--Separating giblets took 48.5 seconds per bird.

Segment 9. Removing feet and head--Worker cut off the feet and head at a rate of 19.1 seconds per bird.

Segment 10. Cleaning giblets--Cleaning giblets was primarily a gizzard cleaning operation which took 46.0 seconds per bird.

Segment 11. Washing--Birds were washed inside and out at a rate of 5.0 seconds per bird.

Segment 12. Wrapping giblets--Giblets were wapped in wax paper at a rate of 15.0 seconds per bird.

Segment 13. Stuffing giblets--The wrapped giblets were placed in the body cavity at a rate of 3.0 seconds per bird.

Summary of the manual operation time is given in Table 1. The work performance presented in the table is the actual working time for each work segment; therefore, an allowance for time spent between work segments is necessary. Time spent shifting from one job to another and walking was about 5 seconds between each job, a total of 60 seconds per bird.

TABLE 1.--Actual working time of each work segment and sequence on processing line for Plant No. 1

Work segment	Job description	Time in seconds
1	Hanging	10.8
2	Killing	4.5
3	Scalding	41.0
4	Picking	189.2
5	Pinning	155.2
6	Cropping	53.0
7	Drawing viscera	102.5
8	Separating giblets	48.5
9	Removing feet and head	19.1
10	Cleaning giblets	46.0
11	Washing	5.0
12	Wrapping giblets	15.0
13	Stuffing giblets	3.0
	Total working time	692.8
	Allow 5 seconds between jobs	60.0
	Total time	752.8[1]

[1] This is equivalent to five birds per hour per worker.

A comparison of this single worker manual operation with a line type operation indicates that many work segments, particularly pinning, picking, drawing viscera, and separating giblets require more time than in a line type operation. There are several reasons for this difference in time as follows: (1) line type operations are designed and constructed to function in horizontal as well as vertical product handling conveniently and comfortably. This minimizes product handling, and therefore, wasted time, (2) line type operations allow a specified working time to each worker and the product moves in one direction, (3) line type operations make it easier to combine work segments, and (4) workers on line type operations are under constant pressure.

D. Costs. Plant No. 1 was a simulated plant of a very small scale. The total investment in equipment was estimated at $60, and $50 was allowed for rent of a place in a rural area including power, fuel, and water. Under these cost assumptions, the daily fixed cost was $1.64, the variable[1] cost was $10, and the total cost was $11.64.

On the basis of time and cost structure of this manual operation, the cost of dressing a fryer was $0.3333. As output increases, either through additional hours or additional workers, the unit fixed cost would diminish rapidly.

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[1] The cost of power, fuel, and water are included in the fixed costs; rent.

E. Modification. Modification involves two kinds; one is to use more variable inputs which would be mainly labor (this will be referred to as Modification I), and the other is to invest more in fixed inputs which would be equipment (this will be referred to as Modification II). In case of Modification I, it is possible for each worker to combine several work segments of a similar type and to specialize. This type of modification would result in a very low level of average fixed cost and also a lower average variable cost due to the increased output per worker as a result of specialization and savings in walking time.

Modification II involves investments in equipment. Observation of the work performance in Table 1 indicates that work segments scalding, picking, pinning, drawing viscera, separating giblets, and cleaning giblets are too much out of proportion to others. Of these time consuming work segments, the combined time of picking and pinning operations is equivalent to all the rest of the operations combined. At the present time, there is no equipment that will perform a perfect pinning operation. As a test model, this plant will acquire a scalding tank with a capacity of 100 birds per hour and a picker with a capacity of 60 birds per hour. The purchase price of the former is assumed to be at \$75 and that of the latter \$150.[1]

When the owner and operator invests in the above mentioned equipment he necessarily has to hire additional workers in order to

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[1] These prices are estimated from equipment manufacturer's list prices.

complement the lowest productive equipment, in this case, the picker.

At an hourly wage rate of $1.25, each second costs $0.00035. On this basis the manual scalding operation which takes about 45 seconds costs $0.01635 per bird. If this operation is done with a scalder which costs $75 and has a 100-bird capacity, the value of the scalder is worth $1.627[1] per hour in terms of wage rate $1.25 per hour. Likewise the value of picker is worth $3.974[2] per hour in terms of wage rate $1.25 per hour.

In order to complement a picker with 60 birds an hour capacity, it would be necessary to employ 8 workers. The unit processing cost after this modification becomes $0.2174[3] per bird. The difference between a completely manual operation and a partially mechanized operation is $0.1159 per bird. Processing costs at different plant utilization levels (Modification II) for fryers are given in Tables 2, 3, and 4 for 365, 90, 60, and 30 days, respectively.

Plant No. 2

A. Description of plant. This plant is located in a county where the "land area"[4] is 564 square miles and "land in farms"[5] is

[1] $1.6350-$0.00078 computed from formula No. 6, p. 33

[2] $3.990-$0.0157 computed from formula No. 6, p. 33.

[3] TFC per day was $2.738, TVC per day was $88.60, AFC was $0.0523, and AVC was $0.2111.

[4] As defined in the U.S. census.

[5] As defined in the U.S. census.

TABLE 2. --Daily output, average fixed cost, average variable cost, and average total cost per bird with changes in plant utilization for Plant No. 1. On the basis of 365-day[1] operation--fryers.

Percent of utilization	Daily output	AFC	AVC	ATC	Per pound[2]
100%	420	$0.0065	$0.2109	$0.2174	$0.0725
90	378	0.0072	0.2343	0.2415	0.0805
80	336	0.0082	0.2636	0.2718	0.0906
70	294	0.0093	0.3013	0.3106	0.1035
60	252	0.0109	0.3515	0.3624	0.1208
50	210	0.0126	0.4219	0.4345	0.1448
40	168	0.0163	0.5273	0.5336	0.1779
30	126	0.0217	0.7031	0.7248	0.2416

[1]Only fixed costs are computed on the basis of 365-day operation.

[2]Based on three pounds per bird.

TABLE 3. --Daily output, average fixed cost, average variable cost, and average total cost per bird with changes in plant utilization for Plant No. 1. On the basis of 90-day[1] operation--fryers

Percent of utilization	Daily output	AFC	AVC	ATC	Per pound[2]
100%	420	$0.0079	$0.2109	$0.2188	$0.0729
90	378	0.0088	0.2343	0.2431	0.0810
80	336	0.0098	0.2636	0.2734	0.0911
70	294	0.0113	0.3013	0.3126	0.1042
60	252	0.0132	0.3515	0.3647	0.1216
50	210	0.0158	0.4219	0.4377	0.1459
40	168	0.0197	0.5273	0.5470	0.1823
30	126	0.0263	0.7031	0.7294	0.2431

[1]Only fixed costs are computed on the basis of 90-day operation.

[2]Based on three pounds per bird.

TABLE 4. --Daily output, average fixed cost, average variable cost, and average total cost per bird with changes in plant utilization for Plant No. 1. On the basis of 60-day[1] operation--fryers

Percent of utilization	Daily output	AFC	AVC	ATC	Per pound[2]
100%	420	$0.0088	$0.2109	$0.2197	$0.0732
90	578	0.0098	0.2343	0.2441	0.0814
80	336	0.0110	0.2636	0.2746	0.0915
70	294	0.0126	0.3013	0.3139	0.1046
60	252	0.0147	0.3515	0.3515	0.1221
50	210	0.0176	0.4219	0.4393	0.1464
40	168	0.0220	0.5273	0.5493	0.1831
30	126	0.0293	0.7031	0.7324	0.2441

[1]Only fixed costs are computed on the basis of 60-day operation.

[2]Based on three pounds per bird.

TABLE 5. --Daily output, average fixed cost, average variable cost, and average total cost per bird with changes in plant utilization for Plant No. 1. On the basis of 30-day[1] operation--fryers

Percent of utilization	Daily output	AFC	AVC	ATC	Per pound[2]
100%	420	$0.0115	$0.2109	$0.2224	$0.0741
90	378	0.0128	0.2343	0.2471	0.0824
80	336	0.0144	0.2636	0.2780	0.0927
70	294	0.0165	0.3013	0.3178	0.1059
60	252	0.0192	0.3515	0.3707	0.1236
50	210	0.0231	0.4219	0.4450	0.1483
40	168	0.0288	0.5273	0.5561	0.1854
30	126	0.0385	0.7031	0.7416	0.2472

[1]Only fixed costs are computed on the basis of 30-day operation.

[2]Based on three pounds per bird.

414 square miles. Poultry density is 1,099 per "land area" square mile and 1.497 per "land in farm" square mile.

The market for processed poultry is local, mainly Grand Rapids and vicinity. This plant is a frame structure with concrete floors. It has a 16' x 23' receiving area and two rooms for processing. One room is 20' x 20' and the other is 19' x 26'. This plant is partially mechanized and would come under the Category A plant classification.

B. Procurement of live poultry. If this plant is operated seven hours a day with a maximum capacity of 570 birds per hour, it would need 3,990 birds per day. Assuming a load of 250 birds per truck at a cost of $0.35 per mile, procurement cost would be $0.0102 per bird.[1] It can be seen that extension of the procurement zone increases procurement cost, hence resulting in a higher live poultry cost at the plant.

This plant has its own truck and picks up poultry as needed for the day. The management has close contact with producers through feed dealers and has precise information about the live poultry market in the area. According to the manager, the procurement market is within a 25 mile radius.

C. Operation of plant.

Segment 1. A, B, & C — Unloading, hanging, and moving crates--Worker unloaded crates from truck at a rate of 9.6 seconds per crate. This work required considerable strength and time because, when the

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[1]The procurement cost will vary with changes in distance and volume of truck.

truck was parked by the receiving room, the truck plus crates was 12 feet high. It took 6.5 seconds for walking between crates and moving them. The same worker hung birds on a manually operated conveyor line at a rate of 3. 5 seconds per bird. Two factors enabled this worker to perform all three jobs. One factor was that he had about 50 feet of conveyor length and the other was the fact that one crate contained several birds.

Segment 2. A & B — Killing and moving conveyor line--Worker stood by the manually operated conveyor line and killed birds at a rate of 2. 5 seconds per bird. He had sufficient space to kill up to six birds when the conveyor line was stationary.

Segment 3. A, B, & C — Scalding and transferring line--Worker unhooked birds from killing line, put them in scalding tank which had a capacity of 24 birds, then transferred them to picker. This worker did the first two jobs in a single action, therefore, it was difficult to measure actual time for each job. It was estimated that about 4. 0 seconds per bird were required for the entire operation.

Segment 4. A, B, & C — Unloading from picker, removing feet, and cleaning floor--Worker unloaded birds from picker at a rate of 3.7 seconds, removed feet, then cleaned floor from time to time. It took a total of 12.9 seconds per bird for these jobs.

Segment 5. — Removing pinfeathers--Pinfeathers were removed at a rate of 11.3 seconds per bird.

Segment 6. A, B, & C — Slitting neck, pulling neck skin and hanging--Worker slit neck, pulled neck skin, then hung birds on eviscerating line at a rate of 4.9 seconds per bird.

Segment 7. — Opening body cavity--Worker opened body cavity at a rate of 4.7 seconds per bird.

Segment 8. — Drawing viscera--Worker removed viscera from body cavity at a rate of 7.4 seconds per bird. He did not separate the viscera.

Segment 9. A & B — Separating viscera and slitting gizzard--Worker separated inedible organs, and cut open gizzard. Liver, heart, and gizzard were still attached to the bird at this stage. This operation took 5.2 seconds per bird.

Segment 10. Emptying gizzard--Feed and other material in the gizzard were removed at a rate of 6. 3 seconds per gizzard.

Segment 11. A & B Peeling gizzard and separating all inedible viscera--Worker peeled the gizzard lining, separated viscera, and put it into proper containers at a rate of 6. 6 seconds per bird.

Segment 12. A & B Washing and inspecting--Worker washed and inspected each bird before putting into chilling tank at a rate of 5. 1 seconds per bird.

A senior worker walked back and forth to relieve congested stages. Summery of the processing time per bird is given in Table 6.

In this plant, the dressing line was manually operated and it was about 70 feet long. The eviscerating line was mechanically operated and it was 94 feet long. The speed of the eviscerating line was one foot per 6. 9 seconds.

D. Costs. Processing costs in this plant varying in percent utilization and number of days of operation are reported in Tables 7 through 10.

It can be seen that the average total cost is the lowest when the plant operates the days with the highest percentage utilization. The reason is obvious. When the plant operates at 100 percent of capacity the averaged fixed cost and the average variable cost are least because such costs are spread over a larger output.

TABLE 6. --Actual working time of each work segment and sequence on the processing line for Plant No. 2

Work segment	Job description	Time in seconds
1	Unloading, hanging, and moving crate	8.6
2	Killing and moving chain	4.1
3	Scalding	4.0
4	Unloading and moving feet	12.9
5	Pinning	11.3
6	Slitting neck and hanging	4.9
7	Opening cavity	4.7
8	Drawing viscera	7.4
9	Separating viscera and slitting gizzard	5.2
10	Emptying gizzard	6.3
11	Peeling gizzard and separating giblets	6.6
12	Washing and inspecting	5.1
	Total time	81.1

On the other hand, when the plant operates at less than 100 percent of capacity, the total fixed as well as variable costs are spread over a smaller output, hence resulting in a higher unit cost. When plants operate less than the total number of days in the year, the AVC is the same as the most number of days of operation but the AFC becomes larger.[1] These extreme cases are shown in Table 7 and Table 10.

E. Modification--Observation of data obtained from Line I and Line II[2] shows a considerable difference between the slowest work segment and the fastest. The "most-time common denominator" in

[1]This assumes depreciation as a function of "use" as well as "time."

[2]Line I refers to dressing line and Line II refers to eviscerating line.

Line I is 12.9 seconds whereas the "least-time common denominator" is 4.0 seconds. In Line II the "most-time common denominator" is 7.4 seconds while the "least-time common denominator" is 4.7 seconds. It is obvious that wasted time between and among these work segments amounts to many hours even in one day's operation. Waiting time becomes more noticeable when work performance in Line I and Line II are compared. The slowness in Line I affects the whole operation in Line II. When this study was conducted the speed of Line II was one foot per 6.8 seconds which was meant that even the slowest work segment needed only one foot of conveyor line space, where in reality, each worker had an average of 13.4 feet of conveyor space.

Two major modifications are necessary in order to increase output; one is to bring the speeds of Line I and Line II to the same rate and the other is to increase the speeds of both lines.

In order to accomplish the above mentioned modification, it would be necessary to make some structural changes in the plant. Installation of the receiving platform at the same level as the receiving room becomes necessary. Secondly, mechanization of Line I is desirable. These modifications will reduce waiting time between unloading and picking. The time saved from these work segments can be added to the pinning operation. As a result, these changes will bring in a nearly equal time ratio between work segments in Line I, which in turn, will provide nearly equal time ratio between Line I and Line II. After recommended modifications are made, the speed could be doubled, from one foot per 6.8 seconds to one foot per 3.4 seconds.

TABLE 7. --Daily output, average fixed cost, average variable cost, and average total cost per bird with changes in plant utilization for Plant No. 2. On the basis of 365-day[1] operation--fryers

Percent of utilization	Daily output	AFC	AVC	ATC	Per pound[2]
100%	3990	$0.0092	$0.0463	$0.0555	$0.0185
90[3]	3591	0.0102	0.0514	0.0616	0.0205
80	3192	0.0115	0.0578	0.0693	0.0231
70	2793	0.0132	0.0661	0.0793	0.0264
60	2394	0.0154	0.0771	0.0925	0.0308
50	1995	0.0184	0.0926	0.1110	0.0370
40	1596	0.0230	0.1157	0.1387	0.0462
30	1197	0.0307	0.1543	0.1850	0.0617

[1]Only fixed costs are computed on the basis of 365-day operation.

[2]Based on three pounds per bird.

[3]This plant normally operates at this capacity.

TABLE 8. --Daily output, average fixed cost, average variable cost, and average total cost per bird with changes in plant utilization for Plant No. 2. On the basis of 90-day[1] operation--fryers

Percent of utilization	Daily output	AFC	AVC	ATC	Per pound[2]
100%	3990	$0.0248	$0.0463	$0.0711	$0.0237
90	3591	0.0275	0.0514	0.0789	0.0263
80	3192	0.0310	0.0578	0.0888	0.0296
70	2793	0.0354	0.0661	0.1015	0.0338
60	2394	0.0413	0.0771	0.1184	0.0395
50	1995	0.0496	0.0926	0.1422	0.0474
40	1596	0.0620	0.1157	0.1777	0.0592
30	1197	0.0827	0.1543	0.2370	0.0790

[1]Only fixed costs are computed on the basis of 90-day operation.

[2]On the basis of three pounds per bird.

TABLE 9. --Daily output, average fixed cost, average variable cost, and average total cost per bird with changes in plant utilization for Plant No. 2. On the basis of 60-day[1] operation--fryers

Percent of utilization	Daily output	AFC	AVC	ATC	Per pound[2]
100%	3990	$0.0326	$0.0463	$0.0789	$0.0263
90	3591	0.0362	0.0514	0.0876	0.0292
80	3192	0.0407	0.0578	0.0985	0.0328
70	2793	0.0466	0.0661	0.1127	0.0376
60	2394	0.0543	0.0771	0.1314	0.0438
50	1995	0.0652	0.0926	0.1578	0.0526
40	1596	0.0815	0.1157	0.1972	0.0657
30	1197	0.1087	0.1543	0.2630	0.0877

[1]Only fixed costs are computed on the basis of 60-day operation.

[2]On the basis of three pounds per bird.

TABLE 10. --Daily output, average fixed cost, average variable cost, and average total cost per bird with changes in plant utilization for Plant No. 2. On the basis of 30-day[1] operation--fryers

Percent of utilization	Daily output	AFC	AVC	ATC	Per pound[2]
100%	3990	$0.0560	$0.0463	$0.1023	$0.0341
90	3591	0.0622	0.0514	0.1136	0.0379
80	3192	0.0700	0.0578	0.1278	0.0426
70	2793	0.0800	0.0661	0.1461	0.0487
60	2394	0.0933	0.0771	0.1704	0.0568
50	1995	0.1120	0.0926	0.2046	0.0682
40	1596	0.1400	0.1157	0.2557	0.0852
30	1197	0.1867	0.1543	0.3410	0.1137

[1]Only fixed costs are computed on the basis of 30-day operation.

[2]On the basis of three pounds per bird.

Plant No. 3

A. Description of plant. This plant is located in a county where the "land area"[1] of 829 square miles and the "land in farms"[2] is 590 square miles. Poultry density is 1.170 per "land area" square mile and 1.644 per "land in farms" square mile.

The market for processed poultry is both local as well as the Detroit terminal market. This plant is a frame structure with concrete floors. It has a 60' x 45' receiving room and two processing rooms connected by a conveyor line. One room is 145' x 58' and the other is 24' x 27'. This plant is highly mechanized and would come under the Category C plant classification.

B. Procurement of live poultry. If this plant operated seven hours a day with a maximum capacity of 720 birds per hour, it would require 5,040 birds per day. Using a truck load of 250 birds at a cost of \$0.35 per mile, procurement costs will be \$0.01257 per bird.

This plant assembles live poultry with its own truck as well as by direct delivery by producers. When delivered by producers, the live poultry price at the plant is K+k where K is the live poultry price at the farm and k is the fixed transportation charge per unit.

C. Operation of plant.

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[1] As defined in the U.S. census.

[2] As defined in the U.S. census.

Segment 1. A & B — Receiving and weighing--Poultry was received at the platform which was about the same height as a truck so that birds were unloaded efficiently. The birds were then weighed and transported to the hanging area, or moved to the receiving room for later use. The average receiving time was 2.0 seconds per bird.

Segment 2. A & B — Hanging and moving crates--Worker hung birds on the line from crates at a rate of 10.2 seconds per bird. He had about 10 feet of hanging space which enabled him to pick up full crates or remove empty crates without interrupting line operation. The rate of pick up or removing a crate was 8.0 seconds per crate. The time for hanging and moving crates took 11.5 seconds per bird.

Segment 3. — Killing--The worker stood at a somewhat stationary position and killed at a rate of 5.2 seconds per bird. Killing was done in a fixed position in order to prevent spreading of blood to the receiving area.

Segment 4. — Scalding--Scalding was accomplished in an automatic spray type scalder 20 feet in length.

The rate depends on the speed of the conveyor line.

Segment 5. Picking--Birds were picked by an automatic picker. The length of the picker was 12 feet and the rate of picking depends on the speed of the conveyor line up to the capacity of the picker.

Segment 6. A & B Removing quills and hanging by the neck--Worker removed quills by using machine and hung each bird by the neck at a rate of 7.0 seconds per bird.

Segment 7. Buffing--Buffing was done by automatic equipment and its rate depends on the speed of the conveyor line up to equipment capacity.

Segment 8. Pinning--Pinfeathers were removed by hand at a rate of 19.0 seconds per bird. The pinning room was U-shaped so that the pinner had flexibility in space by following the bird if necessary.

Segment 9. Singeing--Singeing was done by an automatic gas singer timed by an electronic eye.

Segment 10. Finishing--Finishing was done by automatic equipment 7 1/2 feet in length. Rate of finishing depends on the speed of conveyor line.

Segment 11. A & B — Transferring and slitting neck--Birds were transferred to eviscerating line and the same worker slit neck at a rate of 15.3 seconds per bird.

Segment 12. A & B — Removing oil glands and opening cavity--Worker removed oil glands and opened cavity at a rate of 15.4 seconds per bird.

Segment 13. — Drawing viscera--Worker removed viscera at a rate of 12.7 seconds per bird.

Segment 14. A & B — Washing and inspecting--Worker washed and inspected each bird at a rate of 16.3 seconds per bird.

Segment 15. A, B, & C — Removing feet, weighing, and transferring to chilling tank--This operation took 4.9 seconds per bird.

Segment ZZ[1] — Cleaning and bagging giblets--Between stages 13 and 14 two workers cleaned and bagged giblets at a rate of 16.2 seconds per bag for each worker. This operation need not be on the line.

Summary of actual processing time and sequence is given in Table 11.

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[1] ZZ refers to work segment off the conveyor line.

TABLE 11. --Actual working time of each work segment and sequence on processing line for Plant No. 3

Work segment	Job description	Time in seconds
1	Receiving	2.0
2	Hanging and moving crate	11.5
3	Killing	5.2
4	Scalding	10.0
5	Picking	10.0
6	Removing quills	7.0
7	Buffing	7.5
8	Pinning	19.0
9	Singeing	1.5
10	Finishing	5.6
11	Transferring line and slitting neck	15.3
12	Removing oil gland and opening cavity	15.4
13	Drawing viscera	12.7
14	Washing and inspecting	16.5
15	Removing feet and weighing	4.6
ZZ[1]	Cleaning and bagging giblets	16.2
	Total time	160.1

[1]Letters ZZ indicate work performed off the conveyor line.

D. Costs. Processing costs in this plant varying in percent plant utilization and number of days of operation are given in Tables 12 through 15.

E. Modification. The in-plant operations included in this study are segments from hanging the poultry to the chilling the birds. Line I is 154 feet long and Line II is 66 feet long, and they are mechanically operated. The speed of Line I was one foot per 7.5 seconds and Line II was one foot per 13.4 seconds, which were "normal" operating speeds according to the manager.

Work performance of all segments in this plant was slower than Plant No. 2 not because of the speed and skill of workers but due to the slow speed and longer shackle space for processing hens and caponettes. Workers can perform their assignments only when birds arrive at their working positions. This is also true of the work done by equipment.

Whenever the work performance standard is left to the judgment of the workers in jobs such as pinning, final cleaning, or inspecting, it is better to provide a flexible conveyor line space than limited space because the amount of work to be done on each bird may differ. Flexible line space allows the worker time to follow birds to complete the job or skip it whichever the case may be. Their work performance is the average of all birds passing through their assigned areas rather than performance on each bird. Their working time ranges from zero to some maximum. The worker in pinning, for example, can skip birds that do not need pinning but may spend as much as 70 seconds on one bird. In this case, his working time ranges from zero to 70 seconds.

The speed of Line II was one foot per 13.4 seconds. It had an average of 5 feet per worker while even the slowest worker needs only about a foot at that speed. Wider shackle spacing and a slow conveyor line was responsible for these inefficiencies.

Worker (Segment 10) who transfers poultry from Line I to Line II and slits the neck, should be restricted to transfer of poultry only, because he has to perform two jobs one of which requires the use of a knife while the other does not. Worker (Segment 11) should perform the job of opening the cavity and slitting the neck all in one continuous motion, and worker (Segment 14) should remove the oil gland and cut off the feet, all in one continuous motion.

Plant No. 4

A. Description of plant. This plant is located in a county with a "land area"[1] of 566 square miles and the "land in farms"[2] is 505 square miles. Poultry density is 300 per "land area" square mile and 366 per "land in farms" square mile.

The market for processed poultry is both local as well as distant such as Chicago and New York. This plant is partially mechanized and has a 38' x 18' receiving room, and a 38' x 38' eviscerating and dressing room. This plant would come under the Category A plant classification.

B. Procurement of live poultry. If this plant is operated seven hours a day with a maximum capacity of 500 birds per hour, it would need 3, 500 birds per day. Assuming a truck load of 250 birds at a cost of \$0. 35 per mile, procurement cost will be \$0. 03267 per bird.

C. Operation of plant. This plant went out of business soon after this study was undertaken. Time studies from hanging up to picking stages are not available.

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[1]As defined in the U.S. census.

[2]As defined in the U.S. census.

TABLE 12. --Daily output, average fixed cost, average variable cost, and average total cost per bird with changes in plant utilization for Plant No. 3. On the basis of 365-day[1] operation--caponettes

Percent of utilization	Daily output	AFC	AVC	ATC	Per pound[2]
100%	5040	$0.0074	$0.0336	$0.0410	$0.0082
90	4536	0.0083	0.0374	0.0457	0.0457
80	4032	0.0093	0.0420	0.0513	0.0103
70	3528	0.0106	0.0480	0.0586	0.0117
60	3240	0.0116	0.0523	0.0639	0.0128
50	2520	0.0149	0.0672	0.0821	0.0164
40[3]	2016	0.0186	0.0841	0.1027	0.0205
30	1512	0.0248	0.1121	0.1369	0.0274

[1] Only fixed costs are computed on the basis of 365-day operation.

[2] Based on five pounds per bird.

[3] This plant normally operates at this capacity.

TABLE 13. --Daily output, average fixed cost, average variable cost, and average total cost per bird with changes in plant utilization for Plant No. 3. On the basis of 90-day[1] operation--caponettes

Percent of utilization	Daily output	AFC	AVC	ATC	Per pound[2]
100%	5040	$0.0330	$0.0336	$0.0666	$0.0133
90	4536	0.0367	0.0374	0.0741	0.0148
80	4032	0.0413	0.0420	0.0833	0.0167
70	3528	0.0472	0.0480	0.0952	0.0190
60	3240	0.0514	0.0523	0.1037	0.0207
50	2520	0.0661	0.0672	0.1333	0.0267
40	2016	0.0826	0.0841	0.1667	0.0333
30	1512	0.1102	0.1121	0.2223	0.0445

[1] Only fixed costs are computed on the basis of 90-day operation.

[2] Based on five pounds per bird.

TABLE 14.--Daily output, average fixed cost, average variable cost, and average total cost per bird with changes in plant utilization for Plant No. 3. On the basis of 60-day[1] operation--caponettes

Percent of utilization	Daily output	AFC	AVC	ATC	Per pound[2]
100%	5040	$0.0458	$0.0336	$0.0794	$0.0159
90	4536	0.0509	0.0374	0.0883	0.0177
80	4032	0.0573	0.0420	0.0993	0.0199
70	3528	0.0655	0.0480	0.1135	0.0227
60	3240	0.0713	0.0523	0.1236	0.0247
50	2520	0.0917	0.0672	0.1589	0.0518
40	2016	0.1146	0.0841	0.1987	0.0397
30	1512	0.1528	0.1121	0.2649	0.0530

[1]Only fixed costs are computed on the basis of 60-day operation.

[2]Based on five pounds per bird.

TABLE 15.--Daily output, average fixed cost, average variable cost, and average total cost per bird with changes in plant utilization for Plant No. 3. On the basis of 30-day[1] operation--caponettes

Percent of utilization	Daily output	AFC	AVC	ATC	Per pound[2]
100	5040	$0.0842	$0.0336	$0.1178	$0.0236
90	4536	0.0935	0.0374	0.1309	0.0262
80	4032	0.1052	0.0420	0.1472	0.0294
70	3528	0.1203	0.0480	0.1683	0.0337
60	3240	0.1310	0.0523	0.1833	0.0367
50	2520	0.1684	0.0672	0.2356	0.0471
40	2016	0.2105	0.0841	0.2946	0.0589
30	1512	0.2807	0.1121	0.3928	0.0786

[1]Only fixed costs are computed on the basis of 30-day operation.

[2]Based on five pounds per bird.

Segment 1. Hanging.

Segment 2. Killing.

Segment 3. Scalding.

Segment 4. Picking.

Segment 5. Pinning.

Segment 6. Slitting neck.

Segment 7. Opening cavity.

Segment 8. Cleaning cavity.

Segment 9. Washing.

Segment 10. Hanging by the wing--Birds were hung by the wing to remove excess water at a rate of 4.1 seconds per bird.

Segment 11. Unloading from the line--Birds were removed from the line and placed on tables at a rate of 2.2 seconds per bird.

Segment 12. A & B Pinning and cleaning--Final pinning and cleaning was done at a rate of 38.1 seconds per bird.

Segment 13. Wrapping giblets--Giblets were wrapped at a rate of 12.5 seconds per bag.

Segment 14. Stuffing giblets--Giblets were stuffed in body cavity and placed on running belt at a rate of 7.9 seconds per bird.

Segment 15. Packaging--Worker picked up bird from belt and vacuumed at a rate of 12.2 seconds per bird.

Segment 16. Shrinking--Birds are submerged in hot water for 10 seconds per bird.

Segment 17. Weighing and marking--Birds are weighed and marked at a rate of 6.5 seconds per bird.

Segment 18. Packing and transferring to freezer--Two workers packed six birds in a box and transferred to freezer at a rate of six seconds per bird per worker.

Summary of actual working time from Segments 11 through 18 is reported in Table 16.

D. Costs. Processing costs in this plant varying in percent plant utilization and number of days of operation are given in Tables 17 through 20.

E. Modification. This plant is partially mechanized and uses many part-time workers. As the birds come off the dressing line they are put in chilling tanks without complete removal of pinfeathers and pieces of viscera in the body cavities. When the dressing line is stopped, all the workers from that line are transferred to the eviscerating operation.

TABLE 16.--Actual working time of work segments from hanging through packaging for Plant No. 4

Work segment	Job description	Time in seconds
1	Hanging	----
2	Killing	----
3	Scalding	----
4	Picking	----
5	Pinning	----
6	Slitting neck	----
7	Opening cavity	----
8	Cleaning cavity	----
9	Washing	----
10	Removing feet and head	----
11	Hanging by the wing	4.1
12	Unloading from line	2.2
13	Pinning and cleaning	38.1
14	Wrapping giblets	12.5
15	Stuffing giblets	7.9
16	Vacuuming	12.2
17	Weighing and marking	6.5
18	Packing and transferring to freezer	6.0
	Total time work segments 10 through 18	89.5

In the eviscerating operation, the birds were picked up from the chilling tank and hung by the wings to remove excess water. Birds remained on the line for about ten minutes, then were unloaded by each worker and put on the eviscerating tables. The eviscerated birds were placed on trays for stuffing. The stuffed birds were placed on a moving belt for vacuuming and packing. The workers on eviscerating line were free to move from one position to another as they saw a need in the working area; therefore, work performance

TABLE 17.--Daily output, average fixed cost, average variable cost, and average total cost per bird with changes in plant utilization for Plant No. 4. On the basis of 365-day[1] operation--hens

Percent of utilization	Daily output	AFC	AVC	ATC	Per pound[2]
100%	3500	$0.0255	$0.0838	$0.1093	$0.0219
90	3150	0.0284	0.0931	0.1215	0.0243
80	2800	0.0319	0.1047	0.1366	0.0273
70	2450	0.0365	0.1197	0.1562	0.0312
60	2100	0.0426	0.1306	0.1822	0.0364
50[3]	1750	0.0511	0.1675	0.2186	0.0437
40	1400	0.0638	0.2094	0.2732	0.0546
30	1050	0.0851	0.2792	0.3643	0.0729

[1]Only fixed costs are computed on the basis of 365-day operation.

[2]Based on five pounds per bird.

[3]This plant normally operates at this capacity.

TABLE 18.--Daily output, average fixed cost, average variable cost, and average total cost per bird with changes in plant utilization for Plant No. 4. On the basis of 90-day[1] operation--hens

Percent of utilization	Daily output	AFC	AVC	ATC	Per pound[2]
100%	3500	$0.0905	$0.0838	$0.1743	$0.0349
90	3150	0.1006	0.0931	0.1937	0.0387
80	2800	0.1132	0.1047	0.2179	0.0436
70	2450	0.1293	0.1197	0.2490	0.0498
60	2100	0.1509	0.1396	0.2905	0.0581
50	1750	0.1811	0.1675	0.3486	0.0697
40	1400	0.2264	0.2094	0.4358	0.0872
30	1050	0.3018	0.2792	0.5810	0.1162

[1]Only fixed costs are computed on the basis of 90-day operation.

[2]Based on five pounds per bird.

TABLE 19.--Daily output, average fixed cost, average variable cost, and average total cost per bird with changes in plant utilization for Plant No. 4. On the basis of 60-day[1] operation--hens

Percent of utilization	Daily output	AFC	AVC	ATC	Per pound[2]
100%	3500	$0.1315	$0.0838	$0.2153	$0.0431
90	3150	0.1461	0.0931	0.2392	0.0478
80	2800	0.1644	0.1047	0.2691	0.0538
70	2450	0.1879	0.1197	0.3076	0.0615
60	2100	0.2192	0.1396	0.3588	0.0718
50	1750	0.2631	0.1675	0.4306	0.0861
40	1400	0.3289	0.2094	0.5383	0.1077
30	1050	0.4385	0.2792	0.7177	0.1435

[1]Only fixed costs are computed on the basis of 60-day operation.

[2]Based on five pounds per bird.

TABLE 20.--Daily output, average fixed cost, average variable cost, and average total cost per bird with changes in plant utilization for Plant No. 4. On the basis of 30-day[1] operation--hens

Percent of utilization	Daily output	AFC	AVC	ATC	Per pound[2]
100%	3500	$0.2372	$0.0838	$0.3210	$0.0642
90	3150	0.2646	0.9031	0.3577	0.7515
80	2800	0.2965	0.1047	0.4012	0.0802
70	2450	0.3389	0.1197	0.4586	0.0917
60	2100	0.3954	0.1396	0.5350	0.1070
50	1750	0.4745	0.1675	0.6420	0.1284
40	1490	0.5931	0.2094	0.8025	0.1605
30	1050	0.7908	0.2792	1.0700	0.2140

[1]Only fixed costs are computed on the basis of 30-day operation.

[2]Based on five pounds per bird.

time for each worker has very little meaning. The only work segment which could be used to measure hourly output was the vacuuming work. If the vacuuming operated continuously, the hourly output is estimated at 300 birds.

Even though the plant manager is free to make an investment in equipment in the plant, he is restricted from making structural changes under the lease contract. This building was not designed for a processing operation.

Plant No. 5

A. Description of plant. This plant is located in a county with a "land area"[1] of 564 square miles and the "land in farms"[2] is 414 square miles. Poultry density is 1,099 per "land area" square mile and 1,498 per "land in farms" square mile.

The market for processed poultry is both local as well as distant markets such as Detroit and Chicago. This plant is a newly constructed one. The plant is 140' x 60' and does not have a receiving room. It is highly mechanized and would come under the Category B plant classification.

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[1] As defined in the U.S. census.

[2] As defined in the U.S. census.

B. Procurement of live poultry. If this plant is operated seven hours a day with a maximum capacity of 315 turkeys per hour, it would require 2, 200 turkeys per day. Assuming a truck load of 160 turkeys at a cost of \$0. 35 per mile, procurement cost will be \$0. 0974 per turkey. The actual cost, of course, depends upon the weight of turkeys and volume of the truck.

C. Operation of plant.

Segment 1. Hanging--Turkeys were unloaded directly from truck to hanging line at a rate of 10. 5 seconds per bird. The receiving platform was constructed in such a way that the level of the truck platform was about the same as the receiving platform.

Segment 2. Killing--Birds were killed at a rate of 5. 9 seconds per bird. Worker at this stage had a fixed position and killed only when birds arrived at the killing position. He had to wait about 7. 0 seconds between birds.

Segment 3. Scalding--Scalding was done in a 50 foot long trough installed along the conveyor line. The speed of scalding depends on the speed of the line, but it can be adjusted by extending or shortening the length of the trough.

Segment 4. A & B Transferring and picking--Picking was done by an automatic picker, but the worker at this stage had to transfer from the line to the picker. The time required to transfer, pick, and remove wing feathers was 21. 0 seconds per bird. The actual machine picking time was 5. 4 seconds per bird.

Segment 5. A, B, & C Unloading, removing feet, and hanging--The worker unloaded birds from the picker at a rate of 2. 0 seconds per bird, removed feet at a rate of 6. 8 seconds, and hung birds by the hook at a rate of 3. 2 seconds per bird. The time required at this stage was 12. 0 seconds per bird.

Segment 6. A & B Removing quills and cleaning--The worker completed removal of quills at a rate of 8. 4 seconds per bird. Since he had a very flexible working position due to a long conveyor line, he emptied wastes accumulated in this area to another room which was located about 30 feet away.

Segment 7. Pinning--Two workers removed pins at a rate of 17.5 seconds per bird per worker.

Segment 8. A, B, & C Slitting neck, removing oil gland, and opening cavity--The above three jobs were performed by one worker at a rate of 14.8 seconds per bird.

Segment 9. A & B Drawing viscera and hanging by the neck--Viscera was pulled out of body cavity and the bird is hung by the neck at a rate of 17.3 seconds per bird.

Segment 10. Cropping--The crop was removed at a rate of 14.8 seconds per bird.

Segment 11. Inspecting--A federal inspector inspected birds at a rate of 9.9 seconds per bird. The inspector stopped the line whenever closer inspection was necessary. According to the plant manager, average stoppage is four times a day. Whenever the inspector stops the line, the whole operation has to stop until he completes his inspection.

Segment 12. Cleaning cavity--The body cavity was completely cleaned at this stage at a rate of 10. 5 seconds per bird.

Segment 13. A & B Removing neck and head--Neck and head were removed at a rate of 9. 1 seconds per bird.

Segment 14. Washing--Worker washes each bird with spray nozel at a rate of 15. 0 seconds per bird.

Any work segments hereafter need not be considered as part of the line operation in the sense that these will not have direct affect on the speed of the line. However, it is necessary to keep pace with the conveyor line in order to eliminate an excess accumulation of eviscerated birds. Each work segment is designated by the letter Z to differentiate it from the previous line operations.

Segment 15. Z Separating liver and heart--Worker stood behind the end of Segment 13 and separated liver and heart at a rate of 13. 2 seconds per bird.

Segment 16. Z Opening gizzard--Two workers opened gizzards and emptied feed material at a rate of 22. 0 seconds per gizzard per worker.

Segment 17. Z Peeling gizzard--Gizzards were peeled at a rate of 7. 7 seconds each by using a peeling machine, but the worker doing this job had to wait an average of 8. 0 seconds for the next gizzard.

Segment 18. Z Bagging giblets--Giblets were wrapped at a rate of 16. 0 seconds per package.

Segment 19. Z Stuffing giblets and folding legs--Giblets were placed into the body cavity and legs were folded at a rate of 11. 0 seconds per bird.

Segment 20. Z Packaging--This worker, by using a vacuuming machine, vacuumed at a rate of 14. 0 seconds per bird.

Segment 21. Z Shrinking--Birds were submerged in hot water, then put into a brine tank at a rate of 10. 0 seconds per bird.

Segment 22. Z Taking out of brine tank--A worker took semi-frozen birds from the brine tank and placed them on scales at a rate of 14. 0 seconds per bird.

Segment 23. Z Weighing and marking--Birds were weighed and marked at a rate of 7. 3 seconds per bird.

Segment 24_Z. Packing--Birds were packed individually in cardboard boxes at a rate of 10.0 seconds per bird.

Segment 25_Z. Closing box and labeling--Worker closed boxes and labeled at a rate of 14.0 seconds per box.

Summary of actual working time is given in Table 21.

D. Costs. Processing costs in this plant varying in percent plant utilization and number of days of operation are given in Tables 22 through 25.

E. Modification. In 1959, this plant was engaged solely in turkey processing operation. Processing turkeys is different than processing chickens in that they are heavier, more difficult to handle, and require a longer bleeding time. For these reasons, the shackles must be spaced farther apart than for chickens, and also the speed of the conveyor line must be set at a slower rate.

Hanging live turkeys is a difficult job due to the wildness of these birds. Even though the mean of 10 observations was 10.5 seconds per bird for hanging, the range was from 6.0 seconds to 15.0 seconds. This means that skipping a shackle when the worker has to struggle with a turkey from time to time is inevitable.

It must be emphasized that skipping a shackle at hanging necessarily wastes labor and other costs. It is estimated that at a line speed at one foot per 6.9 seconds, any hanging time between 15 seconds to 18 seconds for one try, or a hanging time of 15 seconds for two consecutive turkeys forces the skipping of a shackle.

If this plant is operated at a maximum hourly output through increased speed, one additional worker will be needed for each of the following segments: hanging, pinning, and drawing viscera.

The work performance in off-the-line operations which include segments 14 through 25 inclusive, is usually slow because these workers are not under the same pressure as the workers on the line. In general, the following relationships exist in off-the-line operations. Worker No. 15 transfers birds only when worker No. 16 is ready for bird, and worker No. 16 in turn transfers to worker No. 17 when worker No. 18 is ready. For example, the worker puts bird in bag when the vacuuming operator is ready for a bird.

TABLE 21.--Actual working time of each work segment and sequence on processing line for Plant No. 5

Work segment	Job description	Time in seconds
1	Hanging	10.5
2	Killing	5.9
3	Scalding	14.6
4	Transferring and picking	21.0
5	Removing feet and hanging	12.0
6	Removing quills	8.4
7	Pinning	17.5
8	Slitting neck, removing oil gland, and opening cavity	14.8
9	Drawing viscera	17.3
10	Cropping	14.8
11	Inspecting	9.9
12	Cleaning cavity	10.5
13	Removing head and neck	9.1
14	Washing	15.0
	Total time--conveyor line operation	181.3
	(Off the Line)	
15	Separating liver and heart	13.2
16	Opening gizzard	22.0
17	Peeling gizzard	7.7
18	Bagging giblets	16.0
19	Stuffing giblets	11.0
20	Vacuuming	14.0
21	Plumping	10.0
22	Taking out from brine tank	14.0
23	Weighing and marking	7.3
24	Packing	10.0
25	Closing box and labeling	14.0
	Total time--off the line........................	151.7
	Grand total time	333.0

TABLE 22. --Daily output, average fixed cost, average variable cost, and average total cost per bird with changes in plant utilization for Plant No. 5. On the basis of 365-day[1] operation--turkeys

Percent of utilization	Daily output	AFC	AVC	ATC	Per pound[2]
100%	2200	$0. 0449	$0. 5045	$0. 5494	$0. 0275
90	1980	0. 0499	0. 5607	0. 6106	0. 0305
80	1760	0. 0561	0. 6307	0. 6868	0. 0343
70	1540	0. 0641	0. 7208	0. 7849	0. 0392
60	1320	0. 0748	0. 8410	0. 9158	0. 0458
50[3]	1100	0. 0897	1. 0092	1. 0989	0. 0549
40	880	0. 1122	1. 2615	1. 3737	0. 0687
30	660	0. 1496	1. 6820	1. 8316	0. 0916

[1]Only fixed costs are computed on the basis of 365-day operation.

[2]Based on twenty pounds per bird.

[3]This plant normally operates at this capacity.

TABLE 23. --Daily output, average fixed cost, average variable cost, and average total cost per bird with changes in plant utilization for Plant No. 5. On the basis of 90-day[1] operation--turkeys

Percent of utilization	Daily output	AFC	AVC	ATC	Per pound[2]
100%	2200	$0. 1714	$0. 5043	$0. 6759	$0. 0338
90	1980	0. 1905	0. 5607	0. 7512	0. 0376
80	1760	0. 2143	0. 6307	0. 8450	0. 0423
70	1540	0. 2449	0. 7208	0. 9657	0. 0483
60	1320	0. 2858	0. 8410	1. 1268	0. 0563
50	1100	0. 3429	1. 0092	1. 3521	0. 0676
40	880	0. 4286	1. 2615	1. 6901	0. 0845
30	660	0. 5715	1. 6820	2. 2535	0. 1127

[1]Only fixed costs are computed on the basis of 90-day operation.

[2]Based on twenty pounds per bird.

TABLE 24. --Daily output, average fixed cost, average variable cost, and average total cost per bird with changes in plant utilization for Plant No. 5. On the basis of 60-day[1] operation--turkeys

Percent of utilization	Daily output	AFC	AVC	ATC	Per pound[2]
100%	2200	$0. 2347	$0. 5045	$0. 7392	$0. 0370
90	1980	0. 2608	0. 5607	0. 8215	0. 0411
80	1760	0. 2934	0. 6307	0. 9241	0. 0462
70	1540	0. 3353	0. 7208	1. 0561	0. 0528
60	1320	0. 3912	0. 8410	1. 2322	0. 0616
50	1100	0. 4695	1. 0092	1. 4787	0. 0739
40	880	0. 5863	1. 2615	1. 8483	0. 0924
30	660	0. 7825	1. 6820	2. 4645	0. 1232

[1]Only fixed costs are computed on the basis of 60-day operation.

[2]Based on twenty pounds per bird.

TABLE 25. --Daily output, average fixed cost, average variable cost, and average total cost per bird with changes in plant utilization for Plant No. 5. On the basis of 30-day[1] operation--turkeys

Percent of utilization	Daily output	AFC	AVC	ATC	Per pound[2]
100%	2200	$0. 4330	$0. 5054	$0. 9375	$0. 0469
90	1980	0. 4811	0. 5607	1. 0418	0. 0521
80	1760	0. 5413	0. 6307	1. 1720	0. 0586
70	1540	0. 6186	0. 7208	1. 3394	0. 0670
60	1320	0. 7217	0. 8410	1. 5627	0. 0781
50	1100	0. 8661	1. 0092	1. 8753	0. 0938
40	880	1. 0826	1. 2615	2. 3441	0. 1172
30	660	1. 4435	1. 6820	3. 1255	0. 1565

[1]Only fixed costs are computed on the basis of 30-day operation.

[2]Based on twenty pounds per bird.

CHAPTER VII

OTHER PROCESSING PLANT PROBLEMS

Percentage Yield from Live to Processed Poultry

Loss in weight from live to processed poultry or percentage yield is an important cost item in processing operation. The price processor pays for live weight at farm becomes higher after birds are processed because of the following reasons:

1. The price processor pays for live poultry, includes inedible portions of poultry. The price paid for the inedible portion is much higher than recovery from processing by-products.
2. The freight cost processor pays for hauling live poultry is actually higher because of inedible portions.
3. The in-transit shrinkage cost.

The percentage yield depends on many factors such as type of feed, age of the bird, and techniques in processing. In any case, processor should try to obtain the highest percentage yield.

Conversion equivalents from live poultry prices at the farm to eviscerated poultry prices at the plant have been prepared and are shown in Table 26. In Table 26, the first column is price of live poultry at farm ranging from 10 cents to 28 cents. The first line is percentage yield from live poultry to eviscerated weight ranging from

Table 26. Conversion Table--Live Poultry Price to Eviscerated Poultry Price.

Live price per pound	Percent yield from live to eviscerated								
	69	70	71	72	73	74	75	76	77
cents	Eviscerated price per pound cents								
10.00	14.49	14.29	14.08	13.89	13.70	13.51	13.33	13.16	12.99
10.25	14.86	14.64	14.44	14.24	14.04	13.85	13.67	13.49	13.31
10.50	15.22	15.00	14.79	14.58	14.38	14.19	14.00	13.82	13.64
10.75	15.58	15.36	15.14	14.93	14.73	14.53	14.33	14.14	13.96
11.00	15.94	15.71	15.49	15.28	15.07	14.86	14.67	14.47	14.29
11.25	16.30	16.07	15.85	15.63	15.41	15.20	15.00	14.80	14.61
11.50	16.67	16.43	16.20	15.97	15.75	15.54	15.33	15.13	14.94
11.75	17.03	16.79	16.55	16.32	16.10	15.88	15.67	15.46	15.26
12.00	17.39	17.14	16.90	16.67	16.44	16.22	16.00	15.79	15.58
12.25	17.75	17.50	17.25	17.01	16.78	16.55	16.33	16.12	15.91
12.50	18.12	17.86	17.61	17.36	17.12	16.89	16.67	16.45	16.23
12.75	18.48	18.21	17.96	17.71	17.47	17.23	17.00	16.78	16.56
13.00	18.84	18.57	18.31	18.06	17.81	17.57	17.33	17.11	16.88
13.25	19.20	18.93	18.66	18.40	18.15	17.91	17.67	17.43	17.21
13.50	19.57	19.29	19.01	18.75	18.49	18.24	18.00	17.77	17.53
13.75	19.93	19.64	19.37	19.10	18.84	18.58	18.33	18.09	17.86
14.00	20.29	20.00	19.72	19.44	19.18	18.92	18.67	18.42	18.18
14.25	20.65	20.36	20.07	19.79	19.52	19.26	19.00	18.75	18.51
14.50	21.01	20.71	20.42	20.14	19.86	19.59	19.33	19.08	18.83
14.75	21.38	21.07	20.77	20.49	20.21	19.93	19.67	19.41	19.16
15.00	21.74	21.43	21.13	20.83	20.55	20.27	20.00	19.74	19.48
15.25	22.10	21.79	21.48	21.18	20.89	20.61	20.33	20.07	19.81
15.50	22.46	22.14	21.83	21.53	21.23	20.95	20.67	20.39	20.13
15.75	22.83	22.50	22.18	21.88	21.58	21.28	21.00	20.72	20.45
16.00	23.19	22.86	22.54	22.22	21.92	21.62	21.33	21.05	20.78
16.25	23.55	23.21	22.89	22.57	22.26	21.96	21.67	21.38	21.10
16.50	23.91	23.57	23.24	22.92	22.60	22.30	22.00	21.71	21.43
16.75	24.28	23.93	23.59	23.26	22.95	22.64	22.33	22.04	21.75
17.00	24.64	24.29	23.94	23.61	23.29	22.97	22.67	22.37	22.08
17.25	25.00	24.62	24.30	23.96	23.63	23.31	23.00	22.70	22.40
17.50	25.36	25.00	24.65	24.31	23.97	23.65	23.33	23.03	22.73
17.75	25.72	25.36	25.00	24.65	24.32	23.99	23.67	23.36	23.05
18.00	26.09	25.71	25.35	25.00	24.66	24.32	24.00	23.68	23.38
18.25	26.45	26.07	25.70	25.35	25.00	24.66	24.33	24.01	23.70
18.50	26.81	26.43	26.06	25.69	25.34	25.00	24.67	24.34	24.03
18.75	27.17	26.79	26.41	26.04	25.68	25.34	25.00	24.67	24.35

(Table 26 continued)

Live price per pound	Percent yield from live to eviscerated								
	69	70	71	72	73	74	75	76	77
cents	Eviscerated price per pound, cents								
19.00	27.54	27.14	26.76	26.39	26.03	25.68	25.33	25.00	24.68
19.25	27.90	27.50	27.11	26.74	26.37	26.01	25.67	25.33	25.00
19.50	28.26	27.86	27.46	27.08	26.71	26.35	26.00	25.66	25.32
19.75	28.62	28.21	27.82	27.43	27.05	26.69	26.33	25.99	25.65
20.00	28.99	28.57	28.17	27.78	27.40	27.03	26.67	26.32	25.97
20.25	29.35	28.93	28.52	28.13	27.74	27.36	27.00	26.64	26.30
20.50	29.71	29.29	28.87	28.47	28.08	27.70	27.33	26.97	26.62
20.75	30.07	29.64	29.23	28.82	28.42	28.04	27.67	27.30	26.95
21.00	30.43	30.00	29.58	29.17	28.77	28.38	28.00	27.63	27.27
21.25	30.80	30.36	29.93	29.51	29.11	28.72	28.33	27.96	27.60
21.50	31.16	30.71	30.28	29.86	29.45	29.05	28.67	28.29	27.92
21.75	31.52	31.07	30.63	30.21	29.79	29.39	29.00	28.62	28.25
22.00	31.88	31.43	30.99	30.56	30.14	29.73	29.33	28.95	28.57
22.25	32.25	31.79	31.34	30.90	30.48	30.07	29.67	29.28	28.90
22.50	32.61	32.14	31.69	31.25	30.82	30.41	30.00	29.61	29.22
22.75	32.97	32.50	32.04	31.60	31.16	30.74	30.33	29.93	29.55
23.00	33.33	32.86	32.39	31.94	31.51	31.08	30.67	30.26	29.87
23.25	33.70	33.21	32.75	32.29	31.85	31.42	31.00	30.59	30.19
23.50	34.06	33.57	33.10	32.64	32.19	31.76	31.33	30.92	30.52
23.75	34.42	33.93	33.46	32.99	32.53	32.10	31.67	31.25	30.84
24.00	34.78	34.29	33.80	33.33	32.88	32.43	32.00	31.58	31.17
24.25	35.15	34.64	34.16	33.68	33.22	32.77	32.33	31.91	31.49
24.50	35.51	35.00	34.51	34.03	33.56	33.11	32.67	32.24	31.82
24.75	35.87	35.36	34.86	34.38	33.90	33.45	33.00	32.57	32.14
25.00	36.23	35.71	35.21	34.72	34.25	33.78	33.33	32.90	32.47
25.25	36.59	36.07	35.56	35.07	34.59	34.12	33.67	33.22	32.79
25.50	36.40	36.43	35.92	35.42	34.93	34.46	34.00	33.55	33.12
25.75	37.32	36.79	36.27	35.76	35.27	34.80	34.33	33.83	33.44
26.00	37.68	37.14	36.62	36.11	35.62	35.14	34.67	34.21	33.77
26.25	38.04	37.50	36.97	36.46	35.96	35.47	35.00	34.54	34.09
26.50	38.41	37.86	37.32	36.81	36.30	35.81	35.33	34.87	34.42
26.75	38.77	38.21	37.68	37.15	36.64	36.15	35.67	35.20	34.74
27.00	39.13	38.57	38.03	37.50	36,99	36.49	36.00	35.53	35.07
27.25	39.49	38.93	38.38	37.85	37.33	36.82	36.33	35.86	35.39
27.50	39.86	39.29	38.73	38.19	37.67	37.16	36.67	36.18	35.71
27.75	40.22	39.64	39.08	38.54	38.01	37.50	37.00	36.51	36.04
28.00	40.58	40.00	39.44	38.89	38.36	37.84	37.33	36.84	36.36

69 to 77 cents a pound for live poultry at farm and yield is 75 percent, 17 cents a pound live weight becomes equivalent to 22.67 cents a pound after the poultry is eviscerated.

Table 27 has been prepared to apply changes in freight cost between live and eviscerated weight. In Table 27, first column is freight rate per pound ranging from one to two cents. First line is percentage yield from live to eviscerated weight ranging from 69 to 77 percent. If, for example, processor pays 1.5 cents a pound to haul live poultry and percent yield is 75 percent, 1.5 cents becomes equivalent to 2.07 cents per pound after poultry is eviscerated.

TABLE 27.--Conversion table--cost of transportation[1] from farm to the processing plant, live poultry to eviscerated

Freight cost/lb in cents	Percent yield from live to eviscerated 69	70	71	72	73	74	75	76	77
	Freight cost after eviscerated in cents								
1.00	1.45	1.43	1.41	1.39	1.37	1.35	1.33	1.32	1.30
1.25	1.81	1.79	1.76	1.74	1.71	1.69	1.67	1.64	1 62
1.50	2.17	2.14	2.11	2.08	2.06	2.03	2.00	1.97	1.95
1.75	2.54	2.50	2.46	2.43	2.40	2.36	2.33	2.30	2.27
2.00	2.90	2.86	2.82	2.78	2.74	2.70	2.67	2.63	2.60

[1]When processor pays freight for live poultry the freight cost includes payment for inedible portions of the poultry. This table shows the difference in freight cost between live and eviscerated poultry.

Processing By-products

At the present time the volume of by-products from the five plants do not warrant the purchasing of equipment for processing inedible by-products as an integral part of the poultry processing operation. Kahle (1957) made a detailed study of the possibility of integrating a by-product processing operation in poultry processing plants. He concluded that plants having a volume under 100, 000 pounds of live weight per week incur a loss from such an operation, but it would be profitable if the weekly live weight volume is above 300, 000 pounds. He further stated that the final solution depends on a number of local factors such as demand for such products.

If, in the future, processing costs continue to increase and at the same time, prices for thighs and breasts increase, it might be profitable to eliminate all expensive processing operations except killing and cutting thighs and breasts from the carcass, and operate a by-product processing plant.

For example, marketable chicken parts from a 2 1/2 pound bird (drawn weight) are:

Parts	Drawn wt. 2 1/2 lbs.	Cost per lb. --41¢	Relative cost
Breast	29.0%	59.0¢	17.1¢
Legs and thighs	32.0	59.0	18.5
Wings	11.0	16.0	1.8
Back and neck	19.0	5.0	0.5
Gizzard and heart	4.0	15.0	0.6
Liver	3.0	57.0	1.7

The first two parts listed, produce 61 percent of the total marketable weight, and return from these two items amounts to over 88 percent of the whole chicken. It is significant to note that the most expensive and equipment and labor time are spent for the cheapest priced parts of chicken in the processing operation.

Kahle (1957) reported the following market prices for poultry processing by-products:

Item	Market price/ton
Poultry by-products meal (55 units of protein)	$60.50
Tankage (unpressed 49 units of protein)	53.90
Tankage (unpressed plus dried blood 52.6 units of protein)	57.86
Dried blood (80 units of protein)	88.00
Feather meal (85 units of protein)	93.50
Mixed meal (67.4 units of protein)	74.14

Distribution of Processed Poultry

Ideally, processed poultry should be sold from the end of the processing line to avoid added costs in handling and storage. If current production is equal to current sales there is no need for storage facilities, assuming, of course, price is constant. If, however, current output exceeds current sales, it becomes necessary to temporarily store the excess output. This incurs fixed as well as variable costs for the storage operation. If demand for the product in the next time period is greater than current output, the temporarily stored product plus the current output can be sold. This storage operation must be distinguished from storage operation for speculative purposes.

A survey of poultry processing operations indicated that most plants have a large capacity for temporary storage. There are two main reasons for having such costly facilities. One is due to procedures in processing operations and the other is due to market conditions.

If the processing procedure is such that the whole working crew processes three-quarters of the day and the same crew packages the processed poultry the rest of the working hours, or if the operator finds unexpected sources of live poultry for a particular day and spends the whole day for processing, there would be no time to deliver the product to outlets. This type of operating procedure requires storage capacity large enough to hold one day's output.

On the other hand, if the temporary market condition is such that the price of processed poultry is unfavorable to the processor he is forced to hold the processed poultry temporarily. This could happen if there is a special promotion of other meat products in the area, or if there is a large shipment of processed poultry from other areas. When the second type of storage situation occurs frequently at short intervals, it would become a serious problem to the processor, because the processor must absorb the total storage costs, and some cases, he may be forced to cease processing operations temporarily when the storage capacity is full.

CHAPTER VIII

DISCUSSION AND RECOMMENDATIONS

Five poultry processing plants were selected and studied with emphasis on in-plant processing costs and efficiency. These five plants differed in the degree of mechanization, processing procedures, and organizational patterns.

Assuming that prices of live poultry as well as processed poultry are constant, normal profit can be expressed by the following equation:

$$R = P_{pp} - (K + P_c + PR_c + D_c + SL + SC \pm U)$$

where R is profit, P_{pp} is price of processed poultry, K is live poultry price at farm, P_c is procurement cost, PR_c is processing costs, D_c is distribution cost of processed poultry, SL is shrinkage and loss, SC is storage cost, and U is processing by-products. The prices of live poultry and processed poultry (P_{pp} and K) are beyond processor's control in competitive market.

Procurement Costs (P_C)

In Michigan where a continuous supply of live poultry for large scale operation is difficult to find, scale of plant must be based on the availability of daily live poultry supplies in the area. Either extension of procurement zone or operation of the plant short of the optimum capacity is very costly. In the former case, price of live poultry at the plant becomes higher because of longer distance, and in the latter case, processing costs become higher because the plant has to operate at less than optimum capacity. Table 28 shows poultry density, daily requirement, and procurement zone for first day of processing for each of the five plants selected in this study. Assuming poultry density is constant, the plants operate five days a week, and broilers are grown and sold in ten weeks, Plant No. 2 has to cover a zone extending as far as 170 miles away before the 3.63 mile zone had a second day supply of broilers, or it has to maintain about 50 broiler producing units of size 3,990 each in order to have a continuous operation at maximum capacity.

TABLE 28.--Poultry density,[1] maximum and normal daily processing capacity,[2] and daily procurement zone[3] for the five selected plants

Item	Plant number				
	1	2	3	4	5
Poultry density per square mile	V[4]	1,099	1,170	300	282
Maximum daily processing capacity	35	3,990	5,040	3,500	2,200
Normal daily processing capacity	35	3,300	2,100	1.750	1,000
Procurement zone first day	V[4]	3.63	4.31	11.67	7.80

[1]Based on land area as defined in the U.S. census.

[2]Based on seven hour processing day.

[3]Based on maximum processing capacity.

[4]Varies depending upon location.

In-Plant Processing Costs (PR_c)

Processing costs are composed of fixed costs and variable costs. Fixed costs are those costs that must be paid regardless of output. Total investment, administration costs, and daily fixed costs for the five selected plants are given in Table 29. Plant No. 2, for example, has to pay $36.76 every day regardless of the level of output.

TABLE 29.--Total investment in land, building, and equipment plus the administration costs for five selected plants

Item	Plant number 1	2	3	4	5
Land	R[1]	$250.00	$1,500.00	R[1]	$200.00
Building	$600.00[2]	17,000.00	20,000.00	$5,400.00[3]	60,000.00
Equipment	60.00	11,600.00	30,000.00	55,000.00	60,000.00
Administration	------	7,800.00	2,000.00	10,400.00	10,400.00
Total	660.00	36,650.00	53,500.00	70,800.00	130,600.00
Daily fixed cost[4]	$1.6949	$36.76	$37.54	$89.38	$98.72

[1]Included in rent.

[2]Rent for $50 a month.

[3]Rent for $450 a month.

[4]Computed from formula No. 5 p. 33.

Slopes of AFC and ATC curves are shown in Figures 9 and 10. It can be seen that if a plant has a high fixed cost, a decrease in AFC as the utilization of the plant increases is very distinct. On the other hand, if the plant has a low fixed cost, a decrease in AFC as the utilization of the plant increases is not very distinct. The plants that have a low fixed cost have a greater range of flexibility with respect to plant utilization. In Figure 9, Plant No. 5 has a high fixed cost per bird and has a very steep slope, whereas, Plants No. 1 and No. 4 have a low fixed cost and have mild slopes. The slopes level off from 80 percent plant utilization to the maximum capacity giving the plants with low fixed cost flexible production adjustments.

In a poultry processing operation, output is a function of rate and hours of operation. However, it is highly undesirable to change output through changes in rate, because there is only one efficient rate for a given plant; the rate is found through time and motion studies based on the "most-time common denominator." The cost structures per bird from maximum and normal plant operations for the five selected plants are reported in Table 20.

Since fixed costs do not enter into short-run costs it is economical to operate as long as the price of the processed poultry is equal to or greater than the variable costs.

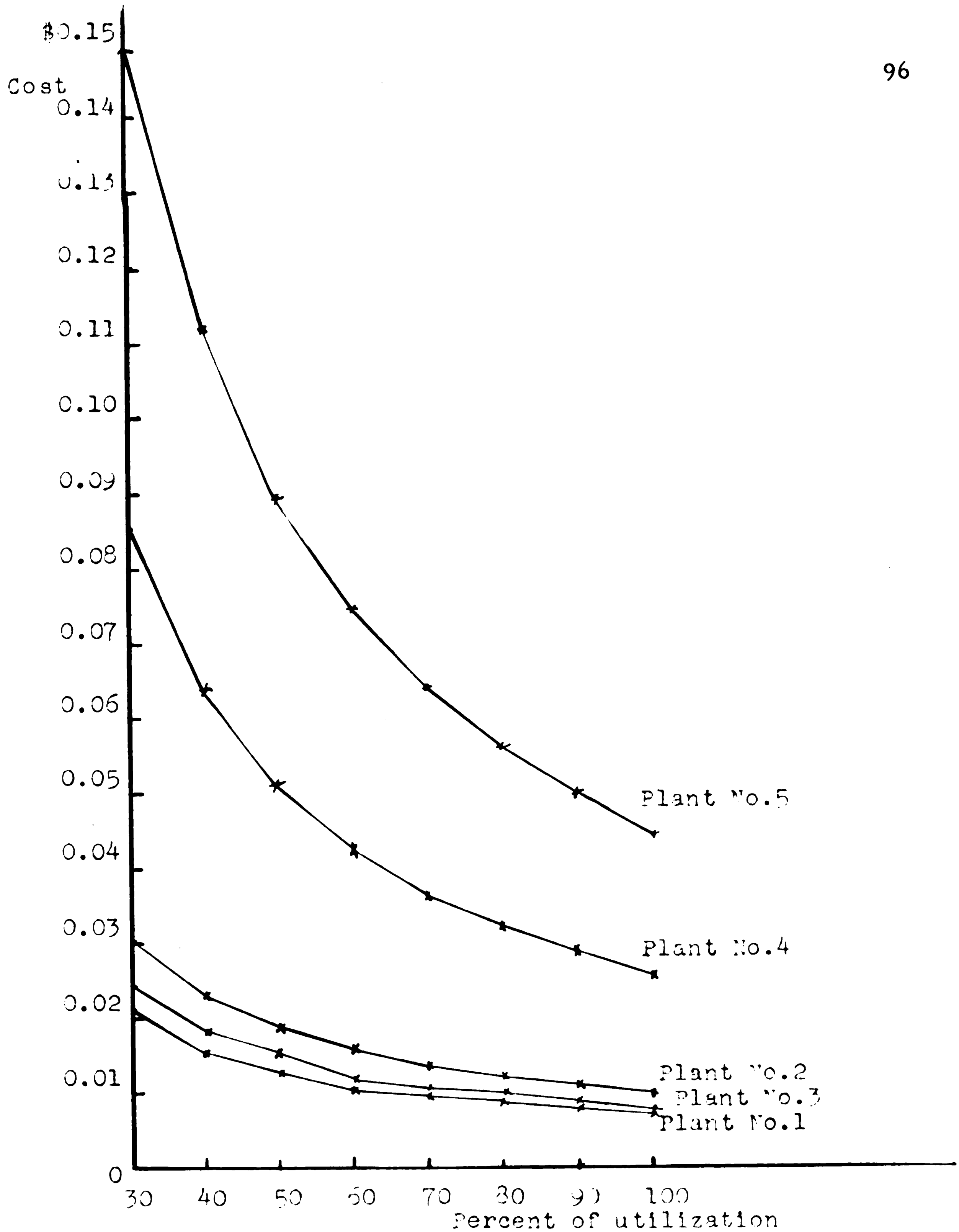

Figure 9. Average Fixed Cost per Bird with Changes in Plant Utilization for the 5 Selected Plants.

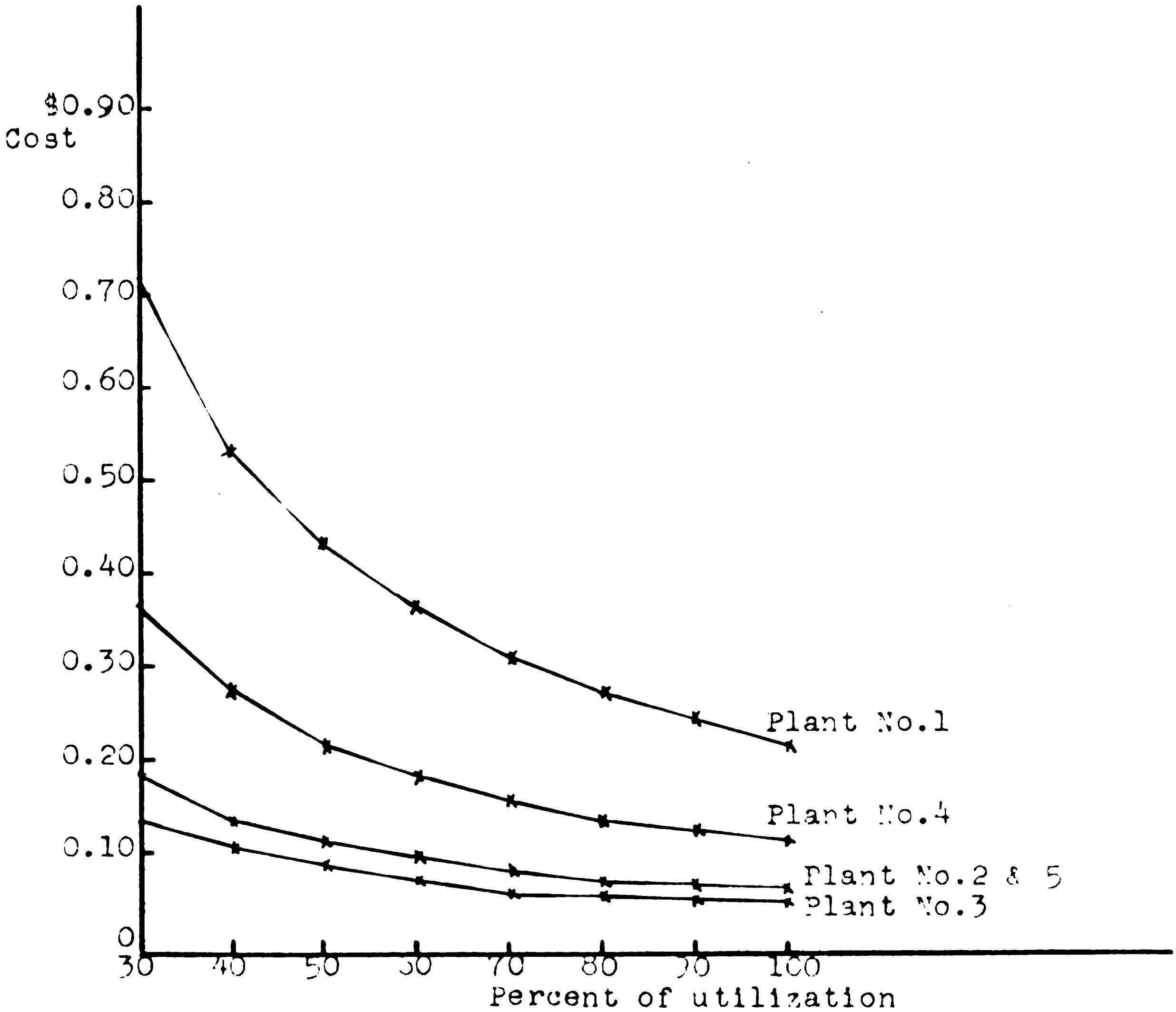

Figure 10. Average Total Cost per Bird with Changes in Plant Utilization for the 5 Selected Plants.

TABLE 30. --Fixed, variable, and total processing costs per bird based on maximum and normal operations for the five selected plants

Item	Plant number 1	2	3	4	5
Fixed costs:					
Maximum	$0.0065	$0.0092	$0.0074	$0.0255	$0.0349
Normal	------	0.0102	0.0179	0.0511	0.0987
Variable:					
Maximum	0.2109	0.0463	0.0336	0.0838	0.5045
Normal	------	0.0514	0.0807	0.1675	1.0092
Total costs:					
Maximum	0.2174	0.0555	0.0410	0.1093	0.5494
Normal	------	0.0616	0.0986	0.2186	1.0989

Distribution Costs (D_c)

The selected plants in this study do not have facilities for transporting processed poultry to distant markets. Consequently, when poultry products are shipped to distant markets, such as Chicago and New York, the plant managers hire commercial carriers. The usual transportation charge is $0.006 - $0.0075 a pound to the Chicago market and $0.01 a pound to the New York market.

A survey showed that the four selected plants sell their processed poultry mainly in local wholesale outlets. Plant No. 1 is a simulated plant, therefore, data are not available, but it is reasonable to assume the operator would sell to local outlets. Plant No. 2 sells all of its output within a 25 mile radius of the plant. Plant No. 3 sells about 50 percent in the immediate area and the remainder of the output to intermediate markets including Detroit. Plants No. 4 and 5 sell on local as well as on distant markets such as Chicago and New York.

The rate for transportation charges differed from plant to plant. Plant No. 4 paid $0.006 per pound transportation charges to the Chicago market and $0.01 to the New York market. Plant No. 5 paid $0.005 per pound up to 170 miles, $0.0075 between 200 and 500 miles, and $0.01 for distances over 500 miles.

Output per Worker

Hourly output per worker varies with changes in conveyor line speed. Hourly output per worker alone does not represent the overall efficiency of the plant. Investment in equipment must be taken into consideration. Table 31 shows hourly output per worker, investment in equipment per worker, and labor cost as percent of total costs.

TABLE 31.--Hourly output per worker, investment in equipment per worker, and labor cost as percent of total cost for the five selected plants

Item		Plant number				
		1	2	3	4	5
Output per worker:	Maximum	60	43.8	65.5	18.5	10.2
	Normal	--	38.5	27.3	9.3	4.6
Investment per worker		$60	$892	$2727	$2037	$2222
Labor as percent of total cost		79.5	66.0	76.3	67.7	32.0[1]

[1] 62.8 percent without packaging cost.

Weekly and Daily Total Variable Costs

Variable costs vary directly with changes in output. The average variable costs can be reduced only through increased output per time period. The weekly and daily total variable costs are given in Table 32.

TABLE 32.--Weekly labor cost, electricity cost, fuel cost, packaging cost, miscellaneous cost, and daily total variable costs for the five selected plants

Item	Plant number 1	2	3	4	5
Labor[1]	$50.00	$779.10	$707.30	$1,350.00	$2,000.00
Electricity[1]	R[2]	34.60	25.00	25.25	367.50
Fuel[1]	R[2]	18.50	43.25	2.00	81.50
Packaging[1]	.63	75.00	57.50	62.50	3,061.50
Miscellaneous[3]	1.00	16.00	14.00	26.00	40.00
Weekly total	51.63	923.20	847.05	1,465.75	5,550.50
Daily total	10.33	184.64	169.45	293.15	1,110.10

[1]From processors' accounting records.

[2]Included in rent (Table 29).

[3]Calculated 2 percent of total wage.

Recommendations

Recommendations for each plant are based on the following figures:[1]

[1]Prices reported in Dairy and Poultry Market News, July, 1958.

Class or kind of poultry	Average weight in lbs.	Live price at farm in cents	Hauling cost farm to plant in cents	Percent yield	Price of processed in cents
Broiler	3	17	1.5	72	30
Roaster	5	25	1.5	70	42
Hens	5	15	1.5	70	38
Turkeys	20	22	1.5	76	39

In order to realize a normal profit, price of processed poultry must cover all the costs listed in the normal profit equation on page 92; namely, live poultry price, procurement costs, processing costs, distribution costs, costs of shrinkage between live and eviscerated, and costs or receipts from processing by-products. If some of the above costs just cover the variable costs, the processor must take a loss equal to the fixed costs. If price of the processed poultry is less than the average variable costs, the loss will be the fixed cost plus some portion of the variable costs; therefore, it would be economical to cease processing.

From the data in Tables 26 and 27, the cost of broiler, roaster, hen, and turkey are calculated to be 25.69 cents, 23.57 cents, and 30.92 cents, respectively after these poultry are eviscerated.

Plant No. 1

The minimum in-plant processing costs of this plant were 21.74 cents per bird or 7.25 cents per pound for processing a three pound broiler. Referring to normal profit equation (p. 92) profit or loss from this plant would be:

$$R = 30 - (17 + 2.08 + PR_c + 1.00 + 6.61 \pm 0) = 30 - (26.69 + PR_c)$$

Therefore the in-plant processing costs (PR_c) must be equal to or less than 3.31 cents per pound in order to realize normal profit. However, Table 2 shows that the minimum in-plant processing cost is 7.25 cents per pound. As a result this plant must take a loss of 3.94 cents for each pound of broiler processed.

The 3.94 cent loss could be minimized if this plant processed poultry from its own farm and does some retailing at the plant, otherwise, it is recommended that plant of this size should not be operated.

Plant No. 2

The minimum in-plant processing costs of this plant was 5.55 cents per bird or 1.85 cents per pound for processing a three pound broiler. Referring to normal profit equation (p. 92), profit or loss from this plant is:

$$R = 30 - (17 + 2.08\, PR_c + 1.00 + 6.61 \pm 0) = 30 - (26.69 + PR_c)$$

Therefore the in-plant processing costs (PR_c) must be equal to or less than 3.31 cents per pound in order to realize normal profit. However, Table 7 shows that the minimum in-plant processing cost is 1.85 cents per pound. As a result, this plant could make 1.46 cents profit per pound if operated at the maximum plant capacity. This plant would be still profitable up to 60 percent plant utilization. However, the plant should not be operated below 40 percent plant capacity, because below this level, the average variable cost exceeds price of the processed poultry.

Plant No. 3

The minimum in-plant processing costs of this plant was 4.10 cents per caponette or 0.82 cents per pound for processing a five pound hen. Referring to normal profit equation (p. 92), profit or loss from this plant is:

$$R = 42 - (25 + 2.14 + PR_c + 1.00 + 10.71 \pm 0) = 42 - (38.85 + PR_c)$$

Therefore the in-plant processing costs (PR_c) must be equal to or less than 3.15 cents per pound in order to realize normal profit. However, Table 12 shows that the minimum in-plant processing cost is 0.82 cents per pound. As a result, this plant could make 2.33 cents profit per pound if operated at the maximum capacity. This plant would be still profitable up to 40 percent plant utilization. However, this plant should not be operated below 40 percent plant capacity, because below this level, the average variable cost exceeds the price of the processed hen.

Since this plant serves as a service function to the main business of the organization, the loss from the processing operation can be justified as long as the gain from the primary business is equal to or greater than the loss from the processing operation.

Plant No. 4

The minimum in-plant processing costs of this plant was 10.93 per hen or 2.19 per pound for processing a five pound poultry. Referring to normal profit equation (p. 92), profit or loss from this plant is:

$$R = 28 - (15 + 2.14 + PR_c + 1.00 + 6.43 \pm 0) = 28 - (24.58 + PR_c)$$

Therefore the in-plant processing costs (PR_c) must be equal to or less than 3.42 cents per pound in order to realize normal profit. However, Table 17 shows that the minimum in-plant processing cost is 2.19 cents per pound. As a result, this plant could make 1.23 cents profit per pound if operated at maximum capacity. This plant would still be profitable at 70 percent plant utilization or above. However, the plant should not be operated below 50 percent plant capacity, because below this level, the average variable cost exceeds the price of the processed poultry.

Plant No. 5

The minimum in-plant processing costs of this plant was 54.94 cents per turkey or 2.75 cents per pound for processing a twenty pound turkey. Referring to normal profit equation (p. 92), profit or loss from this plant is:

$$R = 39 - (22 + 1.97 + PR_c + 1.00 + 6.95 \pm 0) = 39 - (31.92 + PR_c)$$

Therefore the in-plant processing costs (PR_c) must be equal to or less than 7.08 cents per pound in order to realize normal profit. However, Table 22 shows that the minimum in-plant processing cost is 2.75 cents per pound for processing a twenty pound turkey. As a result, this plant could make 4.33 cents profit per pound if operated at the maximum plant capacity. This plant would still be profitable at 70 percent plant utilization or above. However, the plant should not be operated below 60 percent plant utilization, because below this level of utilization, the average cost exceeds the price of the processed poultry.

CHAPTER IX

CONCLUSIONS

1. There are six major inputs in poultry processing: (1) labor, (2) raw material (live poultry and packaging), (3) power, (4) equipment, (5) building, and (6) management. Of these six inputs, the first three are variable and the last three are fixed.

2. Whenever possible, as in the plants studied that operated at one-half of the maximum plant capacity, output should be increased through an increased hourly rate in order to reduce both fixed and variable costs. Changes in hourly rate involve fixed costs as well as variable costs, but changes in output through hours of operation involve changes in variable costs. Double shift operation results in nearly double the output but incurs less than one-half the average costs. Increasing output through overtime operation results in higher wage costs.

3. Michigan processors are in a difficult position since their investment in building and equipment is high, and their per unit cost is high because they are not able to utilize the fixed input to the fullest extent due to an inadequate supply of live poultry. For this reason the fixed assets should be kept as low as possible and output should be flexible through the use of more variable inputs.

4. Normal profit equation: $R = P_{pp} - (K + P_c + PR_c + D_c + SL + SC \pm U)$ where R is profit, P_{pp} is price of processed poultry, K is live poultry price at farm, P_c is procurement cost, PR_c is processing costs, D_c is distribution cost of processed poultry, SL is shrinkage and loss, SC is storage cost, and U is processing by-products; the processor should try to minimize PR_c, SL, and SC cost.

The in-plant processing costs (PR_c) can be minimized through full utilization of the processing plant. This study shows that the average fixed cost declines rapidly up to 60 percent plant utilization then levels off (Figure 9). The decline in average fixed cost is more distinctive for the plants with high fixed costs.

Percentage yield from live poultry to processed poultry is an important cost item. Tables 26 and 27 show the effect of percentage yields on prices of eviscerated poultry and hauling costs.

Form No. 1

CONFIDENTIAL
Research Project
Poultry Processing & Distribution
General Information

Plant No. ____ Firm Name __________________ Location __________________

1. Sources of live poultry: 1)Local farm____ 2)Broker____ 3)Co-Op ____ 4)Feed dealer ____ 5)Out of state ____ 6)Other ____

2. Kinds of poultry: 1)Fryer ____ 2)Roaster____ 3) Turkey ____ 4) Duck ____ 5)Geese ____ 6) Other ____

3. Method of procuring live poultry: 1)Own truck____ 2)Hired truck ____ 3)Producer ____ 4)Feed dealer ____ 5) Other____

4. Period of stay at plant ________ and holding capacity ________.

5. Bases for pricing live poultry: 1)Farm wt. ____ 2)Plant wt. ____ 3) price base (market) ____

6. Terms of payment: 1)Cash____ 2)Extent of credit _______

7. Loss of poultry on arrival: 1)Shrinkage____ 2)Death____ 3)Condemnation ____ 4)Other ____

8. Loss after arrival up to processing : 1)Shrinkage ____ 2)Death ____ 3)Condemnation ____ 4)Other ____

9. Extent of processing: 1)New York dressed ____ 2) Eviscerated ____ 3)Cut-up ____ 4) Other ____

10. Method of holding dressed poultry: 1)Frozen____ 2) Iced____ 3)Other ____

11. Period of holding after dressed____, portion of holding ____, and capacity of holding _____.

12. Method of transportation for dressed poultry: 1)Own truck ____ 2)Hired truck ____ 3)Others ____ (specify equipment)

13. Distance to market: 1)Local____ 2)City____ 3)Other ____

14. Proportion of sale to: 1)Wholesale at plant ____ out ____ 2)Retail at plant ____, out ____ 3)Other ____

15. Bases for pricing dressed poultry: 1)Plant wt.____ 2)Price base (market) ____ 3)Other_____

16. Terms of payment for dressed poultry: 1)Cash____ 2)Extent of credit ____

17. Dressing capacity (eight hour): 1)Turkey ____ 2)Fowl ____ 3)Fryers____

18. Employment: 1)Fulltime men ____ women ____ 2) Part time men ____ women ____

19. Days of operation: J__ F__ M__ A__ M__ J__ J__ A__ S__ O__ N__ D__

20. Sales organization:

Note:

Form No. 2
Date____________

Research Project
Poultry Processing & Distribution
Processing Sequence

Plant No. ___________ Seasonal ___ Location ______________________ Year ____

Operation	Equipment	Number of Workers	Working Position	Comment
Weighing				
Hanging				
Killing				
Scalding				
Picking				
Buffing				
Pinning				
Singeing				
Finishing				
Inspecting				
Checking for pins				
Hanging heads				
Opening				
Drawing				
Splitting neck				
Pulling crop				
Removing vent				
Removing head				
Removing neck				
Removing feet				
Separating giblets				
Cleaning giblets				
Hanging by wings				
Hanging by legs				
Placing giblets				
Grading				
Weighing				
Packing				
Stenciling				
Hauling				
Storing				

Total

Research Project
Poultry Processing & Distribution
Project I. Time & Motion Study

Plant No. ______ Date __________________ Kind of Poultry ______________

Location ________________________________ Year ______ Seasonal ________

Job No. ________ Description ____________ Age of Worker ____ Sex ______

Observations	Waiting Time*	Working Time		Distance from Prev. Job	
		Primary	Secondary	Distance ft.	Time sec.
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
Total					
Average	(a)	(b)	(c)	(d)	(e)

Previous job no. ________ Description ____________________________

Next job no. __________________ Description ________________________

Time: 1)Total conveyer time (e) =
2)Waste time [(e)-(b+c)] =
3)Working time (b)+(c) =

Ratio: 1)Conveyer speed/ft (e) ÷ (d) =
2)Waste (a) ÷ (e) =
3)Working [(b+c) ÷ (e)] =

*Time note engaged in either primary or secondary work.

Note:

Form No. 3-A

Research Project
Poultry Processing & Distribution
Project II. Cost Study-Plant

Plant No. ________________ Seasonal ________________ Date ________________

Location ____________________________________ Year ____________________

I. Fixed costs:

Item	Depreciation	Repair	Current Value	Interest on borrowed Capital	Insurance	Taxes
Land						
Building						
Equipment						
Adm. Staff						
Miscel.						
Grand Total						

Note:

Form No. 3-B

Research Project
Poultry Processing & Distribution
Project II. Cost Study-Plant

Plant No.______________ Seasonal ______________ Date ______________

Location ____________________________ Year____________

II. Variable Costs

Item	Rate	Unit	Interest	Insurance	Other	Total
Labor						
Electricity						
Water						
Oil						
Ice						
Packaging Material						
Miscellaneous Expense						
Total Grand Total						

Note:

Form No. 3-C

Research Project
Poultry Processing & Distribution
Project II. Cost Study-Distribution

Plant No.________________ Seasonal ___________________ Date __________________

Location _____________________________________ Year _____________

III. Distribution Costs:

Item	Rate	Unit	Interest	Depreciation	Insurance	Other	Repair
Labor (driver)							
Truck							
Gas & Oil							
Lodging							
Meals							
Telephone & Teleg.							
Advertising							
Commissions							
Salesman's Salary							
Sales Office Exp.							
Miscellaneous							
Total Grand Total							

Form No. 3-Γ

Research Project
Poultry Processing & Distribution
Project II. Cost Study-Plant

Plant No.__________ Seasonal__________ Date __________

Location __________ Year __________

Labor:

Job Title	Time Allocation	Pay Allocation	Total Time	Pay
President				
Vice president				
General manager				
Assistant manager				
Treasurer				
Accountant				
Secretary				
Office secretary				
Foreman I				
Foreman II				
Workers in plant 1 2 3 4 5 6 7 8 9 10 11 12 13 14				
Distributing 1 2 3				
Others 1 2 3				
Totals				

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