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LEAST-COST EGG MARKETING SYSTEM FOR THE NORTHEAST

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Preface and Acknowledgements

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Introduction

Eggs are produced in all regions of the United States. They are a relatively homogenous product and barriers to movement between regions are limited. Consequently, eggs produced in any one region may compete for markets in any other region. In recent years there has been a considerable shift in location of egg production[1/] and competition among producing areas for markets has been very keen. Historically, the Northeast has been a deficit area while the Southeast and West North Central areas have been surplus regions exporting to the Northeast. Due to competition, price differences among regions have tended to approximate transfer costs which are the costs of transportation as well as allowances for quality changes during transportation. Reduction in the costs of marketing eggs within a deficit region should aid producers in that region in competing with producers from other regions. Such reductions may also encourage cost reductions by producers and handlers in surplus regions who wish to ship eggs to markets in deficit regions.

Once eggs are produced, they must be delivered to consumers for final consumption. This can be accomplished in a number of different

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1/Neveux, J. P. Changes in the Location of the 100 Leading Egg-Producing Counties in the United States, A.E. Res. 247, Cornell Agr. Exp. Sta., Ithaca, N. Y., April 1968.

ways but each method requires the performance of services such as assembly, processing and distribution of product. The method of providing marketing services influences marketing costs. Previous studies have resulted in the identification of at least seven distinct methods of marketing eggs in the Northeast.[2/] If Northeastern egg producers are to improve their competitive position with regard to producers in other areas, they need to perform the marketing services required at a lower cost than their competitors in other regions. The objective of this study is to determine the least-cost combination of alternative marketing methods to serve the market for eggs produced and consumed in the Northeast region of the United States. This region includes Maryland, West Virginia, New York, New Jersey, Delaware, Pennsylvania and New England.

Procedure

1. Marketing Systems

A marketing system, as the term is used in this study, is an organization of components, each performing a desired function or functions, by which eggs are moved from production point to a point where they are available to consumers. The functions performed are assembly, processing and distribution. In the performance of these functions, certain services such as transportation, grading, packaging, delivery, financing, etc. are performed by various components in the system.

2/Yeh, Chung-Jeh. Main Egg Marketing, Bul. 655, Maine Agr. Exp. Sta., Orono, Maine, November 1967, p. 7.

Seven marketing systems (or channels) were identified in previous research studies of the Northeast region.[3/] These systems were modified in this study to the six combinations of components listed below:

1. Producer-processor-consumer
2. Producer-processor-retailer
3. Producer-processor-wholesaler-retailer
4. Processor-retailer
5. Processor-wholesaler-retailer
6. Wholesaler-retailer

In combinations 1-3, eggs are processed by producers and delivered direct to consumers, and retailers or institutions. In combination 4, the processor picks up eggs at producers' farms, processes eggs at a central location, and delivers direct to retail stores or to retailer warehouses. In combination 5, the processor performs the same functions as in 4 except for delivery to retailer--instead, the processor delivers to a wholesaler who then distributes to retailers or institutions. Combination 6 requires wholesalers to assemble eggs from producers (usually outside the Northeast area), process them and distribute to retailers and institutions.

2. Production and Consumption Estimates

Egg production for the region was estimated on a per county basis by use of 1964 U.S. Census of Agriculture data regarding average number of

3/ Ibid.

layers was then multiplied by the national average production per layer (219 eggs per hen per year) to obtain estimated total production per county. Egg consumption was also estimated on a county basis by adjusting consumption data developed by researchers in Maryland[4/] according to U.S. Census estimates of county populations. Counties were then aggregated into basic trading areas as delineated by Rand McNally[5/] and production and consumption estimates were obtained for each trading area by addition of the totals for the counties comprising each area.

3. Cost Functions

Functions for estimating costs of performing various marketing services had been developed previously by various researchers in the Northeast. These functions were used, where appropriate, to estimate costs of performing marketing services under each of the above mentioned systems. A matrix of distances was compiled. Linear programming techniques were then employed to determine which marketing system, or systems, would move eggs from production to consumption point at least-cost.

Costs of Performing Marketing Services

The types of marketing services performed depends upon the system involved but consist essentially of three activities: assembly,

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4/From a forthcoming Maryland Miscellaneous Publication, An Estimate of the Monthly Wholesale Level Demand for Eggs, by F. E. Bender and G. A. Bange.

5/Rand McNally and Co. Commercial Atlas and Marketing Guide, Rand McNally and Company, New York, 1966.

processing, and distribution. Systems in which producers process their own eggs involve no assembly activity, but this activity is present in the other systems. Processing and distribution activities are common to all systems. In this study, assembly refers to the activity of moving eggs from production point to processing point; processing refers to the activity of cleaning, grading, and packing eggs into retail or wholesale containers; distribution refers to the activity of transporting eggs from processing point to final consumer in the case of direct-to-consumer sales or to retailers and institutions in any of the other systems.

1. Assembly Costs

Assembly costs are costs associated with pick up of eggs at production points and transportation to central processing locations. These costs consist of truck and labor costs. Truck costs include fixed costs, those associated with ownership and variable costs associated with operation. Labor costs, all variable, are mainly drivers' wages and salaries but may include part of the costs of loading and unloading.

Massachusetts researchers have developed egg pick-up cost functions by use of regression analysis.[6/] The variables affecting pick-up costs were number of stops per route, round trip distance per route for two types of roads and volume of eggs per route. Cost functions

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6/Yergatian, C. and D. A. Storey. Wholesaler Egg Marketing Costs in Massachusetts: An Analysis of the Effect of Volume and Procurement System, Bul. 559, Massachusetts Agr. Exp. Sta., Amherst, Mass., October 1966.

were developed for trucks with capacities of 125, 225, and 325 cases of eggs per trip. The functions are:

$$1)\quad PC_1 = 26.27 + .0624\ (D) + 2.50\ \left(\frac{L}{60}\right)$$

$$2)\quad PC_2 = 30.16 + .0712\ (D) + 2.50\ \left(\frac{L}{60}\right)$$

$$3)\quad PC_3 = 50.30 + .0826\ (D) + 2.50\ \left(\frac{L}{60}\right)$$

where

$$4)\quad L = 16\ (N) + .7\ (V) + 1.33\ (D_1) + 1.71\ (D_2)^{7/}$$

In the above equations,

PC_1 = total pick-up cost per week in dollars for a 125 case capacity truck

PC_2 = total pick-up cost per week in dollars for a 225 case capacity truck

PC_3 = total pick-up cost per week in dollars for a 325 case capacity truck

D = distance traveled per week in miles

L = total labor time in minutes per week

N = number of stops per week

V = volume of eggs in cases per week

D_1 = turnpike distance in miles

D_2 = rural road distance in miles

The hourly wage rate for truck drivers was assumed to be $2.50.

7/ PC_1 was not given by Massachusetts researchers but was derived from Massachusetts data.

2. Delivery Costs

Delivery costs are costs associated with transportation of eggs from processing point to retail or institutional outlets. The Massachusetts researchers mentioned above also developed delivery cost functions.[8/] The method used was the same as that used to develop pick-up cost functions. Truck costs are held the same as for the pick-up functions but delivery labor costs are different. The function for estimating delivery labor time was as follows:

$$5) \quad L = 7.41\ (N) + .84\ (V) + 3\ (D)$$

The interpretation of the variables in equation 5 is the same as in equation 4 except that D refers to total route miles; no allowance was made in the delivery labor function for miles driven on turnpike as compared with rural roads. This was probably because little driving was done on rural roads during delivery and also because firms included in the Massachusetts study seldom had delivery routes which exceeded 100 miles round trip. In the present study, it was found necessary to include longer delivery routes. When a delivery route exceeded 200 miles round trip, it was assumed that labor time and costs per mile decreased. Consequently, equation 5 was adjusted by reducing the coefficient for D from 3 to 2.25. As for pick-up routes, the hourly wage rate for truck drivers was assumed to be $2.50.

8/Yergatian and Storey. Op. cit.

3. Processing Costs

Processing is defined in this study as the cleaning, grading, and packing of eggs. Researchers from the North Central region have developed annual processing cost schedules for processing plants of various capacities and various distributions of egg sales in cartons and cases.[9/] Included in that analysis were processing plants with automatic and semi-automatic equipment operating on both single and double shifts. Equations correlating annual processing costs with volume processed were developed by regression techniques. The processing cost equations used in this study are for plants utilizing automatic equipment and having a sales mix of 80 percent cartoned eggs and 20 percent bulk in cases. The equations are as follows:

$$6) \quad TPC_S = \$22,876.00 + 1.968\ V$$

$$7) \quad TPC_D = \$40,930.00 + 1.822\ V$$

where

TPC_S = total annual processing costs for single shift plants

TPC_D = total annual processing costs for double shift plants

V = annual volume processed (in cases)

Equation 6 was developed from data for single shift plants that ranged in annual volume from 33,750 to 540,000 cases. Equation 7 was

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9/Sanders, B. L. and L. B. Fletcher. Coordinated Egg Production and Marketing in the North Central States--V: Least-Cost Egg Marketing Organization Under Alternative Production Patterns, Res. Bul. 547, Iowa Agr. Exp. Sta., Ames, Iowa, October 1966.

developed for double shift plants where annual volume ranged from 67,500 to 1,080,000 cases. The data used to estimate equations 6 and 7 were adjusted to include a third shift. Plant capacity allowed by the adjusted data would be 101,250 to 1,620,000 cases per year. The following is the estimating equation for processing costs of a three-shift plant.

$$8) \quad TPC_T = \$121,141 + 1.665\ V$$

4. Costs of Marketing Direct by Producers

Producers who market eggs directly to retail stores and institutions perform processing and delivery services. Producers with laying flocks of 50,000 birds or more would have a weekly volume large enough to use technology comparable to small central processing plants; for these, the processing and delivery cost functions shown above were used. Producers with flocks of under 50,000 layers would, however, use different processing technology and different systems of delivery. For example, a small producer might deliver eggs to customers with a station wagon or passenger car rather than with a truck.

Data relating to processing and delivery costs for producers with flocks of less than 50,000 layers were obtained from a study of direct marketing costs.[10/] Processing costs included direct cash costs for supplies and labor costs for cleaning, grading and packing eggs. Fixed costs were seldom explicitly included since many producers found it difficult to allocate shared costs to different enterprises. For example,

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10/Stemberger, A. P. Egg Distribution Costs for Direct Marketing from Producer to Consumer, A.E. and R.S. publication in process, Pennsylvania Agr. Exp. Sta., University Park, Penna.

processing was in some cases performed in the basement of the farm dwelling and allocation of maintenance, building depreciation, taxes, heat, water and electricity became difficult. Also, no charge was made for management. No processing or delivery cost functions were developed; rather, an average cost for processing and delivery of all producers in the sample was computed for deliveries within a radius of 25 miles of the producer. The wage rate used to obtain these cost estimates was $1.65 per hour including 10 percent for fringe benefits. Processing costs were estimated to average $1.55 per case and delivery costs $2.74 per case.

Data Used in This Study

1. Production and Consumption

Production and consumption of eggs in the Northeast was estimated for each trading area by the procedure outlined on page 3. By use of this method, egg production per week for the Northeast was estimated to be 549,035 cases and consumption per week was estimated at 867,951 cases. The estimated deficit per week of 318,916 was assumed to be imported from other production areas into major Northeastern metropolitan areas.

2. Pick-up and Delivery Routes

As mentioned earlier, county data regarding number of flocks of 400 layers or more was available from U.S. Census data. However, location of these flocks within any given county was not known. In

order to develop number of pick-up routes necessary (and their lengths) a number of assumptions were made. It was assumed that processors would make three pick-up stops per week[11/] for each flock of 400 or more layers (about two cases per stop) on routes shorter than 200 miles round trip. For routes longer than this, it was assumed three stops would be made per week for flocks of 800 birds or more.

Pick-up route distances were computed in the following manner: if eggs were processed outside of the trading area in which they were produced, length of pick-up route was assumed to be the distance from the center of the trading area of production to the center of the trading area where processing took place. If eggs were processed within the trading area in which they were produced, length of pick-up routes was assumed to be one half the distance from the processing plant to the next trading area in which a processing plant was located. Air line miles were converted to road miles according to a previously determined formula.[12/]

Delivery stops, volume per stop and length of delivery routes were obtained in a manner similar to that used for pick-up routes. Work done previously in Massachusetts[13/] and Virginia[14/] gave characteristics

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11/This is consistent with present business practices and quality considerations.

12/Henry, W. F. and C. R. Burbee. Marketing New England Poultry 5. Effects of Firm Size and Production Density on Assembly Costs, Bul. 482, New Hampshire Agr. Exp. Sta., Durham, New Hampshire, April 1964.

13/Yergatian and Storey. Op. cit.

14/Buck, J. T. Egg Delivery Practices and Costs, Bul. 551, Virginia Agr. Exp. Sta., Blacksburg, Va., December 1963.

regarding length of delivery routes, number of stops per route and volume per stop. Results of these studies were used to arrive at the following assumptions regarding delivery: one delivery stop per week for each 180[15/] people on routes of less than 200 miles round trip and one stop per week for each 360[15/] people on routes longer than 200 miles. Route distances were computed from location of processing plant to the center of the trading area in which eggs were distributed.

Trucks of three capacities, 125, 225 and 325 cases, were assumed to be available for both pick up and delivery. Trucks were allocated to each plant in the most efficient manner for the plant's capacity and were assumed to be utilized at between 85-90 percent of capacity when capacity is defined as five routes per week or five times the load limit of the truck. This criterion also determined volume per route. For some plants (those with small volume) a single truck was assumed available for both pick up and delivery.

3. Processing Plants

The range of processing plant capacities included in the analysis was 600 to 32,000 cases per week. Estimates of processing costs for plant capacities beyond this range would have exceeded the limits of available data. As mentioned on page 9, producers with flocks of 50,000 layers or more were assumed to use technology comparable to small

15/Based on total population, number of routes required were obtained by dividing total population in an area by 180 or 360 whichever was appropriate.

central processing plants. Analysis for such operations follows that of central processing plants. Single, double and triple shift plant operations were considered for all plant volumes. Single shift operations had lower processing costs per case for volumes up to 123,657 cases per year (up to 2,378 cases per week) compared to multiple shift plants. For plant volumes between 123,657 to 523,637 cases per year (2,378 to 10,070 cases per week), processing costs were less for double than for single or triple shift plants while triple shift operations had lowest processing costs at volumes greater than 523,637 cases per year (over 10,070 cases per week).

As mentioned on page 9, producers with flocks of less than 50,000 layers who processed their output and sold direct to consumers or retailers were expected to use processing technology and delivery systems different from that of a central processing agency. No processing or delivery cost functions were developed for such producers; rather an average cost for processing and delivery was estimated from data furnished by a sample of producers. Processing costs were estimated at $1.55 per case and delivery costs at $2.74 per case. When a wage rate of $1.65 per hour (including fringe benefits) was used, labor costs for processing were $1.27 per case and for delivery $1.29 per case. The above costs were used for all further analysis involving marketing activities for producers with flock size under 50,000 layers.

Results

To make comparisons among the alternative marketing systems, linear programming techniques were used.[16/] The objective of the analysis was to minimize the sum of marketing costs subject to the restraints that egg output in each basic trading area was to be assembled, processed and distributed to retail or institutional outlets within trading areas in the region. Trading areas with deficit requirements were to meet such requirements by shipments from surplus trading areas within the region as far as possible with greater deficit consumption requirements to be met by imports of eggs from areas outside the Northeast.

Preliminary analyses were first made in small geographical units in Pennsylvania, first at the county level and then by aggregation of several counties. Producer-direct sales to consumers and retailers were considered to take place at $4.29 a case. Producer processor sales direct to retailers were considered for flock sizes of more than 50,000 layers by dividing total number of layers in a county into the appropriate number of flocks of this size. Such producer-processors were assumed to use the same technology as smaller central marketing plants. In spite of the fact that producer-processors had no pick-up costs, all preliminary analyses indicated that a system in which eggs were picked up at farms, processed at central processing plants and distributed from processing plant to retail outlet was most efficient in

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16/The IBM Mathematical Programming 360 linear programming model was used to derive solutions.

cost terms. This was due primarily to two reasons: (1) economies to size in processing overshadowed egg pick-up costs as plant volume increased and (2) capital outlay to move a region's production was less for central plants than for a number of smaller producer-processor units. Consequently, in extending the model to the entire Northeast region, this was the only system analyzed by setting up a number of alternative structures regarding processing plant numbers, capacities and locations.

The unit cost of each marketing service is mutually determined through interaction of performance of all services. For example, increased plant capacity may be accompanied by decreasing average processing costs but, for any given plant location, pick-up and delivery costs will increase as routes increase in length to assemble more eggs or reach enough consumers. On the other hand, smaller plant capacity may increase processing costs per unit but shorter pick-up and delivery routes reduce these costs.

Plant location influences the effect of varying plant size on pick-up and delivery costs. Increasing plant capacity in concentrated production areas would increase average pick-up costs less than if the plant were located in a low production area. Average delivery costs, however, would be greater when plants are located in high production areas rather than consumption centers. In this study, plant locations in both concentrated consumption and production areas are considered. In addition to direct sales by producers, ten sets of alternative methods of serving the region are considered. Each alternative includes a set

of plants processing various volumes of eggs per week. Minimum cost plant locations were determined for each alternative.

Alternative 1 provided for plants in each state to assemble and process all the eggs produced in that state at a single location. Each state's consumption, up to the limits of its output, was deemed satisfied with eggs produced in that state while excess output, if any, was shipped to the closest state where consumption exceeded available local eggs. To obtain the least-cost location, the required number of plants for each state were placed in each basic trading area in the state, costs were computed for each location and the least-cost location determined. The solution thus gave the total cost for assembling, processing and distributing each state's output, as well as cost per case. The total cost for the region was $1,322,193 per week. A summary of plant locations and cost per case for assembly, processing and delivery for each state is given in Table 1.

Alternative 2 provided for three plant sites for the region--one each for New England, New York, Pennsylvania and New Jersey as a group, and Maryland, Delaware and West Virginia as a group. Sites were restricted to three to correspond to the three major metropolitan areas of the region. The number of plants, and their capacities, required to serve each subregion were located within each basic trading area contained in the subregion. Costs were computed for each location and the least-cost location selected. Under the above restrictions, the least-cost solution indicated that New England would be served by five plants,

Table 1. Total cost per case for assembling, processing and distributing Northeast egg output with marketing facilities located at single point in each state.

State	Plant site	Number of plants	Total weekly volume (cases)	Cost per case
New York	Utica	5***	157,481	$2.50
Pennsylvania	Altoona	6***	186,575	2.44
Connecticut	Hartford	2***	39,904	2.14
Rhode Island and Massachusetts	Worcester	2***	36,552	2.20
Vermont	Burlington	1**	8,172	2.37
Maine	Bangor	2***	50,920	2.34
New Hampshire	Manchester	1***	13,466	2.22
Delaware	Wilmington	1***	11,979	2.21
New Jersey	Millville	1***	23,286	2.15
Maryland	Baltimore	1***	11,606	2.53
West Virginia	Charleston	1**	9,094	2.39
Entire Region		23	549,035	2.39

**Double shift plants.

***Three shift plants.

each operating three shifts a day and located at Manchester. These plants would market 149,014 cases weekly at a total cost of $2.35 per case. Pennsylvania, New Jersey and New York would be served by 12 plants operating three shifts each and located in Binghamton. These plants would market 367,342 cases weekly at a total cost of $2.47 per case. Maryland, Delaware and West Virginia would be served by a single plant in Baltimore operating three shifts. This plant would market 32,679 cases weekly at a total cost of $2.44 per case. Total cost per week for the region with this alternative would be $1,339,645.

Alternative 3 provided for processing plants to be located in each basic trading area where production exceeds 9,000 cases per week. Eggs produced in areas with less than 9,000 cases output were assumed to be picked up by the nearest plant. Processing capacity needed per area ranged from 9,597 to 50,794 cases per week. Twenty-three locations were included in this alternative. Plant sites, total weekly volume and costs per case are listed in Table 2. Total cost per week for the region with this alternative would be $1,224,348.

Alternative 4 provided for processing plants to be located in each basic trading area where weekly egg consumption exceeded 9,000 cases. Eggs produced in an area where consumption was less than 9,000 cases weekly were assumed to be handled by the closest plant. Plant sites, total weekly volume and marketing costs per case are listed in Table 3. In general, marketing costs are relatively higher for low volume plants because of higher processing costs per case. Plants at some sites where relatively high volumes are processed also have higher marketing costs. This is because plants at these sites pick up from and deliver eggs to other trading areas. Distances among trading areas included in the routes are great enough to offset lower processing costs. Total costs per week for the region with this alternative would be $1,236,300.

Alternative 5 provided for a processing plant to be located in each basic trading area. All eggs produced in the area were assembled and

Table 2. Total cost per case for assembling, processing and distributing Northeast egg output with marketing facilities located at each basic trading area having production of at least 9,000 cases per week.

Plant site	Number of plants	Total volume weekly (cases)	Cost per case
Albany	1***	33,008	$2.20
Buffalo	1***	15,628	2.26
Newburg	1***	18,653	2.25
New York	2***	50,794	2.15
Rochester	2***	47,570	2.27
Bethlehem	1***	15,166	2.31
Butler	1***	14,766	2.38
Chambersburg	1**	9,597	2.31
Lancaster	2***	44,169	2.19
Philadelphia	1***	20,332	2.12
Pittsburgh	2***	36,609	2.39
Sunbury	1***	29,645	2.24
York	1***	25,385	2.17
Hartford	1***	21,070	2.10
New Haven	1***	18,834	2.13
Bangor	1***	12,052	2.29
Portland	1***	21,058	2.19
Augusta	1***	17,810	2.26
Atlantic City	1**	10,065	2.35
Millville	1***	13,221	2.18
Worcester	2***	36,552	2.20
Manchester	1***	13,466	2.22
Baltimore	1***	11,606	2.53
Wilmington	1***	11,979	2.21
Entire Region	29	549,035	2.23

**Double shifts.

***Three shifts.

Table 3. Total cost per case for assembling, processing and distributing Northeast egg output with marketing facilities located at each basic trading area consuming at least 9,000 cases per week.

Plant site	Number of plants	Total volume weekly (cases)	Cost per case
Albany	1***	30,179	$2.27
Buffalo	1***	19,582	2.24
New York	3***	69,447	2.25
Rochester	1***	18,197	2.22
Syracuse	1***	25,695	2.21
Bethlehem	1***	26,625	2.23
Philadelphia	3***	76,768	2.20
Pittsburgh	2***	47,421	2.29
Wilmington	1***	11,979	2.17
Scranton	2***	35,712	2.40
Hartford	1***	28,759	2.11
New Haven	1***	11,145	2.18
New Bedford	1**	5,767	2.30
Providence	1**	3,941	2.41
Boston	3***	81,315	2.27
Springfield	1**	4,562	2.29
Worcester	1**	5,353	2.33
Baltimore	2***	46,588	2.29
Entire region	27	549,035	2.25

**Two shifts.

***Three shifts.

processed within the area. Each plant satisfied local consumption needs up to local production limits. Any eggs not used for local consumption were to be shipped to the nearest excess consumption area. Local production exceeded 32,000 cases per week in two areas. Two equal capacity plants were allowed in these areas. The range of processing costs was $1.74 to $2.18 per case with higher processing costs for single shift

plants where relatively low volumes were processed. Total marketing costs ranged from $2.10 to $2.70 per case while plant volumes ranged from 2,039 to 25,397 cases per week. Plant locations, volumes processed per week, number of shifts and total marketing costs per case are listed in Table 4. Total costs per week for the region with this alternative would be $1,251,799.

Table 4. Total cost per case for assembling, processing and distributing Northeast egg output with marketing facilities located in each basic trading area.

Basic trading area	Volume per week (cases)	Number of shifts	Cost per case
Albany	15,005	3	$2.19
Auburn	5,007	2	2.40
Batavia	2,330	1	2.58
Binghamton	6,507	2	2.32
Buffalo	10,568	3	2.20
Elmira	6,804	2	2.48
Glens Falls	2,287	1	2.61
Jamestown	5,060	2	2.41
Newburg	11,858	3	2.37
New York	50,794*	3	2.14
Bradford	3,954	2	2.47
Oneonta	4,715	2	2.62
Poughkeepsie	6,795	2	2.36
Rochester	15,867	3	2.14
Syracuse	8,031	2	2.20
Utica	2,829	2	2.54
Watertown	3,024	2	2.51
Bethlehem	9,697	2	2.27
Altoona	5,795	2	2.46
Berwick	3,744	2	2.60
Butler	10,812	3	2.23
Chambersburg	9,597	2	2.31
Harrisburg	7,680	2	2.38
Johnstown	5,293	2	2.36
Lancaster	33,150*	3	2.29

Table 4. Continued.

Basic trading area	Volume per week (cases)	Number of shifts	Cost per case
Lebanon	4,903	2	$2.57
Lewistown	5,339	2	2.48
Philadelphia	20,332	3	2.11
Pittsburgh	11,215	3	2.23
Pottsville	5,909	2	2.44
Reading	6,116	2	2.34
Scranton	5,469	2	2.33
Sunbury	14,653	3	2.29
Uniontown	5,212	2	2.37
York	17,705	3	2.24
Hartford	21,070	3	2.10
New Haven	11,145	3	2.21
New London	7,689	2	2.31
New Bedford	5,767	2	2.35
Providence	3,941	2	2.43
Boston	16,929	3	2.12
Springfield	4,562	2	2.36
Worcester	5,353	2	2.31
Burlington	5,877	2	2.34
Rutland	2,295	1	2.70
Bangor	12,052	3	2.42
Lewiston	8,597	2	2.34
Portland	21,058	3	2.20
Augusta	9,213	2	2.43
Manchester	13,466	3	2.25
Wilmington	11,979	3	2.20
Atlantic City	10,065	2	2.42
Millville	13,221	3	2.20
Baltimore	9,567	2	2.30
Cumberland	2,039	1	2.58
Beckley	3,302	2	2.48
Charleston	5,792	2	2.32
Entire region	549,035	129	2.28

*Two plants.

Alternative 6 also provides for processing plant sites in each basic trading area. However, plant volumes are limited to approximately 2,000 cases per week since production was assumed carried on in units of 150,000 or more layers. All plants are single shift operations. The range of egg production among trading areas is 2,039 to 50,794 cases per week. The range of marketing costs among areas is $2.36 to $2.65 per case. Pick-up costs were not included since under the above assumption on production they would not exist. Costs are generally higher in trading areas where production is greater than consumption because added costs of delivering eggs outside the area are involved. The basic trading areas, volume of eggs handled weekly, number of plants in each area and marketing costs per case for this alternative are listed in Table 5.

Table 5. Costs for assembling, processing and distributing Northeast egg output when marketing facilities limited to 2,000 cases per week volume are located in each basic trading area.

Basic trading area	Number of plants	Average plant volume weekly (cases)	Cost per case
Albany	8	1,876	$2.44
Auburn*	3	1,669	2.53
Batavia*	1	2,330	2.43
Binghamton*	3	2,169	2.42
Buffalo	5	2,114	2.37
Elmira*	3	2,268	2.53
Glens Falls*	1	2,287	2.45
Jamestown	3	1,687	2.51
Newburg*	6	1,976	2.59
New York*	25	2,032	2.45
Bradford*	2	1,977	2.44
Oneonta*	2	2,357	2.61
Poughkeepsie*	3	2,265	2.43
Rochester*	8	1,983	2.40

Table 5. Continued.

Basic trading area	Number of plants	Average plant volume weekly (cases)	Cost per case
Syracuse	4	2,008	$2.39
Utica	2	1,415	2.53
Watertown	2	1,512	2.50
Bethlehem	5	1,939	2.41
Altoona*	3	1,932	2.49
Berwick*	2	1,872	2.52
Butler*	5	2,162	2.36
Chambersburg*	5	1,919	2.47
Harrisburg*	4	1,920	2.52
Johnstown	3	1,764	2.43
Lancaster*	17	1,950	2.50
Lebanon*	3	1,634	2.65
Lewistown*	3	1,780	2.55
Philadelphia	10	2,033	2.38
Pittsburgh	6	1,869	2.40
Pottsville*	3	1,970	2.50
Reading*	3	2,039	2.40
Scranton	3	1,823	2.42
Sunbury*	7	2,093	2.51
Uniontown	3	1,737	2.44
York*	9	1,967	2.48
Hartford*	11	1,915	2.41
New Haven	6	1,858	2.43
New London*	4	1,922	2.45
New Bedford	3	1,922	2.42
Providence	2	1,970	2.44
Boston	8	2,116	2.38
Springfield	2	2,281	2.38
Worcester	3	1,784	2.43
Burlington	3	1,959	2.38
Rutland*	1	2,295	2.49
Bangor*	6	2,009	2.62
Lewiston*	4	3,149	2.50
Portland*	11	1,914	2.52
Augusta*	5	1,843	2.62
Manchester*	7	1,924	2.49
Wilmington	6	1,997	2.40
Atlantic City*	5	2,013	2.58

Table 5. Continued.

Basic trading area	Number of plants	Average plant volume weekly (cases)	Costs per case
Millville*	7	1,889	2.44
Baltimore*	5	1,913	2.43
Cumberland	1	2,039	2.41
Beckley	2	1,651	2.51
Charleston*	3	1,931	2.45
Entire region	280	1,961	2.46

*Plants in these trading areas deliver part of their output to other trading areas.

The number of plants in each area is determined by that area's production with as many plants assigned to each area as will allow average plant capacity to approximate 2,000 cases weekly. Total marketing cost per week for the region with this alternative would be $1,350,626.

Alternative 7 provided for 92 plant locations dispersed throughout the region. Plant volume of eggs processed was limited to approximately 6,000 cases per week. The solution indicated all plants to be double shift operations. One plant processing only 3,185 cases per week was included to handle residual production. The range of total marketing costs was $2.22 to $2.56 per case. Costs were lowest for plants processing eggs from areas in which the plant was located and distributing eggs within the same area. Highest costs were incurred by plants distributing eggs to areas other than where the plant was located.

Plant locations and marketing costs per case for Alternative 7 are shown in Table 6. Total marketing costs per week for the region with this alternative would be $1,284,741.

Table 6. Costs for assembling, processing and delivering Northeast egg output with marketing facilities restricted to capacity of about 6,000 cases per week.

Plant site	Number of plants	Average plant volume weekly (cases)	Cost per case
Buffalo	1	6,000	$2.29
Batavia	1	6,000	2.35
Jamestown	1	6,000	2.35
Bradford	1	6,000	2.36
Rochester	3	6,000	2 at 2.36, 1 at 2.41
Syracuse	1	6,000	2.29
Watertown	1	6,000	2.41
Utica	1	6,000	2.41
Elmira	1	6,000	2.38
Binghamton	2	6,000	2.56 and 2.35
Albany	3	6,022*	1 each at 2.29, 2.34 and 2.28
Poughkeepsie	1	6,022	2.27
Newburg	2	6,000	2.35 and 2.51
New York	6	6,000	2.23 each
Charleston	1	6,000	2.36
Beckley	1	6,000	2.44
Johnstown	1	6,000	2.38
Uniontown	1	6,000	2.39
Butler	2	6,000	2.31 and 2.35
Pittsburgh	2	6,000	2.30 and 2.34
Chambersburg	1	6,019	2.33
Harrisburg	1	6,019	2.33
Altoona	1	6,019	2.43
Lewistown	1	6,019	2.38
Sunbury	2	6,000	2.31 and 2.39
Scranton	1	6,000	2.36
Pottsville	1	6,000	2.36
Lebanon	1	6,000	2.44
Reading	1	6,000	2.36

Table 6. Continued.

Plant site	Number of plants	Average plant volume weekly (cases)	Cost per case
Bethlehem	1	6,000	$2.37
Philadelphia	4	6,000	3 at 2.26, 1 at 2.32
Lancaster	5	6,000	3 at 2.38 each, 1 each at 2.35 and 2.37
York	3	6,000	1 each at 2.37, 2.40 and 2.45
Wilmington	2	6,000**	1 each at 2.26 and 2.27
Baltimore	2	6,000***	1 each at 2.32 and 2.41
Millville	2	6,000	1 each at 2.30 and 2.31
Atlantic City	2	6,000	1 each at 2.34 and 2.36
Burlington	1	6,000	2.31
Manchester	3	6,000	1 each at 2.32, 2.39 and 2.40
Bangor	2	6,026	1 each at 2.30 and 2.40
Augusta	1	6,000	2.22
Lewiston	1	5,948	2.35
Portland	4	6,000	1 each at 2.25, 2.38, 2.40 and 2.56 each
Worcester	1	6,000	2.32
Boston	3	6,000	2 at 2.25 each and 1 at 2.30
New London	2	6,000	2.37 and 2.42
Providence	1	6,000	2.34
New Bedford	1	6,000	2.19
Springfield	2	6,000****	2.27 and 2.45
Hartford	2	6,000	2.24 and 2.28
New Haven	4	6,000	2 each at 2.32 and 1 each at 2.26 and 2.31
Entire region	92	5,967	2.34

*One plant markets only 6,021 cases.

**One plant markets only 5,979 cases.

***One plant markets only 5,708 cases.

****One plant markets only 3,185 cases.

Alternative 8 provided for 46 plant sites throughout the region. Plants were located in each basic trading area (or combination of areas) with production of 12,000 or more cases per week and were assumed to process approximately 12,000 cases each per week. One plant, included to absorb residual production, marketed only 9,185 cases. The solution indicated that all plants would operate three shifts per day. Average total marketing costs ranged from $2.18 to $2.41 per case. As with the other alternatives, most of the difference in marketing costs could be attributed to differences in distances in delivery routes. Plant sites and average marketing costs included in this alternative are listed in Table 7. Total marketing costs per week for the region with this alternative would be $1,246,309.

Table 7. Costs for assembling, processing and delivering Northeast egg output with marketing facilities restricted to capacity of about 12,000 cases per week.

Plant site	Average plant volume weekly (cases)	Cost per case
Buffalo	12,000	$2.26
Jamestown	12,000	2.30
Rochester	12,000	2.22
Auburn	12,000	2.23
Utica	12,000	2.32
Elmira	12,000	2.37
Albany	12,044	2.25
Poughkeepsie	12,043	2.32
New York*	12,000 (each)	2.18
Newburg	12,000	2.34
Charleston	12,000	2.33
Johnstown	12,000	2.30
Butler	12,000	2.32

Table 7. Continued.

Plant site	Average plant volume weekly (cases)	Cost per case
Pittsburgh	12,000	$2.31
Chambersburg	12,038	2.28
Lewistown	12,038	2.36
Sunbury	12,000	2.30
Scranton	12,000	2.31
Pottsville	12,000	2.29
Reading	12,000	2.28
Philadelphia 1	12,000	2.19
Philadelphia 2	12,000	2.22
Lancaster*	12,000 (each)	2.29
York	12,000	2.33
Wilmington	11,979	2.19
Baltimore	11,708	2.29
Millville	12,000	2.22
Atlantic City	12,000	2.27
Rutland	12,000	2.37
Manchester	12,000	2.27
Bangor	12,052	2.29
Augusta	11,948	2.30
Portland 1	12,000	2.25
Portland 2	12,000	2.41
Worcester	12,000	2.24
Boston	12,000	2.21
New London	12,000	2.29
Providence	12,000	2.23
Springfield	9,185	2.29
Hartford	12,000	2.18
New Haven 1	12,000	2.19
New Haven 2	12,000	2.25
Entire region	11,935	2.27

*Three plants.

Alternative 9 provided for 23 plant sites. Plants were located in each basic trading area (or combination of areas) with production of

24,000 or more cases per week and were assumed to process approximately 24,000 cases each per week except one where only 21,185 cases were handled. The solution indicated that all plants would operate three shifts a day and average processing cost was $1.76 per case for each except the smallest plant where it was $1.78 per case. The range of marketing costs was $2.11 to $2.36 per case. In Table 8 are listed plant sites and average marketing costs for this alternative. Total marketing costs per week for the region with this alternative would be $1,133,673.

Table 8. Costs for assembling, processing and distributing Northeast egg output with marketing facilities restricted to capacity of about 24,000 cases per week.

Plant site	Average plant volume weekly (cases)	Cost per case
Buffalo	24,000	$2.21
Auburn	24,000	2.16
Utica	24,000	2.28
Albany	24,087	2.18
Newburg	24,000	2.23
New York	24,000	2.11
Uniontown	24,000	2.36
Pittsburgh	24,000	2.21
Chambersburg	24,076	2.24
Scranton	24,000	2.23
Pottsville	24,000	2.20
Philadelphia	24,000	2.13
Lancaster	24,000	2.18
York	24,000	2.24
Wilmington	23,687	2.24
Millville	24,000	2.16
Manchester	24,000	2.31
Augusta	24,000	2.26
Portland	24,000	2.22
Worcester	24,000	2.14

Table 8. Continued.

Plant site	Average plant volume weekly (cases)	Cost per case
Providence	24,000	$2.16
Hartford	21,185	2.13
New Haven	24,000	2.14
Entire region	23,870	2.21

Alternative 10 provided for 18 plants located in basic trading areas (or combination of areas) with production of 32,000 cases or more per week. Plants were assumed to process approximately 32,000 cases each per week except one which processed 6,768 cases per week. The solution indicated that all plants except the smallest one would operate three shifts per day; the smallest one would operate two shifts per day. Processing costs were $1.74 per case for the large plants and $1.94 for the smallest one. Total marketing costs ranged from $2.08 to $2.37 per case. Plant sites, weekly volumes and marketing costs are listed in Table 9. Total marketing costs per week for the region with this alternative would be $1,133,663.

Minimization of Marketing Costs

The marketing alternatives described are each minimum cost combinations for different market structures. Characteristics differentiating each alternative are summarized in Table 10. Average marketing costs for each alternative are also listed.

Table 9. Costs for assembling, processing and delivering Northeast egg output with marketing facilities restricted to capacity of about 32,000 cases per week.

Plant site	Average plant volume weekly (cases)	Cost per case
Augusta	32,000	$2.22
Manchester	32,386	2.24
Boston	31,990	2.14
Hartford	32,000	2.11
Springfield	31,925	2.31
Utica	31,111	2.22
Rochester	32,000	2.17
Elmira	31,990	2.33
Newburg	32,000	2.23
New York	32,000	2.08
Pittsburgh	31,121	2.25
Altoona	32,275	2.24
Baltimore	32,000	2.22
Millville	32,000	2.12
Bethlehem	31,519	2.28
Lebanon	31,950	2.21
Philadelphia	32,000	2.15
Lancaster	6,768	2.37
Entire region	30,502	2.21

Discussion and Conclusions

This study was designed to determine a least-cost egg marketing system for the North Atlantic region. Marketing activities included egg assembly, processing and distribution from processing point to retail or institutional outlets. Preliminary analysis in small geographical areas indicated that on-farm processing and direct marketing by producers with less than 50,000 layers was more costly than a system in which eggs

Table 10. Summary of assembling, processing and distribution costs for each alternative structure considered.

Alternative	Distinguishing characteristics	Costs per case (dollars)			
		Assembly	Processing	Distribution	Total
1	All processing plants in each state located in one basic trading area.	.25	1.76	.38	$2.39
2	Processing at three locations in the region.	.30	1.74	.40	2.44
3	Plant sites in areas producing 9,000 cases or more per week.	.17	1.79	.27	2.23
4	Plant sites in areas consuming 9,000 cases or more per week.	.20	1.77	.28	2.25
5	Plant sites in each basic trading area. Volume set by local output.	.14	1.87	.27	2.28
6	Plant sites in all basic trading areas. Plant volumes about 2,000 cases weekly.	--	2.19	.27	2.46
7	Plant volumes 6,000 cases weekly.	.15	1.95	.24	2.34
8	Plant volumes 12,000 cases weekly	.16	1.86	.25	2.27
9	Plant volumes 24,000 cases weekly.	.18	1.76	.27	2.21
10	Plant volumes 32,000 cases weekly.	.19	1.74	.28	2.21

were picked up at farms, processed at central processing plants and distributed from processing plant to retail or institutional outlets. Producers with more than 50,000 layers were assumed large enough to use technology appropriate to central processing plants and were included in the analysis. Ten alternative structures regarding processing plant numbers, capacities and locations were postulated and a least-cost solution for moving weekly Northeast egg output determined for each configuration. Linear programming was the technique used to derive solutions.

It was assumed that similar processing technology was used by all plants, whether central plants or producer owned, at capacities appropriate to size of operation. Identical wage rates were assumed for all plants throughout the region. Eggs were assumed to be a homogeneous product that could be moved anywhere within the region without any trade barriers. Each basic trading area's consumption needs were assumed to be met by the area's production with any surplus being exported to deficit trading areas within the region. Since the Northeast as a whole is a deficit area, enough eggs were assumed imported from production areas outside the region and these eggs were then assumed to move through the channels appropriate to each alternative.

Under the above assumptions, the least-cost alternative provided for 18 plants operating three shifts a day and processing approximately 32,000 cases of eggs per week. Plant locations and marketing costs are given in Table 9 (page 32). Within the range of data considered,

economies of size in processing offset increasing pick-up and delivery costs. Alternative 6, in which all production was assumed to be carried on in flocks of about 150,000 layers with eggs processed on farms (no pick-up costs included) was the most expensive of the 10 alternatives considered--due mostly to higher processing costs of low-volume plants. However, the difference in costs between this alternative and alternative 10 is not very great--being about 40 cents per case. The 10 alternatives postulated cover a wide range of industry structure yet the difference in costs between the extremes is not too great. This would indicate that very great cost savings are not apt to result from a restructuring of the industry even though it may be drastic.

While there appear to be substantial economies to size in processing, it appears that on-farm processing at relatively low weekly volume may be able to compete with large-volume central processing. However, fragmentation of processing facilities into greater number of smaller units may result in loss of market power relative to larger operations and this could result in more intense competition for markets and lower prices.

The solution determined in this study should not necessarily be considered as the optimum number, location or size of processing plants needed to move the Northeast's weekly egg output from producer to retail outlet. Assumptions made regarding egg consumption, standard wage rates and technology and its use may be somewhat restrictive and the assumption

that eggs are a homogeneous product may not be strictly valid. If, for example, local producers are able to differentiate their product, then many other opportunities may be open. If, in addition, premium prices may be obtained for a differentiated product, perhaps the objective of maximizing net returns may be more relevant than a least-cost marketing system. However, results of this study do indicate that economies to size in processing are substantial and that industry structure may be modified quite severely without greatly affecting costs as long as large volumes are maintained. On-farm processing appears able to compete with other methods--and may be preferable from the producer point of view if it can be combined with differentiation of product and premium prices. The possibility of differentiated products and price premiums and its effect on industry structure, costs and returns, and competitive position of producers remain to be studied and will be the subject of future study.